DEPARTMENT OF CIVIL ENGINEERING,

JHARSUGUDA ENGINEERING SCHOOL, JHARSUGUDA

(A Govt. of Odisha Polytechnic)

CIVIL ENGINEERING LABORATORY-I MANUAL

3RD SEMESTER

LIST OF EXPERIMENT

EXPERIMENT NO. – 01

AIM:- To determine tensile test on a metal.

OBJECTIVE:- To conduct a tensile test on a mild steel specimen and determine the following:

(i) Limit of Proportionality

(ii) (ii) Elastic limit

(iii) Yield strength

(iv) (iv) Ultimate strength

(v) Young's modulus of elasticity

(vi) Percentage elongation

(vii) Percentage reduction in area.

APPARATUS :-

(i) Universal Testing machine (UTM)

(ii) Mild steel specimens

(iii) Graph paper

(iv) Scale

(v) Vernier Calliper

DIAGRAM:-

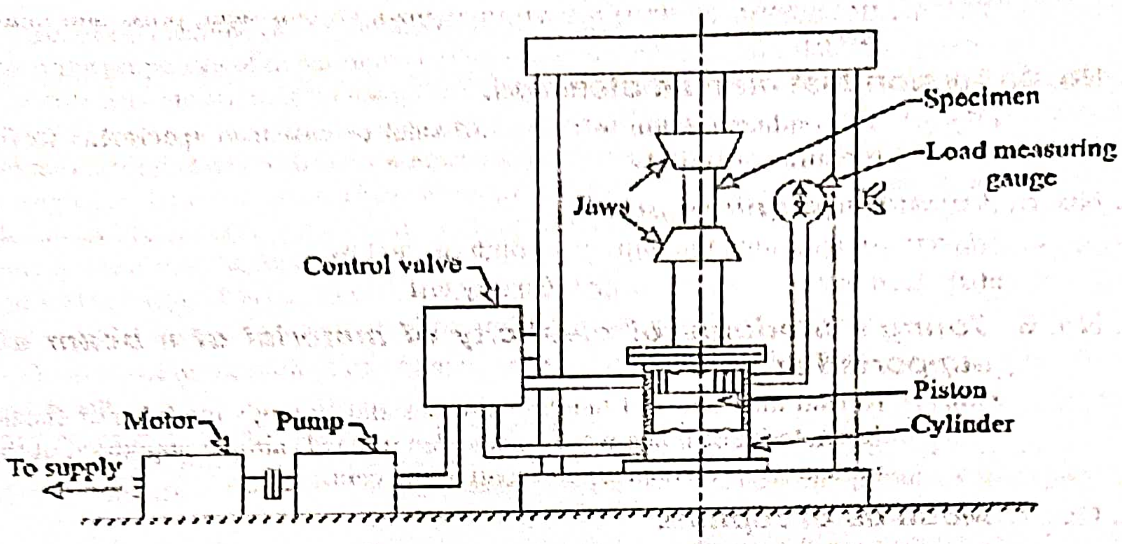
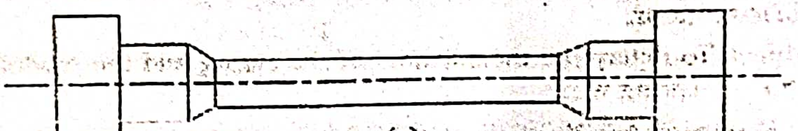
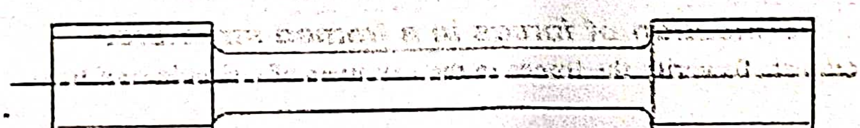


Fig. 1. Tensile testing machine.



