CIVIL ENGINEERING LABORATORY-I LAB MANUAL

SEMESTER-3RD

DEPARTMEMT OF CIVIL ENGINEERING

GOVERNMENT POLYTECHNIC

NABARANGPUR

SL NO.	Name of the Experiment
1.	LABORATORY RULES AND REGULATIONS
A.	**Test On steel**
1.	Determination of Young's Modulus of steel inUniversal Testing Machine
B.	**Tests on Cement, Sands, Bricks, Blocks &Aggregates**
1.	Determination of finenessof Cement by sieving
2.	Determination of normal Consistency, Initial and final setting time of cement
3.	Determination of soundness of cement by Le-Chatelier apparatus
4.	Determination of compressive strength ofCement
5.	Determination of Compressive strength of Burnt clay, Fly Ash Bricksand Blocks
6.	Grading of Fine & Coarseaggregate by sieving for Concrete
7	Determination of Specific Gravity and Bulking of Sand
8	Determination of Specific Gravity and Bulk density ofCoarse aggregate
9	Grading of Road Aggregate
10	Determination of Flakiness,Elongation index of Road Aggregates
11	Determination of CrushingValue Test of aggregates
12	Los- Angeles Abrasion Test of aggregate
13	Impact Test of aggregate
14	Determination of soundness test of road Aggregates
C	**Tests on Concrete**
1	Determination of Compressive Strength ofconcrete cubes

2	Determination of Workability of concrete by Slump cone method
3	Determination of Workability of concrete by Compaction Factor Method
4	Non Destructive testes on concrete using reboundhammer
5	Non Destructive testes onconcrete using Ultrasonic Pulse Velocity measuringInstrument

LABORATORY RULES AND REGULATIONS

General Rules

1. Be alert and proceed with caution at all times in the laboratory
2. Do not touch any equipment, other materials in the laboratory area until you are instructed to doso.
3. Do not operate machinery unless you have received instructions on their correct usage
4. Students are not allowed to do any load test on test frame, without supervision by the project supervisor
5. Clear away the rubbish and clean up the work area and apparatus provided for each experiment after use.
6. Clean up the machine after use.
7. Do not abuse the equipment and tools.
8. Any damage to equipment or apparatus must be reported immediately to the duty personnel.
9. Waste material should be disposed off properly.
10. Exercise extreme care when handling sharp-pointed or sharp-edged tools.
11. All accidents that occur in the laboratory must be reported.
12. Report all breakage, and tools and machines that are faulty.
13. Do not use tools that are blunt or in poor condition.
14. You must always concentrate/ focus on your work and know where the Emergency switch is located.

Experiment no.-1

TENSILE STRENGTH OF STEEL

AIM OF THE EXPERIMENT:-

Determination of tensile strength and Young's Modulus of steel in Universal Testing Machine and the percentage of elongation of steel.

THEORY AND SCOPE:-

Ultimate load is taken by the material before failure is known as failure load stress and corresponding to this is known as tensile strength. It is indicated that the maximum stress-strain curve and in general indicates when cracking occurs.

Its value does not depend on the size of the test specimen. However, dependent on the preparation of specimen,temp., test environment and material.

Various tensile strength are-

(a) Yield strength: The stress at which elastic deformation changes to plastic deformation causing it to deformpermanently.
(b) Ultimate strength: The maximum strength that the material can withstand when subjected to tension orcompression or shear.It is the maximum stress strain curve.
(c) Breaking strength: The stress corresponding to the point of rupture on the stress-strain curve.
(d) Proof stress: The stress corresponding to 0.002 strain Factor of safety=ultimate stress/working stressTensile strength > Yield strength

Grade of steel	Fe415	Fe500	Fe550
Proof stress(N/$mm2$)	415	500	550
Minimum tensile strength(N/$mm2$)	485	545	585
% of elongation reqd.(minimum)	14.5	12.5	8

APPARATUS REQUIRED:-

Universal Testing Machine

MATERIALS REQUIRED:-

Steel rod of 10 mm diameter.

OBSERVATION AND CALCULATION:-

Sample	Initial length	Final length	Ultimate Load	% of Elingation
10ϕ				
10ϕ				

CALCULATION:-

For tensile strength:

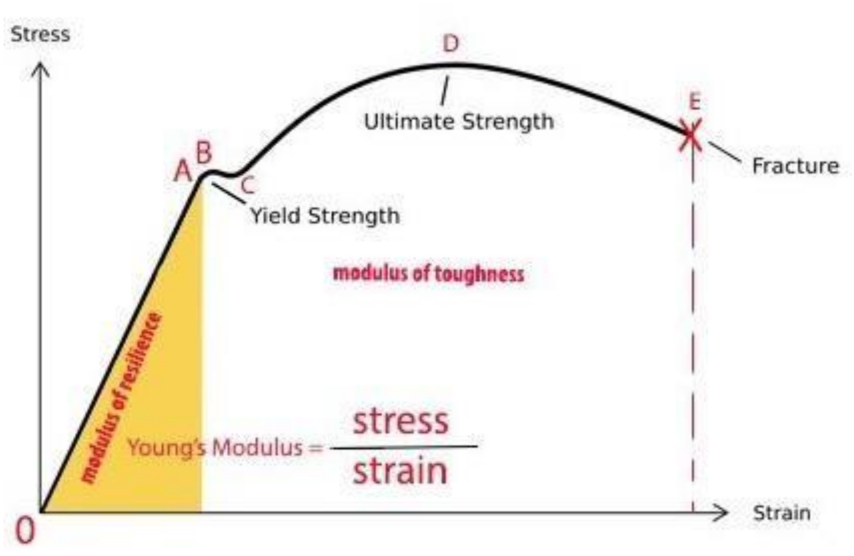
Maximum load taken by 10 mm ϕ for 1st sample=KN

Area of c/s=___$mm2$

Tensile strength=(Maxm load taken by the sample)/Area of specimen=____N/mm2

CONCLUSION:-

The 1 st sample was failed/passedin tensile strength and.So the rod was successfully passed/failed throughtensile strength test and % of elongation was found to be %.



Stress-Strain diagram for Mild steel

Experiment No-2

FINENESS OF CEMENT

AIM OF THE EXPERIMENT:-

To determine the fineness of a cement sample by sieving through a 90-micron IS sieve.

THEORY AND SCOPE:-

The degree of fineness of cement is a measure of the mean size of the grains in cement. The rate of hydration and hydrolysis and consequent development of strength in cement mortar depends upon the fineness of cement. The finer cement has quicker action with water and gains early strength though its ultimate strength remains unaffected. However, the shrinkage and cracking of cement will increase with the fineness of cement.

APPARATUS REQUIRED:-

90 micron IS Sieve (conforming to IS: 460 part-I), pan, weighing balance (sensitive to 0.1 gm)

MATERIALS REQUIRED:-

Cement free from any air lump

PROCEDURE:-

- Take 500 gm of cement (W1) in a plate and weigh accurately and transfer it to a clean dry IS test sieveby breaking down of any air set lumps.
- Then sieve the cement with gentle wrist motion until most of the fine material passed through and the residue looked fairly clean.
- Take the weight of the residue as W2.

Figure 1: 90 µ IS sieve

OBSERVATIONS AND CALCULATION:-

Mass of cement taken on IS sieve=500 gm
Mass of residue after sieving=   gm

Fineness=(Mass of residue in gms/Mass of cement taken on IS sieve) percent

$= (W_2/W_1) \times 100$

RESULT:-
Residue of cement is -----percent.

CONCLUSION:-

The cement is suitable for use in construction as the fineness of the cement is less than 10%.

PRECAUTIONS:-

- Any air set lump in the sample should be broken down with fingers but it should not be rubbed on the sieve.
- The sieve must be cleaned thoroughly before starting the experiment.
- The care should be taken to ensure that no cement is spilled. After sieving all residue must be taken out carefully and weighed.

Experiment no.-3

STANDARD CONSISTENCY OF CEMENT

AIM OF THE EXPERIMENT:-

To determine the standard consistency of a given cement sample by Vicat apparatus.

THEORY AND SCOPE:-

The object of conducting this test is to find out the amount of water to be added to the cement to get a paste of normal consistency, i.e., the paste of a certain standard solidity which is used to fix the quantity of water to be mixed in cement before performing tests for setting time, soundness and compressive strength.

APPARATUS REQUIRED:-

1. Vicat apparatus with plunger of 10 mm dia and 50 mm long, Vicat mould with glass plate. The vicat mould is of single piece truncated conical form with internal dia 70±5 mm at top, 80±5 mm at the bottom and a height of 40±2 mm.
2. Gauging trowel, measuring jar(100 ml),weighing balance of capacity 1 kg (sensitive up to 0.1 gm w),stop watch, non-porous plate, standard spatula.

MATERIALS REQUIRED:-

Cement free from any air lump, water

PROCEDURE:-

- For preparing one mould take 400 gm of cement passing 850-micron IS sieve and prepare a paste of cement with a weighed quantity of water (100 ml) taking care that the time of gauging is between 3 minutes to 5 minutes. The gauging time is counted from the time of adding water to the dry cement until commencing to fill the mould.

- Fill the vicat mould resting upon non-porous plate with this plate. After completely filling the mould, smooth off the surface of the paste by single movement of palm making it level with the top of the mould. The mould may be slightly shaken to expel air.

- Place the test block in mould with the non-porous resting plate under the rod attached with the plunger A. Lower the plunger gently to touch the surface of the test block and release it quickly, allowing it tosink into the paste.

- Prepare the trial pastes with varying percentages of water(firstly at an interval of 4%,that is of

24%,28%and 32%and then at an interval of 1%n and 0.25% between the percentage range determined by the previous test) and test as described above until the amount of water necessary for the standard consistency as defined is obtained.