(a)



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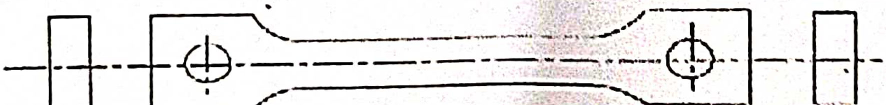


(c)

THEORY:- The tensile test is most applied one, of all mechanical tests. In this test ends piece are fixed into grips connected to a straining device and to a load measuring device. If the applied load is small enough, The deformation of any solid body is entirely elastic. An elastically deformed solid will return to its original from as soon as load is removed. However , if the load is too large, the material can be deformed permanently . The initial part of the tension curve which is recoverable immediately after unloading is termed. As elastic and the rest of the curve which represents the manner in which solid undergoes plastic deformation is termed plastic. The stress below which the deformations essentially entirely elastic is known as the yield strength of material. In some material the onset of plastic deformation is denoted by a sudden drop in load indicating both an upper and lower yield point. However, some materials do not exhibit a sharp yield point. During plastic deformation, at larger extensions strain hardening cannot compensate for the decrease in section and thus the load passes through a maximum and then begins to decrease. This stage the " ultimate strength" which is defined as the ratio of the load on the specimen to original cross-=sectional area, reaches a maximum value. Further loading will eventually cause 'neck' formation and rupture.

PROCEDURE:-

1) Measure the original length and diameter of the specimen. The length may be length of gauge section which is marked on the specimen with a preset punch or the total length of the specimen.
2) Insert the specimen into grips of the test machine and attach strain measuring device to it.
3) Begin the load application and record load versus elongation data.
4) Take readings more frequently as yield point is approached .
5) Measure elongation values with the help of dividers and ruler.
6) Continue the test till Fracture occurs.
7) By joining the two broken halves of the specimen together, measure the final length and diameter of specimen.

OBSERVATION:- A) material:

A) Original Dimensions

Length=______________

Diameter=______________

Area=____________

B) Final Dimensions:

Length=______________

Diameter=____________

Area=____________

OBSERVATION TABLE:-

Sl. no	Load (N)	Original gauge Length	Extension (mm)	Stress= Load/Area (N/mm^2)	Strain= Increase in length/Original length
1					
2					
3					
4					
5					

To Plot the stress strain curve and determine the following.

(i) **Limit pf proportion** Load at limit of proportionality/Original area of cross-section = ...N/n

(ii) **Elastic Limit** = Load at elastic limit/Original area of c/s N/mm^2

(iii) **Yield strength**

= Yield load/Original area of cross-section =....N/mm^2

(iv) **Ultimate Strength** = maximum tensile load/Original area of cross-section=N/mm^2

(v) **Young's modulus, E = Stress below proportionality limit/Corresponding strain N/mm^2**

(vi) **Percentage elongation**

= Final length (at fracture)- Original length/Original length= ...%

(vii) **Percentage reduction in area**

= Original area- area at fracture/Original area =.......%

RESULTS:- i) Average Breaking stress=

ii) Ultimate Stress =

iii) Average % Elongation =

PRECAUTION:-

1. **If the strain measuring device is an extensometer it should be removed before necking begins.**
2. **Measure deflection on scale accurately & carefully.**

EXPERIMENT NO. – 02

TESTS ON CEMENT

FINENESS

AIM

To determine the fineness of cement by dry sieving as per IS: 4031 (part 1)- 1996.

PRINCIPLE

The fineness of cement is measured by sieving it through a standard sieve. The portion of cement, the grain sizes of which, is larger than the specified mesh size is thus determined.

APPARATUS

i) 90 µm IS Sieve

ii) Balance capable of weighing 10g to the nearest 10mg

iii) A nylon or pure bristle brush, preferably with 25 to 40 mm bristle, for cleaning the sieve

PROCEDURE

i) Weigh approximately 10g of cement to the nearest 0.01g and place it on the sieve.

ii) Agitate the sieve by swirling , planetary and linear movements, until no more fine material passes through it.

iii) Weigh the residue and express its mass as a percentage R1 of the quantity first placed on the sieve to the nearest 0.1 percent.

iv) Gently brush all the fine material off the base of the sieve.

v) Repeat the whole procedure using a fresh 10g sample to obtain R2. Then calculate R as the mean of R1 and R2 as a percentage, expressed to the nearest absolute, carry out a third differ by more than 1 percent absolute, carryout a third sieving and calculate the mean of the three values.

REPORTING OF RESULTS

Report the value of R, to the nearest 0.1 percent, as the residue on the 90µm sieve.

EXPERIMENT NO. – 03

CONSISTENCY

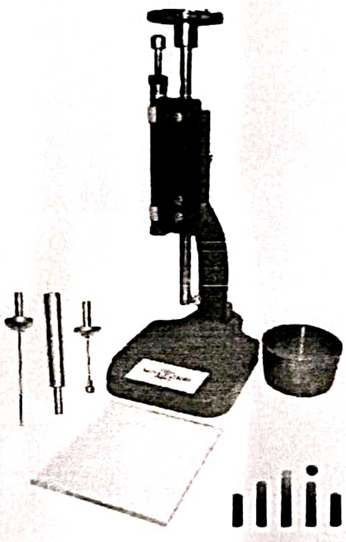
AIM

To determine the quantity of water required to produce a cement paste of standard as per IS:4031 (part 4)-1988.

PRINCIPLE

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 7mm from the bottom of the vicat mould.

APPARATUS



i) Vicat apparatus conforming to IS: 5513-1976

ii) Balance, whose permissible variation at a load of 1000kg should be ± 1.0g

iii) Gauge trowel conforming to IS: 10086-1982

PROCEDURE

i) Weigh approximately 400g of cement and mix it with a weighed quantity of water. The time of gauging it with a weighed quantity of water. The time of gauging should be between 3 to 5 minutes.

ii) Fill the vicat mould with paste and level it with a trowel.

iii) Lower the plunger gently till it touches the cement surface.

iv) Release the plunger allowing it to sink into the paste.

v) Note the reading on the gauge.

vi) Repeat the above procedure taking fresh samples of cement and different quantities of water until the reading on the gauge is 5 to 7mm.

REPORTING OF RESULTS

Express the amount of water as a percentage of the weight of dry cement to the first place of decimal.

EXPERIMENT NO. – 04

INITIAL AND FINAL SETTING TIME

AIM

To determine the initial and the final setting time of cement as per IS☹part 5)-1988.

APPARATUS

i) Vicat apparatus conforming to IS:5513-1976

ii) Balance, whose permissible variation at a load of 1000g should be ± 1.0g

iii) Gauging trowel conforming to IS:10086-1982

PROCEDURE

i) Prepare a cement paste by gauging the cement with 0.85 times the water required to give a paste of standard consistency

ii) Start a stop-watch, the moment water is added to the cement.

iii) Fill the vicat mould completely with the cement paste gauged as above, the mould resting on a non-porous plate 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.

A) INITIAL SETTING

Place the test block under the rod bearing the needle. Lower the needle gently in order to make contact with the surface of the cement paste and release quickly, allowing it to penetrate the test block. Repeat the procedure till the needle fails to pierce the test block to a point 5.0 ± 0.5mm measured from the bottom of the mould.

The time period elapsing between the time, water is added to the cement and the time, the needle fails to pierce the test block by 5.0 ± 0.5mm measured from the bottom of the mould, is the final setting time.

B) FINAL SETTING TIME

Replace the above needle by the one with an annular attachment.

The cement should be considered as finally set when, upon applying the needle gently to the surface of the test block, the needle makes an impression therein, while the attachment fails to do so. The period elapsing between the time, water is added to the cement at the time, the needle makes an impression on the surface of the test block, while the attachment fails to do so, is the final setting time .

REPORTING OF RESULTS

The results of the initial and the final setting time should be reported to the nearest five minutes.

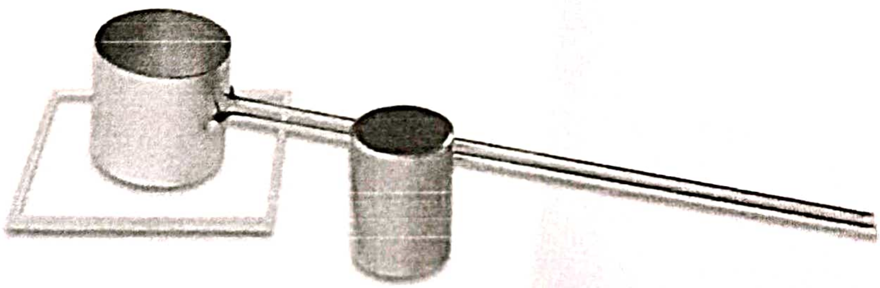
EXPERIMENT NO. – 05

SOUNDNESS

AIM

To determine the soundness of cement by Le-Chatelier method as per IS:4031 (part 3)-1988

APPARATUS



i) The apparatus for conducting the Le-Chatelier test should conform to IS: 5514-1969

ii) Balance, whose permissible variation at a load of 1000g should be ± 1.0g

iii) Water bath

PROCEDURE

i) Place the mould on a glass sheet and fill it with the cement paste formed by gauging cement with 0.78 times the water required to give a paste of standard consistency .

ii) Cover the mould with another piece of glass sheet, place a small weight on this covering glass sheet and immediately submerge the whole assembly in water at a temperature or 27 ± 2°C and keep it there for 24 hrs.

iii) Measure the distance separating the indicator points to the nearest 0.5mm (say d1)

iv) Submerge the mould again in water at the temperature prescribed above. Bring the water to boiling point in 25 to 30 minutes and keep it boiling for 3 hrs.

v) Remove the mould from the water , allow it to cool and measure the distance between the indicator points (say d2)

vi) (d2-d1) represents the expansion of cement.