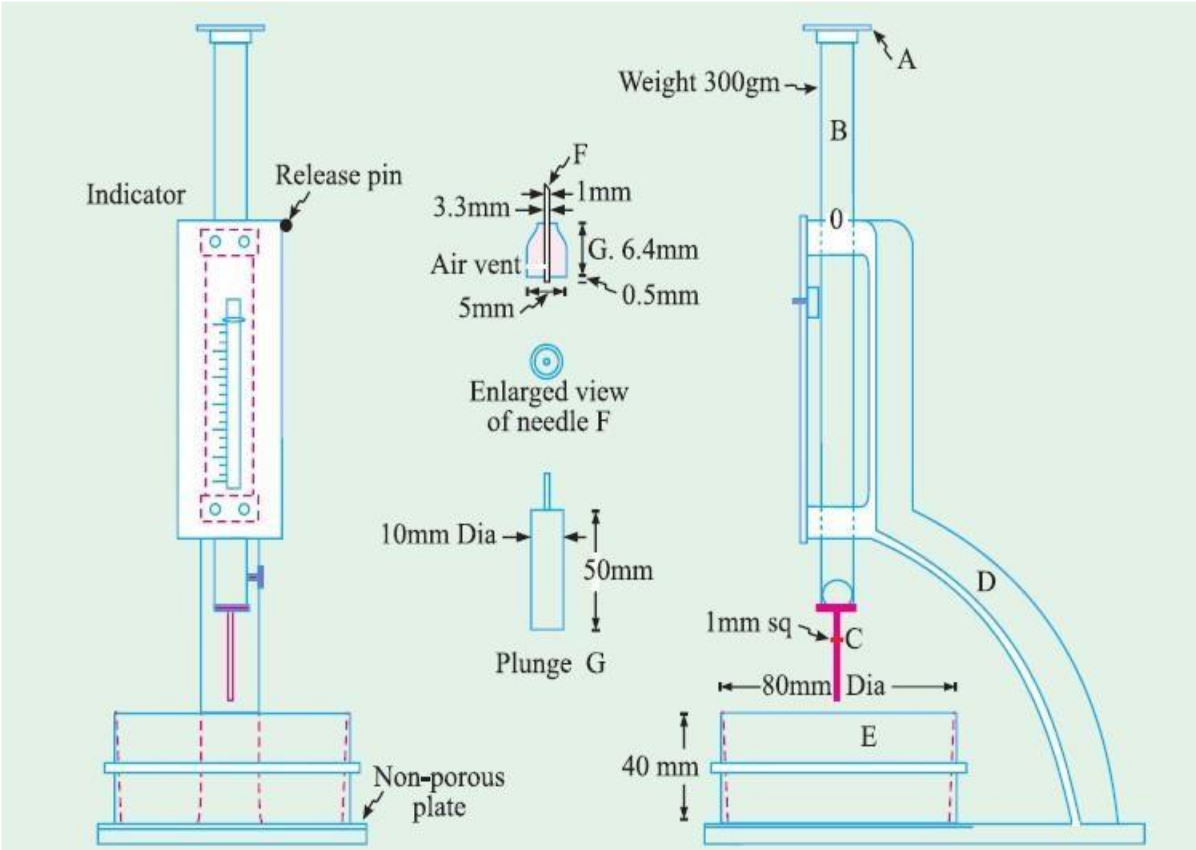


Figure: Schematic diagram of Vicat's apparatus

OBSERVATIONS AND CALCULATIONS:-

Sl No	Mass of cement Sample (gm)	Quantity of Water added in (ml)	% of water added	Unpenetrated depth, mm	Remarks

CONCLUSION:-

Hence the percentage of water required to produce a cement paste of standard consistency is --------by weight of cement.

PRECAUTIONS:-

- The experiment should be conducted at a temperature of 27±2ºC and humidity of 90%.

- After a half minute from the instant of adding water, it should be thoroughly mixed with fingers for at least one minute. A ball of this paste is prepared and then it is pressed into the test mould, mounted on the non-porous plate.
- The plunger should be released quickly without pressure or jerk, after the rod is brought down to touch the surface of the test block.
- For each repetition of the experiment fresh cement is to be taken.
- Plunger should be cleaned during every repetition and make sure that it moves freely.

REFERENCE:-

1. IS: 4031 (Part-IV) Determination of consistency of standard cement paste.
2. IS: 5513 – Specification for vicat’s apparatus
3. IS: 3535 (part-I)- Method of sampling hydraulic cement

Experiment no.-4

SETTING TIME OF CEMENT

AIM OF THE EXPERIMENT:-

To determine the initial and final setting time of a given cement sample by Vicat apparatus.

THEORY AND SCOPE:-

In order that the concrete may be placed in position conveniently, it is necessary that the initial setting time ofcement is not too quick and after it has been laid hardening should be rapid so that the structure can be made use of as early as possible. The initial set is a stage in the process of hardening after which any cracks that may appear will not re-unite. The concrete is said to be finally set when it has obtained sufficient strength andhardness.

Therefore certain limits for initial and final setting times have to be specified.

APPARATUS EQUIRED:-

1. Vicat apparatus with needle for the initial setting time and annular collar for final setting time, Vicat mould with glass plate. The vicat mould is of single piece truncated conical form with internal dia 70±5 mm at top, 80±5 mm at the bottom and a height of 40±2 mm.
2. Gauging trowel, measuring jar (100 ml), weighing balance of capacity 1 kg (sensitive up to 0.1 gm w), stop watch, non-porous plate, standard spatula.

MATERIALS REQUIRED:-

Cement free from any air lump, water

PROCEDURE:-

Preparation of Test Block :

- Prepare a neat cement paste by gauging the cement with 0.85P water, where P= standard consistency as found. The gauging time is kept between 3 to 5 minutes. Start the stop watch at the instant when thewater is added to the cement.
- Fill the Vicat mould and smooth off the surface of the paste making it level with the top of the mould. The cement block thus prepared is known as test block.

Determination of Initial Setting Time:

➢ For the determination of initial setting time, place the test block confined in the mould and resting on non-porous plate under the rod attached with the needle B, lower the needle gently in contact with the surface of the test block and release quickly, allowing it to penetrate into the test block.

- Repeat this procedure until the needle fails to pierce the block for about 5 mm measured from the bottom of the mould. The period elapsed between the time when water is added to the cement and the time at which the needle fails to pierce the test block by about 5 mm is the initial setting time.

Determination of Final Setting Time:

- For the determination of final setting time replace the needle B of the Vicat apparatus by the needle with an annular attachment C. The cement is considered finally set when, upon applying the needle C gently to the surface of the test block, the needle makes an impression thereon, while the attachment fails to do so.

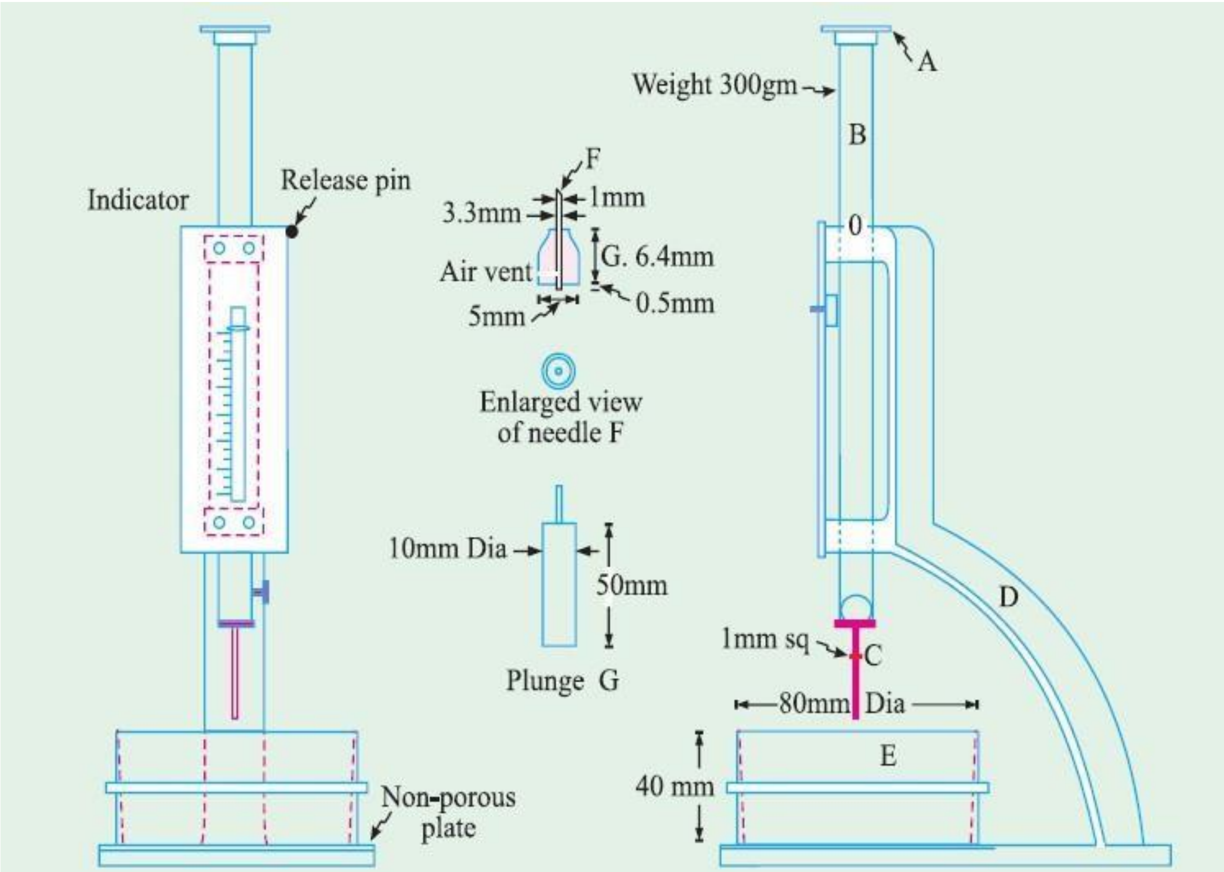


Figure: Schematic diagram of Vicat's apparatus

OBSERVATIONS AND CALCULATIONS:-

Time in minutes						
Initial reading						
Final reading						
Height not penetrated, mm						

RESULT:-

Initial setting time of cement and final setting time are found to be------ minute and --------

minute respectively.

CONCLUSION:-

As the cement used was Portland-pozzolana-cement the setting time found from the experiment is greater thanthe setting time of ordinary Portland cement i.e.

Initial setting time______minutes.

Final setting time______minutes or hours.

PRECAUTIONS:-

- The experiment should be conducted at a room temperature of 27±2ºC and at a relative humidity of 90 percent.
- After a half minute from the instant of adding water, it should be thoroughly mixed with fingers for at least one minute. A ball of this paste is prepared and then it is pressed into the test mould, mounted on the non-porous plate.
- The plunger should be released quickly without pressure or jerk, after the rod is brought down to touch the surface of the test block.
- For each repetition of the experiment fresh cement is to be taken.
- Plunger should be cleaned during every repetition and make sure that it moves freely and there are no vibrations.

REFERENCE:

1. IS: 4031 (Part- IV) -1988- Determination of consistency of standard cement paste

2. IS : 4031 Part V) – 1988

3. IS : 5513-1976- Specification for vicat's apparatus

Experiment no.-4

SOUNDNESS TEST OF CEMENT

AIM OF THE EXPERIMENT: To verify the soundness of cement by Le- Chetelier apparatus method.

THEORY AND SCOPE:-

Cement is said to be fine it does not undergo significant volume change during hardening processand it is presumed to be unsound, when the percentage of free time and magnesia is more than that specified. However, the unsoundness may be reduced by limiting the magnesia content to less than 0.5 percent, by allowing the cement to aerate for several days and though proper mixing.

There are two methods by which the soundness of cement can be determined namely

- Le-Chetelier method and (2) Auto clave method. In Le-Chetelier test, the expansion in cement should not be more than 10mm according to: 269. However, it may be noted that expansion due to the presence of free lime only is mostly reflected in Le-Chetelier's test.

In this method, the field condition of exposure of cement to natural weathering agent is stimulated by accelerated hydration due to boiling of the specimen in water in the laboratory.

APPARATUS REQUIRED :

1. Le-chetelier apparatus
2. Glass plates -2 no's
3. Load weight
4. Trowel
5. Thermometer
6. Measuring cylinder
7. Enamel tray
8. Weighing balance
9. Water bath
10. Stop watch

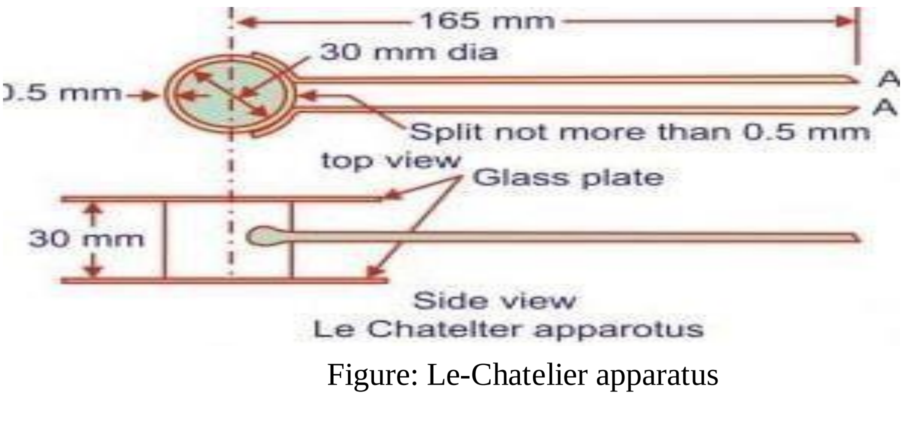


Figure: Le-Chatelier apparatus

MATERIAL REQUIRED:-

1. Ordinary Portland cement of around 50gms. The sample is to be taken in accordance with the requirements of 1S:3535 and the representative sample of the cement selected is to be thoroughly mixed

before testing.

2. Portable or distilled water.

PROCEDURE:

- About 50gm (W) of cement of known normal consistency (P) is weighted for each mould.
- The amount of water equal to 0.78P * W measured with the help of measuring cylinder (where P &W are as defined above)
- The cement sample and water are mixed properly to form a paste.
- The brass spilt cylinder mould is placed one glass plate and the above cement paste is filled up in it.
- Care is taken to keep the edge of the mould gently together, while filling the cement paste is the mould.
- The split cylinder with sample is covered with another piece of glass plate and the lead weight is placed over it.
- The above assembly is submerged in fresh and clean water maintained at a temperature of 27#2”C and kept it there for 24 hours.
- After curing, the distance separating the indicator points is accurately measured in mm.
- Again, the mould is submerged in water at the same above prescribed temperature in a water container or water bath.
- The water in the water bath is allowed to boil for 3 hours with the mould kept submerged in it by raising the temperature to boiling point in about 25 to 30 minutes.
- Then the mould is removed from water, allowed to cool in natural manner and the distance between the indicator points is measured.
- The difference between the two measurements represents the Le- chetelier expansion of cement on hydration.

PRECAUTIONS:

1. Weighing of the cement and measurement of the water is to be done accurately.
2. The edge of the split cylinder mould is to be kept together gently while filling it with the cement paste.
3. Gauging time 3-5 minutes is to be maintained from addition of water to the cement till the mould is filled up.
4. Mould is to be handled carefully while conducting the test ; otherwise the dimension of the specimen may change due to disturbance of the gap between the two jaws.
5. The temperature of water in the bath is to be correctly maintained.

OBSERVATION AND CALCLATION:-

Sl No.	Particular of Spcimen	Specimen No.		
1	Weight of the cement sample (W)			
2	Normal consistency of the sample cement (P)			
3	Amount of water added to the sample = 0.78PX W			
4	Time at which the sample is put in water at 27 ± 2^0C			

5	Time when water is brought to the boiling point			
6	Distance between the pointer ends before heating (D_1) mm			
7	Time of boiling			
8	Distance between the pointer ends after heating (D_2) mm			
9	Difference (D_2- D_1) in mm			

RESULT:-

Average value of Le- Chatelier expansion of the cement has been found to be____________mm.

DISCUSSION:-

The expansion of the cement as measured by Le-Chetelier apparatus is not to be more than 10mm for ordinary port land cement , rapid hardening cement, low heat port land cement and blast furnace slag cement.

REFERENCE:-

1) I.S:4031 – Method of physical test for hydraulic cement – (Part - III) Determination of soundness of cement.

Experiment no.-5

COMPRESSIVE STRENGTH OF CEMENT MORTAR

AIM OF THE EXPERIMENT:-

To determine the compressive strength of 1:3cement sand mortar cubes after 7 days and 28 days of curing.

THEORY AND SCOPE:-

The compressive strength of cement mortar determined in order to verify whether the cement confirms to IS specification (IS:269-1976) and whether it will be able to develop the required compressive strength of concrete.

According to IS specifications the ultimate compressive strength of cubes of cement sand mortar of the ratio 1:3, containing (P + 3) percent of water, where P is the normal consistency of cement. The fine aggregate used in the preparation of the mortar is standard sand, washed, cleaned and dried at 100 ^{0}C to 110 ^{0}C & cooled. This test can be considered as a final check on the quality of cement and can be calculated by measurement of applied load on the contact area of the cube. Ordinary Portland cement should have minimum compressive strength of 16 Mpa, 22 Mpa and 33 Mpa at 3, 7 and 28 days respectively. 28 days of compressive strength of cement is referred to as grade of cement (without mention of the unit Mpa) i.e. cement of 33, 43 or 53 grade.

APPARATUS REQUIRED:-

Cube moulds- 7.06 cm size (9 no.s), Vibrating machine, Enamel trough, Measuring cylinder- 100 ml/ 200 ml capacity, Trowels, Nonporous plates, Weighing balance of accuracy 0.02 gm Grease/lubrication oil, Compression Testing Machine.

MATERIALS REQUIRED:-

Cement, water

PROCEDURE:-

A) Preparation of mortar for the cubes:

- of uniform colour. The interior surface of the cube moulds are oiled.
- Calculate the material required. The material for each cube shall be mixed separately and the quantity of cement and standard sand shall be as follows Cement= 200 gm Standard sand= 600 gm
- The mixture of cement and standard sand in the proportion of 1:3 by mass, on a non porous plate or china dish, was placed, mixed (when dry) with a trowel for one minute was.

Percentage of water was used $(\frac{P}{4}+3)$ and time of gauging is about 3-4 minute.

- The assembled mould was placed on the table of the vibrating machine and it was firmly held in position with clamps.
- Immediately after mixing the mortar, the entire quantity of mortar was filled in the cube mould and compacted by Vibrating machine. The period of vibration shall be 2 minutes at the specified speed of 12000±400 cycles per minute.
- The mould was removed from the machine and it was kept at a temperature of 27±2ºC on an atmosphere at least 90% relative humidity for 24 hrs after completion of vibration.
- After 24 hrs, the cube was removed from the mould and immediately after submerged in clean and fresh water and kept there until taken out just prior to breaking. The water in which the cubes are submerged, shall be renewed after 7 days and be maintained at temperature of 27±2ºC.The cubes were kept wet till they are placed in machine for testing.

B) Testing

- The test cube is placed on the platform of compression testing machine (by keeping any of its transverse surfaces horizontal) co- axially without any packing between the cube and the steel plates of the testing machine.
- The test cube at a particular age is tested and the corresponding readings are recorded.

OBSERVATIONS AND CALCULATIONS:-

Sl No.	7 days strength			28 days strength		
	Area of specimen (A) mm^2	Load (KN)	Strength (N/mm^2)	Area of specimen (A) mm^2	Load (KN)	Strength (N/mm^2)

RESULT:-

The compressive strength of cement is found as

follows: At 7 days → N/mm^2

At 28 days → N/mm^2

CONCLUSION:-

Referring to the specification of cement, the test result indicates that the cement satisfies / does not satisfy the requirements of strength development at ages of ------------- and ----------- days.

PRECAUTIONS:-

- The mortar shall not be compressed to moulds with hand.
- The results which fall outside of the average results should be neglected on either side.
- The cube should be tested on their and not on their faces.
- The inside of the cube mould should be boiled to prevent the mortar from adhering on the sides o mould.
- The size of sand particle should be such that not more than 10 percentage by weight shall pass a 60-micron IS Sieve and shall completely pass through a 85-micron IS Sieve.
- The time of wet mixing shall not be more than 3 minutes.If the time of mixing exceeds 4 minutes to being a uniform colour.The mixture shall be rejected and fresh mortar should prepared.
- The cubes shall not be allowed to dry until they are broken.

REFERENCE:-

1. IS:4031 (Part-VI)- Method of physical tests for hydraulic cement; determination of compressive strength.
2. IS: 650- Specification of standard sand for testing of cement.

Experiment no.-6

COMPRESSIVE STRENGTH OF BURNT CLAY BRICK

AIM OF THE EXPERIMENT:-

To determine the compressive strength of bricks.

THEORY AND SCOPE:-

Bricks are the most commonly used building blocks used in construction works as masonry walls, paving bricks or in floorings where these are primarily subjected to compressive stresses. The strength of masonry wall is dependent upon the basic strength of bricks as well as mortar. Therefore it is important to test the bricks for their compressive strength to assess the load carrying capacity of structural units constructed out of them. As per IS: 1077-1970, the minimum crushing strength of bricks is 3.5 N/mm^2 (50 kg/ cm^2) and bricks having compressive strength less than 5 N/mm^2 (50 kg/cm^2) are not used for structural works.

The common bricks are classified on the basis of their average compressive strength as given in the following table:

Class Designation	35	30	25	20	17.5	15	12.5	10	7.5	5	3.5
Average compressive strength (not less than), N/mm2	35.00	30.00	25.00	20.00	17.5.00	15.00	12.5.00	10.00	7.5	5.0	3.5

PROCEDURE:

- Remove the unevenness observed on the bed faces of the specimen to provide too smooth & parallel faces by grinding and measure the dimensions of the specimen.
- Immerse the specimen in water at room temperature for 24 hours.
- Take the specimen out of water and drain out any surplus moisture at room temperature.
- Fill the frog (where provided) and all voids in the bed faces flush with cement mortar (one cement: 1 clean coarse of sand of grade 3 mm and down.
- Store the specimen under the damp jute bags for 24 hours followed by immersion in clean water for 3 days.
- Take the specimen out of water and wipe out any traces of moisture.
- Place the specimen with flat faces horizontal, and mortar filled face facing upwards between two 3 – ply plywood sheets each of 3 mm thickness and carefully center the specimen between the plates of the testing machine.
- Apply the load axially at an uniform rate of 14 N/mm2 per minute till the failure occurs and note down the maximum load at failure.

- Calculate the compressive strength in N/mm2 using the formula. Compressive strength = (Maximum load at failure) / Average area of the bed faces.
- Report the average of results and classify the sample of bricks tested (use Table 1 as reference)

TABULATION:

Sl No.	Dimensions of the brick, mm		Average cross sectional area, mm2	Maximum load at failure, N	Compressive strength, N/mm2	Remarks
	Length	**Width**				
1						
2						
3						
4						
5						

RESULT:

- Average compressive strength =______________________________N/mm2

CONCLUSION:-

The average compressive strength of bricks is within the permissible limit.

PRECAUTIONS:-

- The bricks should be collected of uniform size.
- The frog and all the void spaces are to be properly filed with cement mortar so as to give a plane surface for loading.
- After filling the frog and any other voids the bricks should be fully immersed in water.
- The testing sample should be placed with flat face horizontal and mortar face facing upwards and the load is to be applied centrally.