REPORTING OF RESULTS

Calculate the mean of the two values to the nearest 0.5mm to represents the expansion of cement.

EXPERIMENT NO. – 06

COMPRESSIVE STRENGTH OF CEMENT

1. Objective

The compressive strength of hardened cement is the most important of all the properties. Therefore, it is not surprising that the cement is always tested for its strength at the laboratory before the cement is used in important works. Strength tests are not made on neat cement paste because of difficulties of excessive shrinkage and subsequent cracking of neat cement.

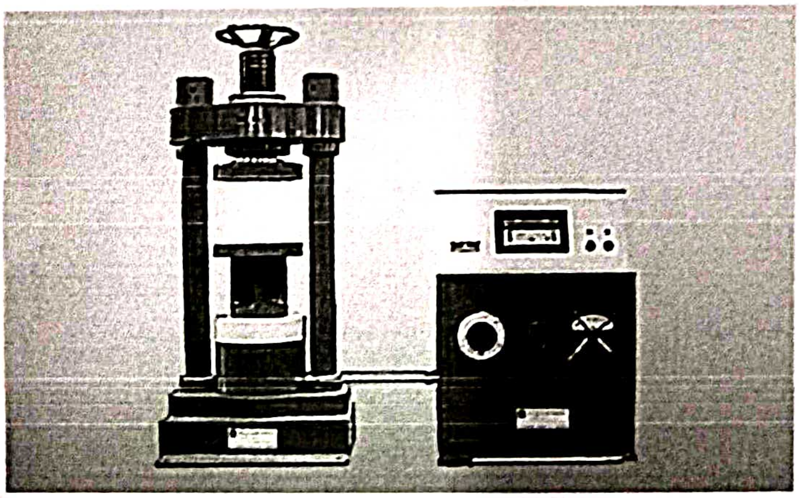
2. Apparatus Required

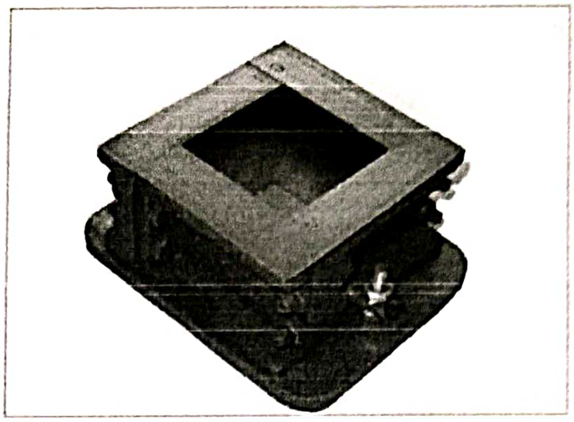
i.Standard sand

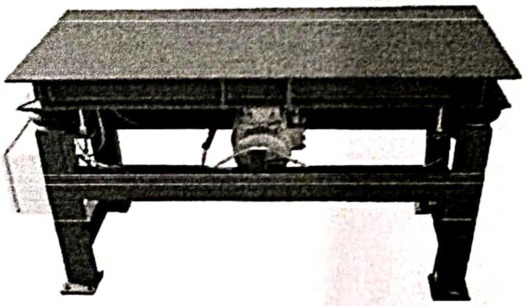
ii.Vibration Machine

iii.Cube Mould

iv.Compression Testing Machine








METIS

v. Balance

On balance in use , the permissible variation at a load g shall be + 1.0 g. The permissible variation on new balance shall be one-half of this value. The sensibility reciprocal shall be not greater than twice the permissible variation.

vi. Graduated Glass Cylinders

Graduated glass cylinders of 150 to 200 ml capacity. The permissible variation on these cylinders shall be + The main graduation lines of the cylinders shall be numbered. The least graduations shall extend at least one seventh of the way around, and, intermediate graduations shall extend at least one one-fifth of the of the way around the cylinder. The graduation lines may be omitted for the lowest 5 ml.