REFERENCE:

IS: 5454 – Method of sampling for clay building bricks.

IS: 1077 – Common burnt clay building bricks- Specification.

EXPERIMENT NO. 7

SIEVE ANALYSIS OF COARSE AND FINE AGGREGATES

AIM OF THE EXPERIMENT:

Determination of gradation of Fine & Coarse aggregate by sieving for concrete

APPARATUS REQUIRED:-

Indian standard test sieves(4.75mm,2.36mm,1.18mm,600μm,300μm,150μm) ,weighing balance,sieve shaker,trays,drying oven for fine aggregates.

Indian standard test sieves 80mm,40mm,20mm,10mm and 4.75mm(refer 460- 1978),weighing balance, sieve shaker,trays,drying oven. For coarse aggregates.

MATERIALS REQUIRED:-

Fine aggregates, Coarse aggregates.

THEORY AND SCOPE:-

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 : 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
600μ	15-34	35-59	60-79	80-100
300μ	5-20	8-30	12-40	15-50
150μ	0-10	0-10	0-10	0-15

Table : Grading of single-graded coarse aggregates

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

PROCEDURE FOR FINE AGGREGATE:

- Take 1kg of fine aggregate from a laboratory sample.Care shall be taken to ensure that the sieves are clean before use.
- Carry out sieving by using sieve shaker. Shake each in order 4.75mm, 2.36mm, 1.18mm, 600μm, 300μm, 150μm over a clean tray for a period 2 minutes Shaking.
- The shaking shall be done with a varied motion, backward and forwards, left to right, circular clockwise and anti clockwise and with frequent jarring, so that the material is kept moving over the sieve surface in frequently changing directions.
- Material shall not be forced through the sieve by hand pressure. Lumps of fine material, if present, may be broken by gentle pressure with fingers against the side of the sieve.
- Find the mass of aggregate retained on each sieve taken in order.

OBSERVATIONS AND CALCULATIONS:-

Sl No.	IS Sieve size	Mass retained(gm)	Percentage retained(gm)	Percentage passing	Cumulative percentage retained
1					
2					
3					
4					
5					
6					
7					
					$\sum=$

Fineness Modulus of fine aggregate= $\frac{\sum \text{Sum of cumulative percentage retained on sieve}}{100}$

PROCEDURE FOR GRADATION OF COARSE AGGREGATE:-

- The sample is brought to an air dry condition either by drying at room temperature or by heating at a temperature of 1000C t0 1100C and cooled.
- The air dried sample of course aggregate is then weighed accurately.
- The sample of aggregate is sieved successively on the appropriate sieves starting with¬ the largest in order 80mm,40mm,20mm,10mm and 4.75mm over a clean tray for a period 2minutes Shaking.
- The shaking shall be done with a varied motion, backward sand forwards, left to right,¬ circular clockwise and anti-clockwise, and with frequent jarring, so that the material is kept moving over the sieve surface in frequently changing directions.
- Material shall not be forced through the sieve by hand pressure. Lumps of fine¬ material, if present, may be broken by gentle pressure with fingers against the side of the sieve.
- Lumps of fine material, if present, is to be broken by gentle pressure with fingers¬ against the side of the sieve.
- Find the mass of aggregate retained on each sieve taken in order

Figure: Indian standard sieves

Table : Grading limit for coarse aggregate IS:383- 1970

OBSERVATION AND CALCULATION:-

Sl No.	IS Sieve size	Mass retained(gm)	Percentage retained(gm)	Percentage passing	Cumulative percentage retained
1					
2					
3					
4					
5					
6					
7					
					∑=

CALCULATION:-

$$\text{Fineness Modulus coarse aggregate} = \frac{\sum \textbf{Cummulative percentage retained} + \mathbf{500}}{\mathbf{100}}$$

RESULT:-   (Fine Aggregate)

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

ii. The given sample of fine aggregate belongs to Grading Zones I / II / III / IV.

iii. Particle size distribution or grading curve is plotted between the cumulative percentages finer or passing vs. Particle size or sieve size on a semi-logarithimic scale.

RESULT:-   (Coarse Aggregate)

I. The given sample of aggregate confirms to grading requirements of single size/ graded aggregate of nominal size --.

II. A particle size distribution curve or grading curve is plotted with ordinate showing percentage of aggregate passing or finer and the abscissa showing the sieve size on logarithmic scale i.e. a semi log plot. The grading curve indicates whether the grading of a given sample of aggregate is too coarse, too fine or deficient in a particular size. Thus

   (a) If the actual grading curve is lower than the specified grading curve, the aggregate is coarser indicating the possibility of segregation of the mix.

   (b) If the actual grading curve lies well above the specified grading curve, the aggregate is finer indicating greater water requirement.

   (c) If the grading curve is steeper than the specified grading curve, it indicates the excess a middle size particles and may lead to harsh mix.

   (d) If

RESULT:-   (Fine Aggregate)

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

ii. The given sample of fine aggregate belongs to Grading Zones I / II / III / IV.

iii. Particle size distribution or grading curve is plotted between the cumulative percentages finer or passing vs. Particle size or sieve size on a semi-logarithimic scale.

RESULT:- (Coarse Aggregate)

I. The given sample of aggregate confirms to grading requirements of single size/ graded aggregate of nominal size --.

II. A particle size distribution curve or grading curve is plotted with ordinate showing percentage of aggregate passing or finer and the abscissa showing the sieve size on logarithmic scale i.e. a semi log plot. The grading curve indicates whether the grading of a given sample of aggregate is too coarse, too fine or deficient in a particular size. Thus

  (a) If the actual grading curve is lower than the specified grading curve, the aggregate is coarser indicating the possibility of segregation of the mix.

  (b) If the actual grading curve lies well above the specified grading curve, the aggregate is finer indicating greater water requirement.

  (c) If the grading curve is steeper than the specified grading curve, it indicates the excess a middle size particles and may lead to harsh mix.

  (d) If

III. A comparison of this curve is made with the standard curve for single size and graded coarse aggregate.

CONCLUSION:-

The experiment has an important bearing on the on the concrete mix. From the result of sieve analysis one isable to proportion the fine and coarse aggregate in order to get combine mix of required gradation.

PRECAUTIONS:-

1. Material is not to be forced through the sieve by hand pressure but light brushing with a soft brush on the underside of the sieve may be used to clear the sieve openings.
2. There should be no loss of material or fines during the process of weighing, sieving or transferring and the total weight on the sieves and bottom pan should tally with the sample weight taken.

REFERENCE:-

1. IS: 383- Specification for coarse and fine aggregate from natural sources for concrete.

2. IS: 2386-(Part-1) Method of test for aggregates for concrete, particle size and shape.

REFERENCE:-

1. IS: 2386-(Part-1) Method of test for aggregates for concrete, particle size and shape.

2. IS: 383- Specification for coarse and fine aggregate from natural sources for concrete.

3. IS: 460- IS specification for test sieve

EXPERIMENT NO-8

DETERMINATION OF SPECIFIC GRAVITY AND BULKING OF

SANDAIM OF THE EXPERIMENT:

To determine the specific gravity and bulking phenomena in sand.

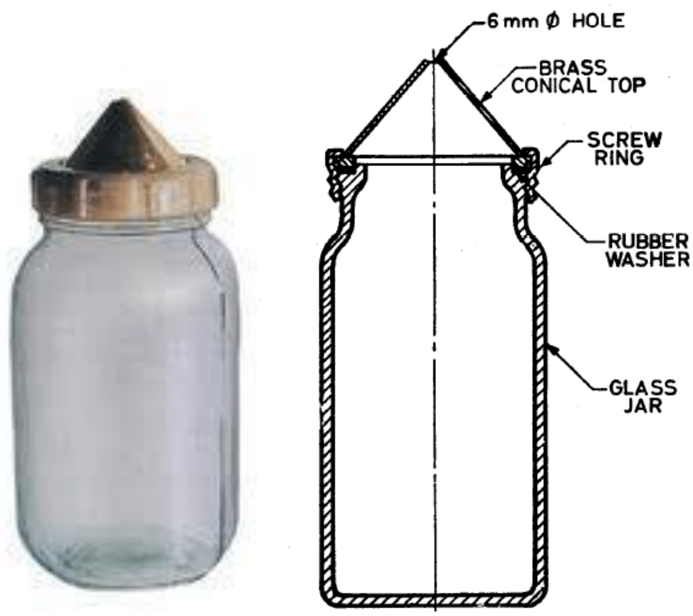
APPARATUS:

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

THEORY:

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.

Specific gravity is the weight of aggregate relative to the weight of equal volume of water.



(Pycnometer)

PROCEDURE:

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 SolidsW2 - W1 / ((W4 - W1) - (W3 - W2))

TABULATION:

SL 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		

RESULT:

Specific gravity of fine aggregate____.

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:

SL 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.

REFERENCE: IS 2386 PART III-1963

EXPERIMENT NO – 9

Gradation of coarse aggregates (fineness modulus)

Aim of the Experiment:

Gradation of coarse aggregates (fineness modulus) (IS 383 1970).

Test Standard Reference:

To determine the fineness modulus of coarse aggregates by classifications based on IS: 383-1970.

Theory:

Fineness modulus of coarse aggregates represents the average size of the particles in the coarse aggregate by an index number. It is calculated by performing sieve analysis with standard sieves. Higher the aggregate size higher the Fineness modulus hence fineness modulus of coarse aggregateis higher than fine aggregate. In general, however, a smaller value indicates a finer aggregate.

Apparatus:

Set of IS sieve, weighing balance, trays and mechanical sieve-shaker.

Procedure:

1. Take 5 kg of coarse aggregate by quartering from the test sample.
2. Arrange the relevant sieves one above the other with the sieve size increasing from the top and put the pan at the bottom.
3. Put the set of sieves over the sieve shaker and shake 2 to 3 minutes.
4. Weigh the amount of aggregate retained on each sieve.

Precautions:

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

Observation and Result:

Sl. No.	Sieve size	Weight retained	% Weight retained	Cumulative % retained (C)	% Weight passing (finer)

$\sum C =$

Conclusion:

Fineness modulus (excluding C for pan) = $\sum C/100$ =

EXPERIMENT NO-10

Determination of Flakiness Index and Elongation Index of Course Aggregates

AIM: To determination of Flakiness Index and Elongation Index of Course Aggregates.

THEORY : Particle shape and surface texture influence the properties of freshly mixed concrete more than the properties of hardened concrete. Rough-textured, angular, and elongated particles require more water to produce workable concrete than smooth, rounded compact aggregate. Consequently, the cement content must also be increased to maintain the water-cement ratio. Generally, flat and elongated particles are avoided or are limited to about 15 % by weight of the total aggregate.

Apparatus : The metal gauge shall be of the pattern shown in Fig. 10.1, Balance, Gauging Trowel, Stop Watch,etc.

Procedure :

1. Sample - A quantity of aggregate shall be taken sufficient to provide the minimum number of 200 pieces ofany fraction to be tested.
2. Sieving - The sample shall be sieved in accordance with the method described in Exp. 2.5 with the sievesspecified in Table 3.18.

Table 3.18. Shows Dimensions of Thickness and Length Gauges (IS: 2386 (Part I) – 1963)

Size of Aggregate Thickness		Length of Gauge* mm	Gauge† mm
Passing through IS Sieve	Retained on IS Sieve		
63 mm	50 mm	33.90	–
50 mm	40 mm	27.00	81.0
40 mm	25 mm	19.50	58.5
31.5 mm	25 mm	16.95	–
25 mm	20 mm	13.50	40.5
20 mm	16 mm	10.80	32.4
16 mm	12.5 mm	8.55	25.6
12.5 mm	10.0 mm	6.75	20.2
10.0 mm	6.3 mm	4.89	14.7

* This dimension is equal to 0.6 times the mean Sieve size.

† This dimension is equal to 1.8 times the mean Sieve size.

3. Separation of Flaky material- Each fraction shall be gauged in turn for thickness on a metal gauge of the pattern shown in Fig. , or in bulk on sieves having elongated slots. The width of the slot used in the gauge or sieve shall be of the dimensions specified in co1 3 of Table 3.18 for the appropriate size of material.
4. Weighing of Flaky Material - The total amount passing the gauge shall be weighed to an accuracy of at least

0.1 percent of the weight of the test sample.

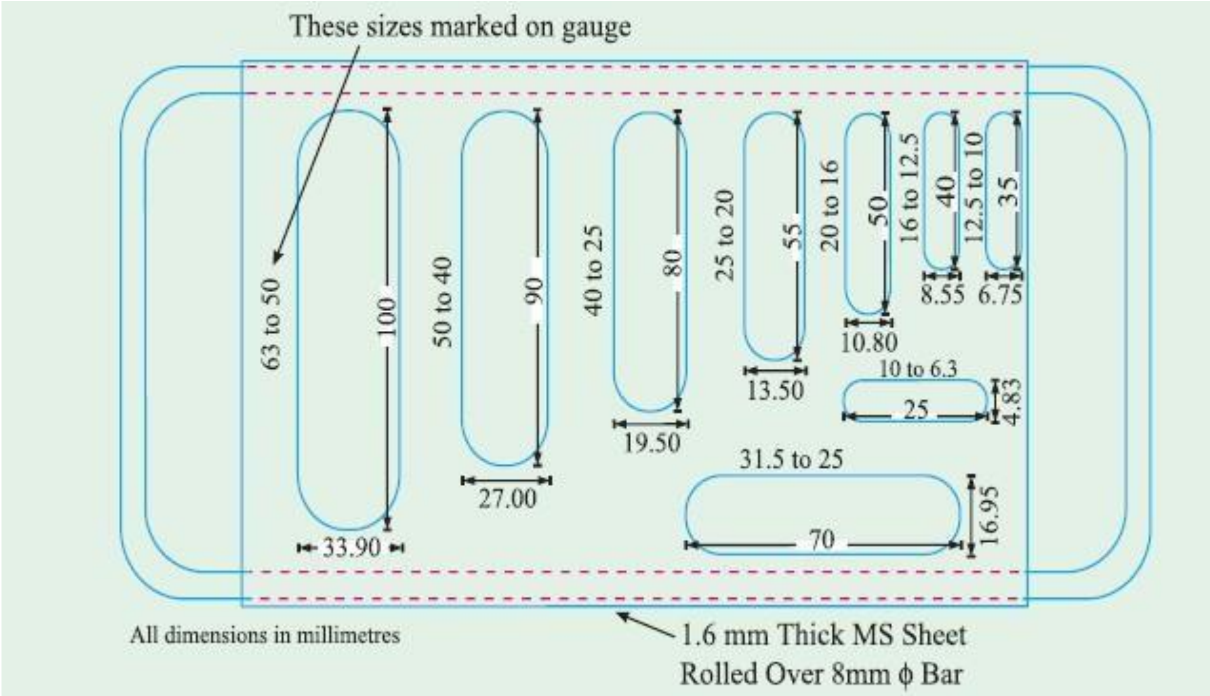
5. The flakiness index is the total weight of the material passing the various thickness gauges or sieves, expressed as a percentage of the total weight of the sample gauged.

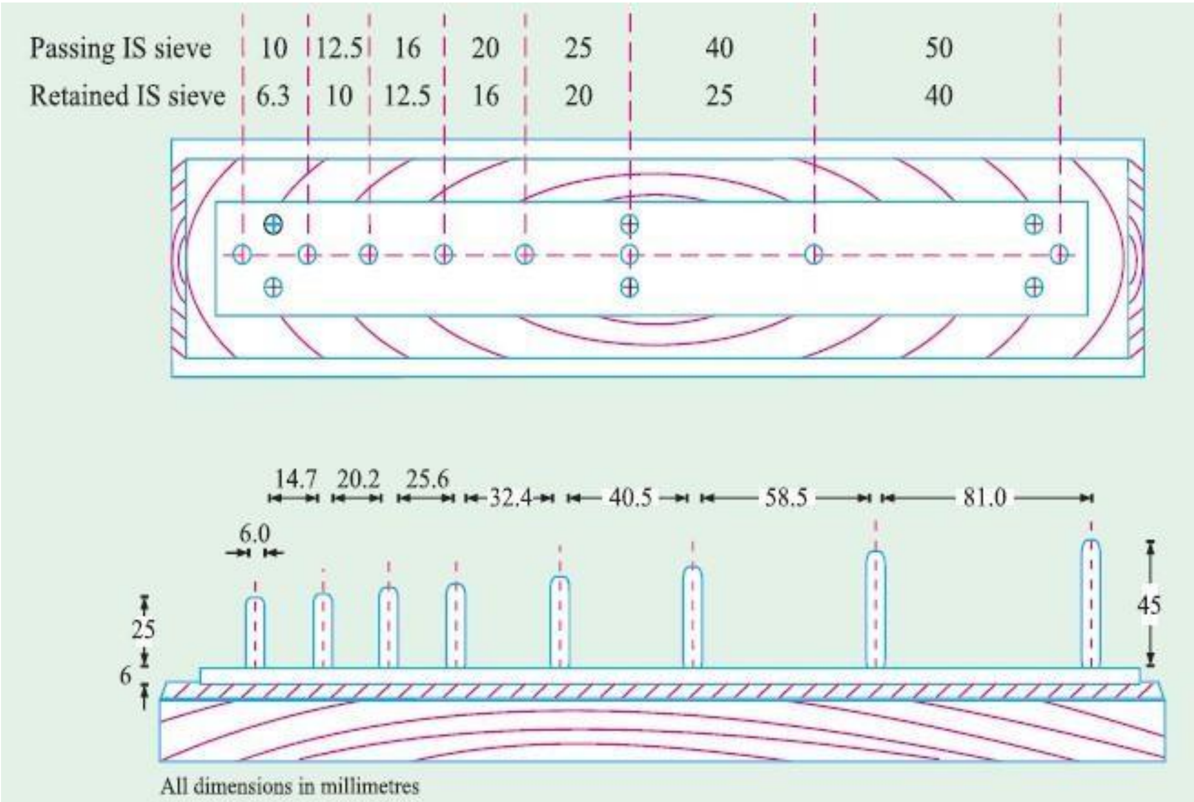
6. Sieving - The sample shall be sieved in accordance with the method described in Exp. 2.6 with the sieves specified in Table 3.18.

7. Separation of Elongated Material- Each fraction shall be gauged individually for length on a metal length gauge of the pattern shown in Fig . The gauge length used shall be that specified in co1 4 of Table 3.18 for the appropriate size of material.

8. Weighing of Elongated Material - The total amount retained by the length gauge shall be weighed to an accuracy of at least 0.1 percent of the weight of the test sample.

9. The elongation index is the total weight of the material retained on the various length gauges, expressed as a percentage of the total weight of the sample gauged.


These sizes marked on gauge
63 to 50
100
33.90
50 to 40
90
27.00
40 to 25
80
19.50
25 to 20
55
13.50
20 to 16
50
10.80
16 to 12.5
40
8.55
12.5 to 10
35
6.75
10 to 6.3
25
4.83
31.5 to 25
70
16.95
All dimensions in millimetres
1.6 mm Thick MS Sheet
Rolled Over 8mm ϕ Bar


Passing IS sieve 10 12.5 16 20 25 40 50
Retained IS sieve 6.3 10 12.5 16 20 25 40
14.7
20.2
25.6
32.4
40.5
58.5
81.0
6.0
25
6
45
All dimensions in millimetres

OBSERVATION :

1. Total weight of course aggregate .... g (Flakiness Index)

Size of aggregate thickness		Thickness Gauge mm	Weight Retained on Thickness Gauge	Percentage of Weight Retained (%)	Remark
Passing through IS sieve	Retained on IS sieve				
63 mm	50 mm	33.90			
50 mm	40 mm	27.00			
40 mm	31 mm	19.60			
31 mm	25 mm	16.95			
25 mm	20 mm	13.50			
20 mm	16 mm	10.80			
16 mm	12.5 mm	8.55			
12.5 mm	10 mm	6.75			
10 mm	6.3 mm	4.89			
		Total			

2. Total weight of course aggregate .... g (Elongation Index)

Size of aggregate thickness		Thickness Gauge mm	Weight Retained on Thickness Gauge	Percentage of Weight Retained (%)	Remark
Passing through IS sieve	Retained on IS sieve				
63 mm	50 mm	--			
50 mm	40 mm	81.00			
40 mm	31 mm	58.5			
31 mm	25 mm	--			
25 mm	20 mm	40.5			
20 mm	16 mm	32.4			
16 mm	12.5 mm	25.6			
12.5 mm	10 mm	20.2			
10 mm	6.3 mm	14.7			
		Total			

CALCULATION:

$$\text{Flakiness index on an aggregate is} = \frac{\text{Total of thickness of retained on thickness gauge}(\%)}{100}$$

$$\text{Elongation index on an aggregate is} = \frac{\text{Total of thickness of retained on length gauge}(\%)}{100}$$

CONCLUSION/RESULT :

i. The flakiness index of a given sample of fine aggregate is ....%
ii. The elongation index of a given sample of fine aggregate is...........%

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

Experiment no.-11

CRUSHING VALUE OF COARSE AGGREGATE

AIM OF THE EXPERIMENT:-

To determine the crushing value of coarse aggregate.

APPARATUS REQUIRED:-

A 15-cm diameter open-ended steel cylinder, with plunger and base-plate, of the general form and dimensions shown in Fig. A straight metal tamping rod, A balance of capacity 3 kg, readable and accurate to one gram, IS Sieves of sizes 12.5, 10 and 2.36 mm, For measuring the sample, cylindrical metal measure of sufficient rigidity to retain its form under rough usage and of the following internal dimensions: Diameter 11.5 cm and Height 18.0 cm.

MATERIALS REQUIRED:-

Course aggregate

THEORY AND SCOPE:-

The 'aggregate crushing value' gives a relative measure of the resistance of an aggregate to crushing under a gradually applied compressive load. With aggregate of 'aggregate crushing value' 30 or higher, the result maybe anomalous, and in such cases the 'ten percent fines value' should be determined instead.

Figure: Crushing test apparatus

PROCEDURE:-

- The material for the standard test shall consist of aggregate passing 12.5 mm IS sieve and retained on 10 mm IS sieve, and shall be thoroughly separated on these sieves before testing.
- The aggregate shall be tested in surface dry condition. If dried by heating, the period of drying shall not exceed 4 hours, the temperature shall be 100 to 110^{0}C and the aggregate shall be cooled to room temperature before testing.