3. Reference

IS 4031(part 6): 1988 methods of physical Tests for Hydraulic cement- Determination of Compressive strength of Hydraulic cement than Masonry Cement (First revision). Reaffirmed – May 2014)

4. Procedure

1. Preparation of test specimens- clean appliances shall be used for mixing and the temperature of water and that of the test room at the time when the above operations are being performed shall be 27 $\pm 2^{\circ}$c . Potable /distilled water shall be used in preparing the cubes.
2. The material for each cube shall be mixed separately and the quantity of cement , standard sand and water shall be as follows:

Cement 200g and standard sand 600g

Water ((p/4) + 3.0) percent of combined mass of cement and sand , where p is the percentage of water required to produce a paste of standard consistency determined as described in IS: 4031 (part 4)- 1988

3. Place on a nonporous plate, a mixture of cement and standard sand. Mix it dry with a trowel for one minute and then with water until the mixture is of uniform colour. The quantity of water to be used shall be as specified in step 2. The time of mixing shall in any event be not less than 3 min and should the time taken to obtain uniform colour exceed 4 min., the mixture shall be rejected and the operation repeated with fresh quantity of cement , sand and water.
4. Moulding specimen- In assembling the moulds ready for use, treat the interior faces of the mould with a thin coating of mould oil.
5. Place the assembled mould on the table of the vibration machine and hold it firmly in position by means of a suitable clamp. Attach a hopper of suitable size and shape securely at the top of the mould to facilitate filling and this hopper shall not be removed until the completion of the vibration period.
6. Immediately after mixing the mortar in accordance with step 1 and 2 , place the mortar in the cube mould and prod with the rod. Place the mortar in the hopper of the cube mould and prod again as specified for the first layer and then compact the mortar by vibration.
7. The period of vibration shall be two minutes at the specified speed of 12000 $\pm$ 400 vibration per minute.
8. At the end of vibration, remove the mould together with the base plate from the machine and finish the top surface of the cube in the mould by smoothing the surface with the blade of a trowel.
9. Curing specimens- keep the filled moulds in moist room for 24 $\pm$ 1 hour after completion of variation At the end of that period , remove them from the moulds and immediately submerge in clean fres water and keep there until taken out just prior to breaking.
10. The water in which the cubes are submerged shall be renewed every 7 days and shall be maintained a temperature of 27 ± 2° C. After they have been taken out and until they are broken , the cubes s not be allowed to become dry.

11. Test three cubes for compressive strength for each period of curing mentioned under the relevant specifications (i.e. 3 days, 7 days, 28 days)
12. The cubes shall be tested on their sides without any packing between the cube and the steel platens of the testing machine. One of the platens shall be carried on a base and shall be self-adjusting, and the load shall be steadily and uniformly applied, starting from zero at a rate of 35 $N/mm^2/min$.

OBSERVATION AND RECORDING

Sr. No	Age of Cube	Cross Sectional Area (mm^2)	Load(N)	Compressive Strength (N/mm^2)	Avg. Compressive Strength (MPa)
1	3 Days				
2					
3					
4	7 days				
5					
6					
7	28 Days				
8					
9					

Recording during compressive Test on cement

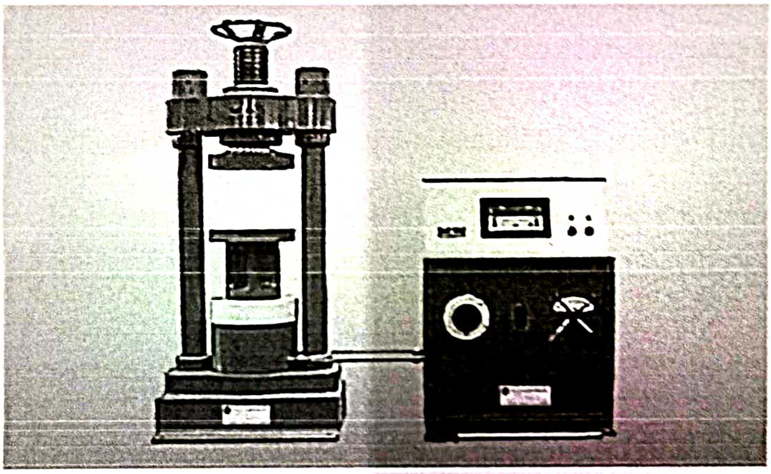
EXPERIMENT NO. – 07

COMPRESSION TEST

AIM

To determine the compressive strength of concrete specimens as per IS:516-1959

APPARATUS



i) Compression testing machine conforming to IS : 516=1959

AGE AT TEST

Tests should be done at recognized ages of the test specimens, usually being 7 and 28 days. The ages should be calculated from the time of the addition of water to the drying of ingredients.