- The cylinder shall be filled with 3 layers of approximately equal depth, each layer being tamped 25 times with the rounded end of tamping rod and finally levelled off using the tamping rod as a straight edge.
- The weight of material comprising the test sample shall be determined (weight A) and the same weight of sample can be taken for the repeat test.
- The apparatus with the test sample and plunger in position, shall then be placed between the platens of testing machine and loaded at as uniform rate as possible so that the total load is reached in 10 minutes.
- The load shall be released and whole of the material removed from the cylinder and sieved on a 2.36 mm IS sieve for the standard test. The fraction passing the sieve shall be weighed (weight B)

OBSERVATION AND CALCULATION:-

The ratio of the weight of fines formed to the total sample weight in each test shall be expressed as apercentage, the result being recorded to the first decimal place

Aggregate crushing strength value=A/B *100

A = Weight in gm of saturated surface dry sample.

B = Weight in gm of fraction passing through appropriate sieves.

TABULATION:

Sl No.	Description	Test-1	Test-2
1	Weight in gm of saturated surface dry sample.(A)		
2	Weight in gm of fraction passing through appropriate sieves. (B)		
3	Aggregate crushing strength value =A/B *100		

RESULT/ CONCLUSION:-

i. The aggregate crushing value of given sample of coarse aggregate is .... %

ii. The aggregate crushing value should not be more than 45 per cent for aggregate used for concrete other than for wearing surfaces, and 30 per cent for concrete used for wearing surfaces such a runways, roads and air field pavements.

EXPERIMENT NO-12

Determination of Los Angeles abrasion value of aggregates.

Aim: Determination of Los Angeles abrasion value of given aggregate sample.

Theory: Due to the movements of traffic, the road stones used in the surfacing course are subjected to wearing action at the top. Resistance to wear or hardness is hence an essential property for road aggregates, especially when used in wearing course. Thus road stones should be hard enough to resist the abrasion dueto the traffic. When fast moving traffic fitted with pneumatic tyres move on the road, the soil particles present between the wheel and road surface causes abrasion on the road stone. Steel tyres of animal drawn vehicles which rub against the stones can cause considerable abrasion of the stones on the road surface. Hence in order to test the suitability of road stones to resist the abrading action due to traffic, tests arecarried out in the laboratory.

Los Angeles Abrasion Test:

The principle of Los Angeles abrasion test is to find the percentage wear due to the relative rubbing action between the aggregates and steel balls used as abrasive charge; pounding action of these balls also exist while conducting the test. Some investigators believe this test to be more dependable as rubbing and pounding action simulate the field conditions where both abrasion and impact occur.

Apparatus: The apparatus consists of Los Angeles machine and sieves.

Los Angeles machine consists of a hollow steel cylinder, closed at both ends, having an inside diameter 70 cm and an inside length of 50 cm, mounted on stub shafts about which it rotates on a horizontal axis. An opening is provided in the cylinder for the introduction of the test sample. A removable cover of the opening is provided in such a way that when closed and fixed by bolts and nut, it is dust-tight and the interior surface is perfectly cylindrical. A removable steel shelf projecting radially 8.8 cm into the cylinder and extending to the full length of it, is mounted on the interior surface of the cylinder rigidly, parallel to the axis. The shelf isfixed at a distance of 125 cm from the opening, measured along the circumference in the direction of rotation refer Figure 5.1. Abrasive charge, consisting of cast iron spheres approximately 4.8 cm in diameter and 390 to 445 g in weight are used. The weight of the sphere used as the abrasive charge and the number of spheres to be used are specified depending on the graduation of the aggregates tested. The aggregate gradinghave been standardized as A,B,C, D, E, F, and

G for this test and the IS specifications for the grading and abrasive charge to be used are given in Table IS sieve with 1.70 mm opening is used for separating the fines after the abrasion test.

Procedure:

1. Clean aggregates dried in an oven at 105-110^{0}C to constant weight, conforming to any one of the grading A to G, as per Table 5.1 is used for the test.
2. The grading or gradings used in the test should be nearest to the grading to be used in the construction. Aggregates weighing 5 kg for grading A,B, C or D and 10 kg for gradings E,F or G may be taken as test specimen and placed in the cylinder.
3. The abrasive charge is also chosen in accordance with Table 5.1 depending on the grading of the aggregate and is placed in the cylinder of the machine.
4. The cover is then fixed dust-tight. The machine is rotated at a speed of 30 to33 revolutions per minute.
5. The machine is rotated for 500 revolution for gradings A,B,C and D, for gradings E,F and G, it shall be rotated for 1,000 revolutions.
6. The machine should be balanced and driven in such a way as to maintain uniform peripheral speed.
7. After the desired number of revolutions, the machine is stopped and the material is discharged from the machine taking care to take out entire stone dust.
8. Using a sieve of size larger than 1.70 mm IS sieve, the materials is first separated into two parts and the finer position is taken out and sieved further on a 1.7 mm IS sieve.
9. The portion of material coarser than 1.7 mm size is washed and dried in an oven at 105 to 110^{0}C to constant weight and weighed correct to one gram.

Grading	Weight in grams of each test sample in the size range, mm (passing and retained on square holes)										Abrasive charge	
	80-63	63-50	50-40	40-25	25-20	20-12.5	12.5-10	10-6.3	6.3-4.75	4.75-2.36	Number of Spheres	Weight of Charge,g
A	-	-	-	1250	1250	1250	1250	-	-	-	12	5000±25
B	-	-	-	-	-	2500	2500	-	-	-	11	4584±25
C	-	-	-	-	-	-	-	2500	2500	-	8	3330±20
D	-	-	-	-	-	-	-	-	-	5000	6	2500±5
E	2500*	2500*	5000*	-	-	-	-	-	-	-	12	5000±25
F	-	-	5000*	5000*	-	-	-	-	-	-	12	5000±25
G	-	-	-	5000*	5000*	-	-	-	-	-	12	5000±25

TABLE : Specifications for Los Angeles Test

*Tolerance of ± 2 percent is permitted.

TABULATION:

Sl No.	Description	Test-1	Test-2
1	Original weight of aggregate= W_1g		
2	Weight of aggregate retained on 1.70 mm IS sieve after the test=W2 g		
3	Loss of weight due to wear= W1-W2		
4	Los Angels abrasion Value, %		

CALCULATIONS: The difference between the original and final weights of the sample is expressed as apercentage of the original weight of the sample is reported as the percentage wear.

Let the original weight of aggregate= W_1g

Weight of aggregate retained on 1.70 mm IS sieve after the test = W_2 g

Loss in weight due to wear = (W_1-W_2)g

$$\text{Los Angels abrasion Value, \% = Percentage wear} = \frac{(W1-W2)}{W1} \times 100$$

RESULT : The result of the Los Angeles abrasion test is expressed as a percentage wear and the percentage valueof two test may be adopted as the Los Angeles abrasion value.

REFERENCE: The apparatus is standardized as per **IS: 2386 (Part IV) – 1963** consists of: Los Angeles abrasionmachine.

TABLE: Max. Allowable Los Angeles Abrasion Values of Aggregates in Different of Pavement Layers

Serial No	Types of pavement layer	Los Angeles abrasion Value, maximum %
1.	Water Bound macadam (WBM), sub-base course	60
2.	(i) WBM base course with bituminous surfacing	
	(ii) Bituminous Macadam base course	50
	(iii) Built-up spray grout base course	
3.	(i) WBM surfacing course	
	(ii) Bituminous Macadam binder course	40
	(iii) Bituminous penetration macadam	
	(iv) Buil-up spray grout binder course	
4.	(i) Bituminous carpet surface course	
	(ii) Bituminous surface dressing, single or two coats	
	(iii) Bituminous surface dressing, using precoated aggregates	35
	(iv) Cement concrete surface course (as per IRC)	
5.	(i) Bituminous/Asphaltic concrete surface course	
6.	(ii) Cement concrete pavement surface course (as per ISI)	30

Experiment No.13

Determination of aggregate impact value.

Aim: Determination of aggregate impact value of given aggreagate.

Theory: Toughness is the property of a material to resist impact. Due to traffic loads, the road stores are subjected to the pounding action or impact and there is possibility of stones breaking into smaller-. The road stones should therefore be tough enough to resist fracture under impact. A test designed evaluate the toughness of stones i.e., the resistance of the stones to fracture under repeated impacts may be called an impact test for road stones. The aggregate impact it has been standardized by the Indian standard institution. The aggregate impact value indicates a relative measure of the resistance of aggregate a sudden shock or an impact which in some aggregates differs from its resistance to a slow compressive load. The method of test covers the procedure for determining the aggregate impact value of coarse aggregates.

Apparatus: The apparatus consists of an impact testing machine, a cylindrical measure tamping rod, IS sievebalance and oven.

(a) *Impact testing machine :* The machine consists of a metal base with a plane lower surface superior well on a firm floor, without rocking. A deteachable cylindrical steel cup of internal diameter 10.2cm and depth 5cm is rigidly fastened centrally to the base plate. A metal hammer of weight between 13.5 and 140 kg having the lower end cylindrical in shape, 10 cm in diameter and 5 cm long, with 2 mm chamber at the lower edge is capable of sliding freely between vertical guides, and fall concentric over the cm. There is an arrangement for raising the hammer and allowing it to fall freely between vertical guides from a height of 38cm on the test sample in the cup, the height of fall being adjustable upto 0.5 cm. A key is provided for supporting the hammer while fastening or removing the cup. Refer Figure 12.1.

(b) *Measure :* A cylindrical metal measure having internal diameter 7.5 cm and depth 5 cm for measuring aggregate.

(c) *Tamping rod :* A straight metal tamping rod of circular cross section, 1 cm in diameter and 23 cm long, rounded at one end.

(d) *Sieve :* IS sieve of sizes 12.5 mm, 10 mm and 2.36 mm for sieving the aggregates.

(e) *Balance :* A balance of capacity not less than 500 g to weigh accurate upto 0.1 g.

(f) *Oven :* A thermostatically controlled drying oven capable of maintaining constant temperature between100^{0}C and 110^{0}C.

Procedure:

1. The test sample consists of aggregates passing 12.5 mm sieve and retained on 10 mm sieve and dried inan oven for four hours at a temperature 100^{0}C to 110^{0}C and cooled.
2. The aggregates are filled upto about one-third full in the cylindrical measure and tamped 25 times withrounded end of the tamping rod.
3. Further quantity of aggregates is then added upto about two-third ful in the cylinder and 25 strokes of

the tamping rod are given.

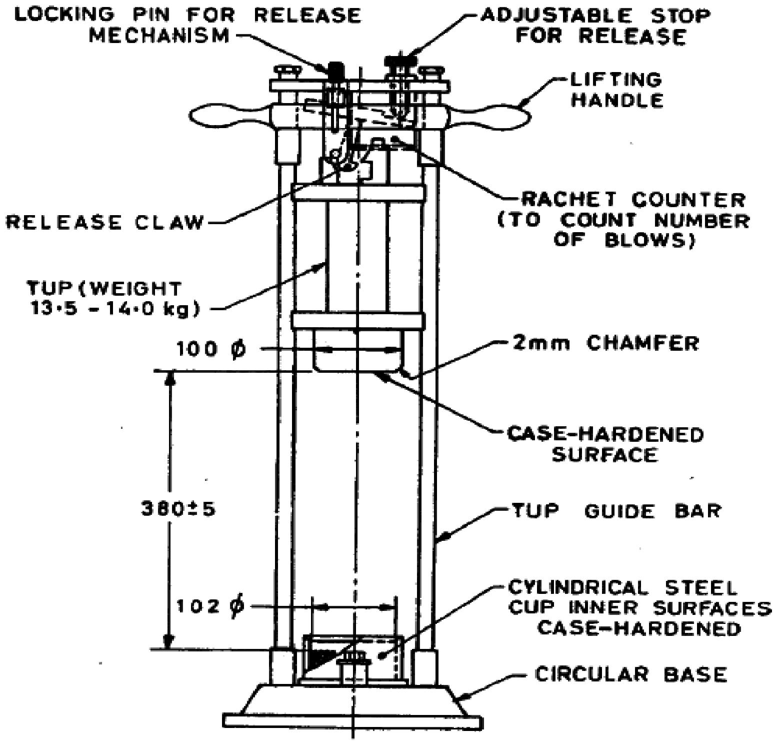


Figure: Impact testing machine

4. The measure is now filled with the aggregates to over flow, tamped 25 times. The surplus aggregates are struck off using the tamping rod as straight edge.
5. The net weight of the aggregates in the measure is determined to the nearest gram and this weight of the aggregates is used for carrying out duplicate test on the same material. The impact machine is placed with its bottom plate fiat on the floor so that the hammer guide columns are vertical. The cup is fixed firmly in position on th base of the machine and the whole of the test sample from the cylindrical measure is transferred to the cupand compacted by tamping with 25 strokes.
6. The hammer is raised until its lower face is 38 cm above the upper surface of the aggregates in the cup, and allowed to fall freely on the aggregates. The test sample is subjected to a total of 15 such blows, each being delivered at an interval of not less than one second.
7. The crushed aggregate is then removed from the cup and the whole of it sieved on the 2.36 mm sieve until no further significant amount passes. The fraction passing the sieve is weighed accurate to 0.1 g. The fraction retained on the sieve is also weighed and if the total weight of the fractions passing and retained on the sieve is added, it should not be less than the original weight of the specimen by more than one gram; if the total weight is less than the original by over one gram, the result should be discarded and a fresh test made.

The above test is repeated on fresh aggregate sample.

Calculation:

The aggregate impact value is expressed as the percentage of the fines formed in terms of the total weight ofthe sample.

Let the original weight of the oven dry sample be W_1 g and the weight of fraction passing 2.36 mm IS sievebe W_2 g.

Aggregate impact value= $\frac{W_2}{W_1}$ x 100 percent

This is recorded correct to the first decimal place.

Results: The mean of the two results is reported as the aggregate impact value of the specimen to the nearest whole number. Aggregate impact value is to classify the stones in respect of their toughness property as indicated below :

Aggregate impact values

<10% Exceptionally strong : 10-20% Strong

10-30% Satisfactorily for road surfacing ; >35% Weak for road surfacing

Maximum Allowable Impact Value of Aggregate in Different Types of Pavement Material/Layers

Serial No.	Types of pavement material/layer	Aggregate impact value, maximum,%
1	Water bound macadam (WBM), sub base course	50
2.	Cement concrete, base course (as per ISI)	45
3.	(i) WBM base course with bitumen surfacing	
	(ii) Built up-spray grout, base course	40
4.	Bituminous macadam, base course	35
5.	(i) WBM, surfacing course	
	(ii) Built-up spray grout, surfacing course	
	(iii) Bituminous penetration macadam	
	(iv) Bituminous macadam, binder course	
	(v) Bituminous surface dressing	
	(vi) Bituminous carpet	
	(vii) Bituminous/Asphltic concrete	
	(viii) Cement concrete, surface course	30

EXPERIMENT NO : 14

Determine Compressive Strength of Cubic Concrete Specimens

AIM:

The test method covers determination of compressive strength of cubic concrete specimens.

REFERENCE CODES:

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

THEORY:

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

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

APPARATUS:

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

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

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

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

PROCEDURE:

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

2. **Proportioning** - The proportions of the materials, including water, in concrete mixes used for determining the suitability of the materials available, shall be similar in all respects to those to be employed in the work.
3. **Weighing** - The quantities of cement, each size of aggregate, and water for each batch shall be determined by weight, to an accuracy of 0.1 percent of the total weightof the batch.
4. **Mixing Concrete** - The concrete shall be mixed by hand, or preferably, in a laboratory batch mixer, in such a manner as to avoid loss of water or other materials. Each batch of concrete shall be of such a size as to leave about 10 percent excess after moulding the desired number of test specimens.
5. **Mould** - Test specimens cubical in shape shall be 15 × 15 × 15 cm. If the largest nominal size of the aggregate does not exceed 2 cm, 10 cm cubes may be used as an alternative. Cylindrical test specimens shall have a length equal to twice the diameter.
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 neithersegregation 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 testing machine shall be wiped clean and any loose sand or other material removed from the surfaces of the specimen which are to be in contact with the compression platens.
9. In the case of cubes, the specimen shall be placed in the machine in such a manner that the load shall be applied to opposite sides of the cubes as cast, that is, not to the top and bottom.
10. The axis of the specimen shall be carefully aligned with the centre of thrust of the spherically seated platen. No packing shall be used between the faces of the test specimen and the steel platen of the testing machine.
11. The load shall be applied without shock and increased continuously at a rate of approximately 140 kg/sq cm/min until the resistance of the specimen to the increasing load breaks down and no greater load can be sustained.
12. The maximum load applied to the specimen shall then be recorded and the appearance of the concrete and any unusual features in the type of failure shall be noted.

OBSERVATION:

Data for the calculating of the mix proportion

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

Calculations of Mix Proportion

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

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

CONCLUSION:

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

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

EXPERIMENT NO. : 15

SLUMP TEST

AIM:

To determine the workability or consistency of concrete mix of given proportion by slump test.

APPARATUS:

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

REFERENCE CODE:

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

THEORY:

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

PROCEDURE

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

OBSERVATIONS:

1) Type of cement=………………

2) Brand of cement=……………….

3) Density of concrete=...............

TABULATION:

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

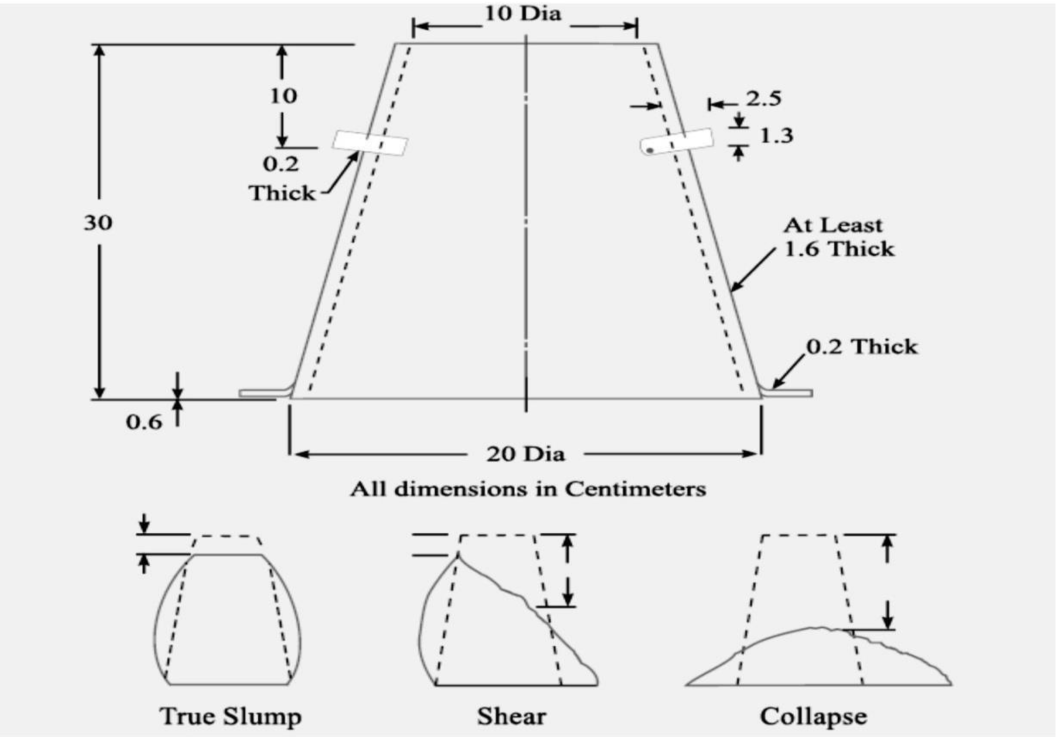


Figure: Different Types of Slump

Result:

The slump of concrete= ....mm

(indicate Low/Medium/ High Degree of workability)

EXPERIMENT NO. : 16

COMPACTION FACTOR TEST

AIM:

To determine the workability of freshly mixed concrete by Compacting Factor Test.

APPARATUS:

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

REFERENCE CODE:

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

THEORY:

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

PROCEDURE:

1. Grease the inner surface of the hoppers and the cylinder and fasten the hopper doors.
2. Weigh the empty cylinder accurately (W1 Kg) an Fix the cylinder on the base with nuts and bolts.
3. Mix coarse and fine aggregates and cement dry until the mixture is uniform in colour and then with water until concrete appears to be homogeneous.
4. Fill the freshly mixed concrete in upper hopper gently with trowel without compacting.
5. Release the trap door of the upper hopper and allow the concrete of fall into the lower hopper bringing the concrete into standard compaction.
6. Immediately after the concrete comes to rest, open the trap door of the lower hopper and allow the concrete to fall into the cylinder, bringing the concrete into standard compaction.
7. Remove the excess concrete above the top of the cylinder by a trowel.
8. Find the weight of cylinder i.e. cylinder filled with partially compacted concrete(W2kg)
9. Refill the cylinder with same sample of concrete in approx. 4 layers, tamping each layer with tamping for 25 times in order to obtain full compaction of concrete.
10. Level the mix and weigh the cylinder filled with fully compacted concrete (W3 Kg).
11. Repeat the procedure for different for different a trowel.