NUMBER OF SPECIMENS

At least three specimens, preferably from different batches, should be taken for testing at each selected age..

PROCEDURE

i) The specimens, prepared according to IS : -1959 and stored in water, should be tested immediately on removal from the water and while still in wet conditions. Specimens when received dry should be kept in water for 24 hrs. Before they are taken for testing. The dimensions of the specimen, to the nearest 0.2mm and their weight should be noted before testing.

ii) The bearing surfaces of the compression testing machine should be wiped clean and any loose sand or other material removed from the surfaces of the specimen, which would be in contact with the compression platens.

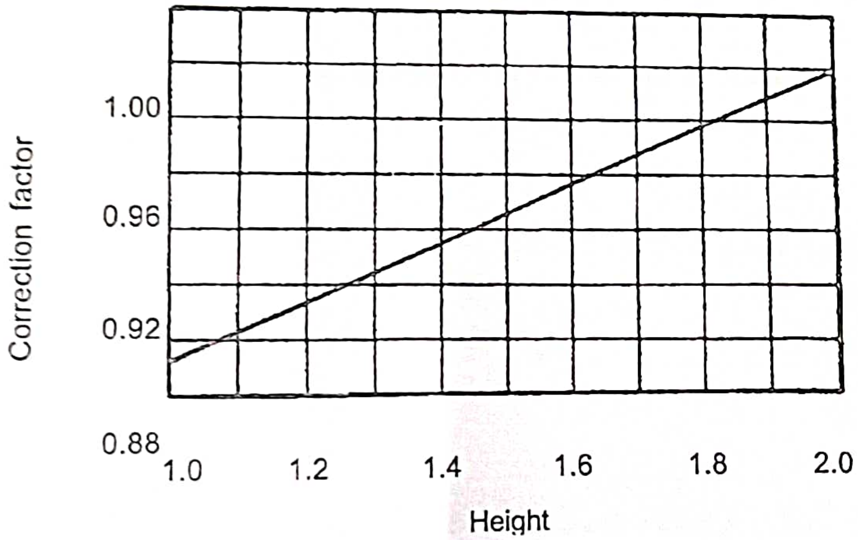
iii) In the case a of cubical specimen, the specimen should be placed in the machine in such a manner that the load could be applied to the opposite sides of the cubes, not to the top and the bottom. The axis of the specimen should be carefully aligned with the centre of the thrust of the spherically seated platen. No packing should be used between the faces of the test specimen and the steel platen of the testing machine. As the spherical seated block is brought to rest on the specimen, the movable portion should be rotated gently by hand so that uniform seating is obtained.

iv) The load should be applied without shock and increased continuously at a rate of approximately 140kg/sq.cm/minute until the resistance of the specimen to the increasing load breaks down and no greater load can be sustained. The maximum load applied to the specimen should then be recorded and the appearance of the concrete and any unusual features in the type of failure should be noted.

CALCULATION

The measured compressive strength of the specimen should be calculated by dividing the maximum load applied to the specimen during the test by the cross-sectional area, calculated from the mean dimensions of the section and should be expressed to the nearest kg/sq.cm. An average of three values should be taken as the representative of the batch, provided the individual variation is not more than ±15% of the average. Otherwise repeat tests should be done.

A correction factor according to the height/diameter ratio of the specimen after capping should be obtained from the curve given below:-



Correction factor for height-diameter ratio of a core

The product of this correction factor and the measured compressive strength is known as the corrected compressive strength , this being the equivalent strength of a cylinder having a height/diameter ratio of two. The equivalent cube strength of the concrete should be determined by multiplying the corrected cylinder strength by 1.25.

REPORTING OF RESULTS

The following information should be included in the report on each test specimen;

i) Identification mark

ii) Date of test

iii) Age of specimen

iv) Curing conditions, including date of manufacturing of specimen

v) Weight of specimen

vi) Dimensions of specimen

vii) Cross-sectional area

viii) Maximum load

ix) Compressive strength

x) Appearance of fractured faces of concrete and type of fracture, if unusual.