OBSERVATIONS AND CALCULATIONS:

Weight of cylinder W1 =....................................... Kg

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

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

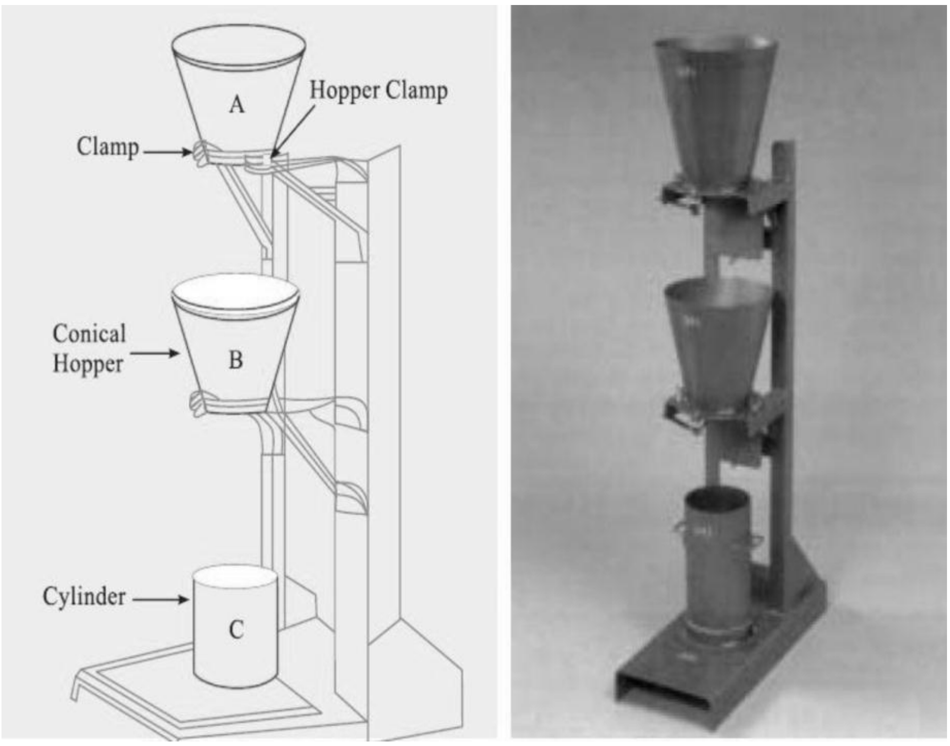


Figure: Compaction factor apparatus

RESULTS:

Compaction factor IS =…………………………………..

EXPERIMENT NO. : 17

NON-DESTRUCTIVE TESTING OF CONCRETE USING 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.

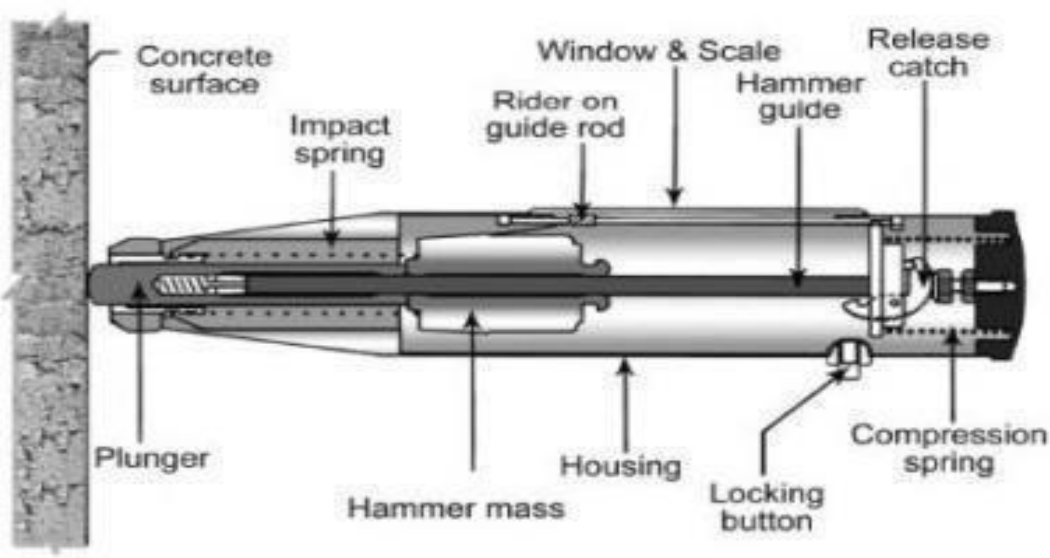


Figure: Rebound Hammer

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

EXPERIMENT NO: 18

NON-DESTRUCTIVE TESTING OF CONCRETE BY ULTRASONIC PULSE VELOCITY METHOD

AIM OF THE EXPERIMENT

The ultrasonic pulse velocity method is used for non-destructive testing of plain, reinforced and prestressed concrete whether it is precast or cast in-situ

Objects: The main objects of the ultrasonic pulse velocity method are to establish

- The Homogeneity of the Concrete
- The Presence of Cracks, Voids and other Imperfections
- Changes in the Structure of the Concrete Caused by the Exposure Condition,Corrosion, Wear etc. which may occur with time,
- The Quality of the Concrete in Relation to the Specified Standard Requirements.
- The Quality of One Element of Concrete in Relation to the Another.
- The Values of the Dynamic Elastic Modulus of the Concrete.

Principle: This is one of the most commonly used method in which the ultrasonic pulses generated by electro-acoustical transducer are transmitted through the concrete. In solids, the particles can oscillate along the direction of sound propagation as longitudinal waves or the oscillations can be perpendicular to the direction of sound waves as transverse waves. When the pulse is induced into the concrete from a transducer, it undergoes multiple reflections at the boundaries of the different material phases within the concrete. A complex system of stress waves is developed which includes longitudinal (Compressional), shear (Transverse) and surface (Rayleigh) waves. This transducers convert electrical signals into mechanical vibrations (transmit mode) and mechanical vibration into electrical signals (receive mode). The travel time is measured with an accuracy of +/- 0.1 microseconds. Transducers with natural frequencies between 20 kHz and 200 kHz are available, but 50 kHz to 100 kHz transducers are common.

The receiving transducer detects the onset of the longitudinal waves which is the fastest wave. Because the velocity of the pulses is almost independent of the geometry of the material through which they pass and depends only on its elastic property. Under certain specified conditions, the velocity and strength of concrete are directly related. The common factor is the density of concrete; a change in the density results in a change in a pulse velocity, likewise for a same mix with change in density, the strength of concrete changes. Thus lowering of the density caused by increase in water-cement ratio decreases both the compressive strength of concrete as well as the velocity of a pulse transmitted through it.

Pulse Velocity method is a convenient technique for investigating structural concrete. The underlying principle of assessing the quality of concrete is that comparative higher velocities are obtained when the quality of concrete in terms of density, homogeneity and uniformity is good. In case poorer quality of concrete, lower velocities are obtained. If there is a crack, void or flaw inside the concrete which comes in the way of transmission of the pulses, the pulse strength is attenuated and it passes around the discontinuity, thereby making path length longer. Consequently, lower velocities are obtained. The actual pulse velocity obtained depends primarily upon the material and the mix proportion of the concrete. Density and modulus of elasticity of aggregate also significantly affect the pulse velocity.

Transducers: Piezoelectric and magnetostrictive types of transducers are available in the range of 20 kHz to 150 kHz of natural frequency. Generally, high frequency transducers are preferable for short path length and low frequency transducers for long path lengths. Transducers with a frequency of 50 to 60 kHz are useful for most all-round applications.

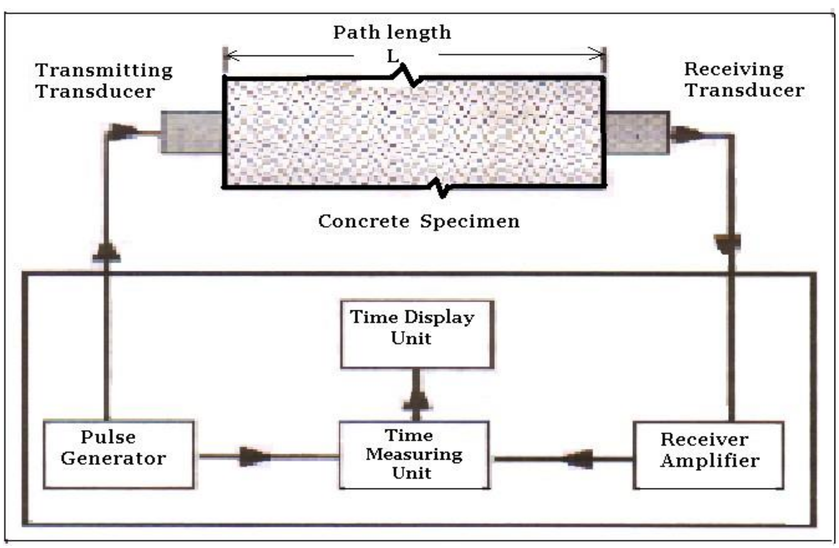


Fig. : Schematic Diagram of Ultrasonic Pulse Velocity Method

There are three possible ways of measuring pulse velocity through concrete :

a. **Direct Transmission (Cross Probing) through Concrete** : In this method transducers are held on opposite face of the concrete specimen under test as shown in fig. The method is most commonly used and is to be preferred to the other two methods because this results in maximum sensitivity and provides a well defined path length.

b. **Semi-direct Transmission through Concrete :** Sometimes one of the face of the concrete specimen under test is not accessible, in that case we have to apply semi-direct method as shown in fig. In this method, the sensitivity will be smaller than cross probing and the path length is not clearly defined.

c. **Indirect Transmission (Surface Probing) through Concrete :** This method of pulse transmission is used when only one face of concrete is accessible. Surface probing is the least satisfactory of the three methods because the pulse velocity measurements indicate the quality of concrete only near the surface and do not give information about deeper layers of concrete. The weaker concrete that may be below a strong surface cannot be detected. Also in this method path length is less well defined. Surface probing in general gives lower pulse velocity than in the case of cross probing and depending on number of parameters.

Fig. : Different Methods of Propagating Ultrasonic Pulses through Concrete

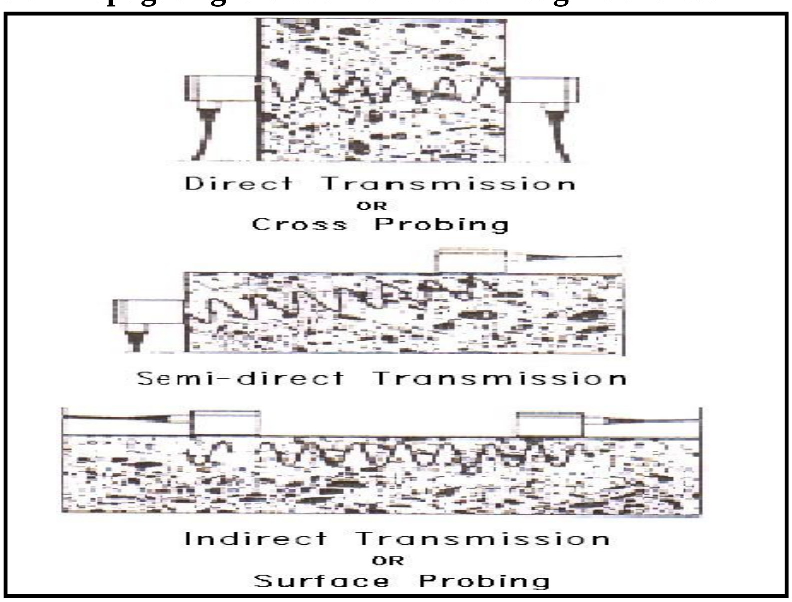


Table : Velocity Criteria For Concrete Quality GradingAs per Table 2 of IS 13311 (Part 1) : 1992

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

Note : In case of doubtful quality of concrete, it may be necessary to carry out further test