EXPERIMENT NO. – 08

TESTS ON AGGREGATES

SIEVE ANALYSIS

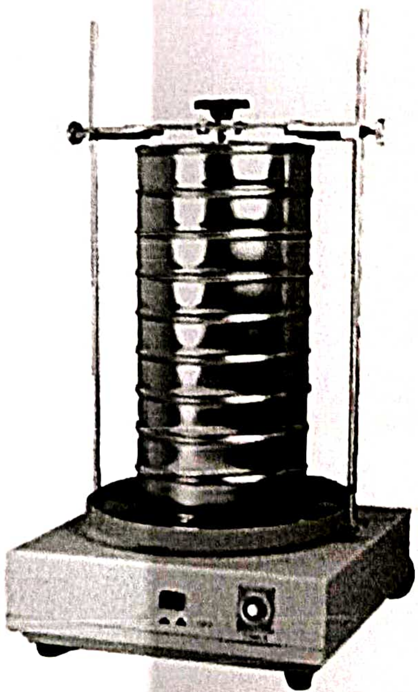
AIM

To determine the particle size distribution of fine and coarse aggregates by sieving as per IS: 2386 (part 1)-1963

PRINCIPLE

By passing the sample downward through a series of standard sieves, each of decreasing size openings, the aggregates are separated into several groups, each of which contains aggregates in a particular size range.

APPARAUS



i) A set of IS sieves of sizes- 80mm, 63mm,50mm, 40mm, 31.5mm, 25mm, 20mm, 16mm, 12.5mm, 10mm, 6.3mm, 4.75mm, 3.35mm, 2.36mm, 1.18mm, 600µm, 300 µm, 150 µm, and 75 µm

ii) Balance or scale with an accuracy to measure 0.1 percent of the weight of the test sample

SAMPLE

The weight of sample available should not be less than the weight given below:-

Maximum size present in substantial proportions (mm)	Minimum weight of sample despatched for testing (kg)
63	100
50	100
40	50
25	50
20	25
16	25
12.5	12
10.0	6
6.3	3

The sample for sieving should be prepared from the larger sample either by quartering or by means of a sample divider.

PROCEDURE

i) The test sample is dried to a constant weight at a temperature of 110±5°C and weighed.

ii) The sample is sieved by using a set of IS sieves.

iii) On completion of sieving , the material on each sieve is weighed.

iv) Cumulative weight passing through each sieve is calculated as a percentage of the total sample weight.

v) Fineness modules is obtained by adding cumulative percentage of aggregates retained on each sieve and dividing the sum by 100.

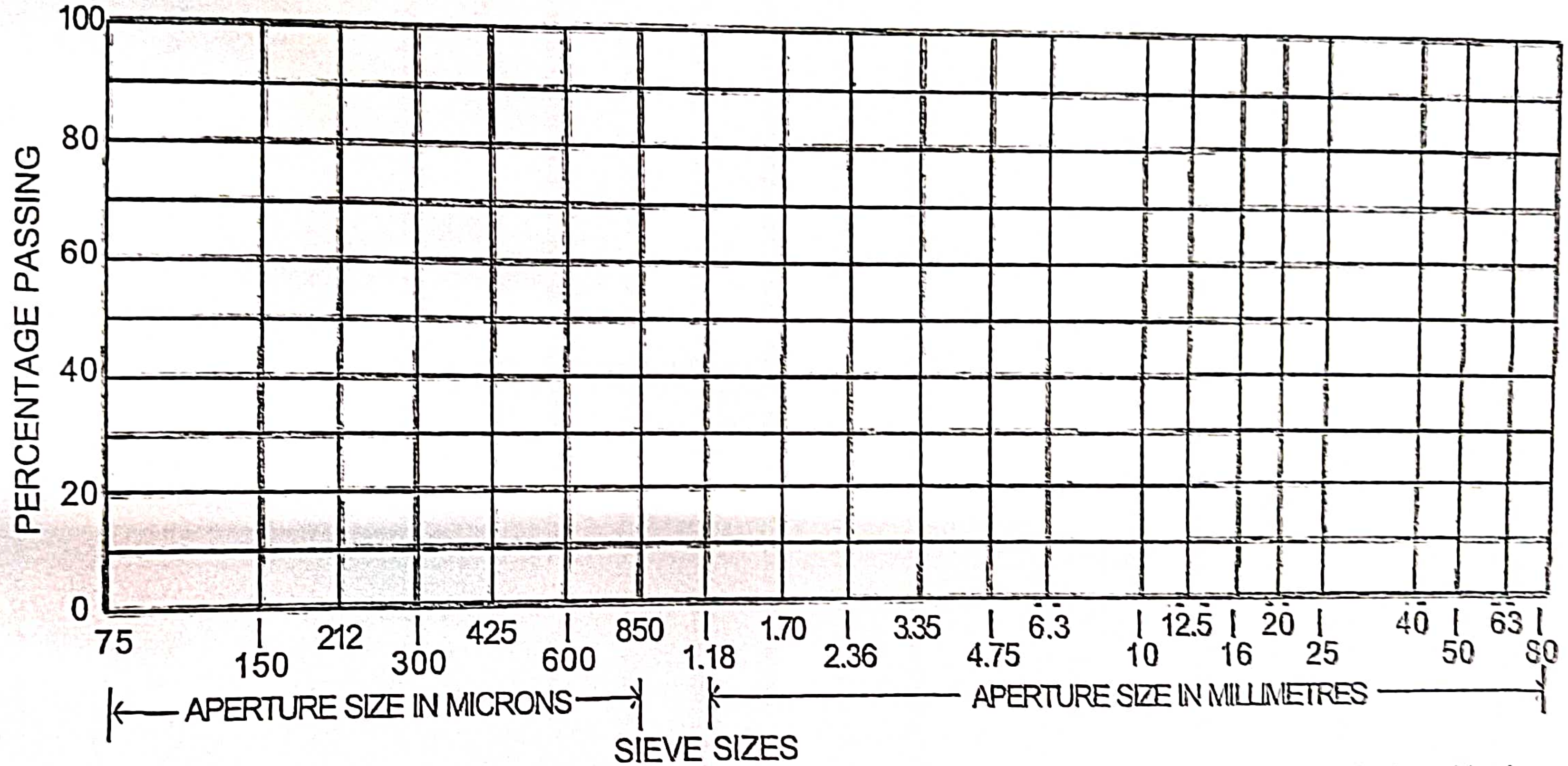
REPORTING OF RESULTS

The results should be calculated and reported as:

i) The cumulative percentage by weight of the total sample

ii) The percentage by weight of the total sample passing through one sieve retained on the next smaller sieve, to the nearest 0.1 percent.

The results of the sieve analysis may be recorded graphically on a semi-log graph with particle size as abscissa (log scale) and the percentage smaller than the specified diameter as ordinate.A sample chart is provided below.



Note - The vertical scale of this chart is an arithmetic scale and the horizontal scale is logarithmic.

CHART FOR RECORDING SIEVE ANALYSIS RESULTS

EXPERIMENT NO. – 09

SPECIFIC GRAVITY OF AGGREGATE

1. **Objective**

Specific gravity is defined as the ratio of weight of aggregate to the weight of equal volume of water. The specific gravity of an aggregate is considered to be a measure of strength or quality of the material. Aggregate having low specific gravity are generally weaker than those with high specific gravity. This property helps in a general identification of aggregates.

2. **Apparatus Required**

1: Wire Mesh Bucket

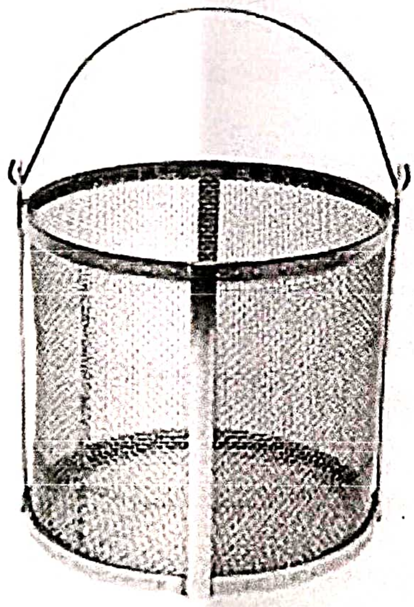
Wire basket of not more than 6.3 mm mesh or a perforated container of convenient size with thin wire hangers for suspending it from the balance.

2: Set up of specific Gravity Test (To be used for Aggregate>6.3 mm)

The setup consists of container for filling water and suspending the wire basket in it and an airtight container of capacity similar to that of basket , a shallow tray and two dry absorbent clothes.

3: Pycnometer

Pycnometer of 1000 ml for aggregates finer 6.3 mm.



3. **Reference**

IS 2386 (part 3) :1963 methods of test for Aggregates for concrete: Determination of specific Gravity ,

Reaffirmed –Dec02016

4. **Procedure**

Procedure for specific gravity Determination for Aggregates coarser Than 6.3mm

1. About 2 kg of aggregate sample is taken, washed to remove fines and then placed in the wire basket. The wire basket is then immersed in water , which is at a temperature of 22°C to 32°C.
2. Immediately after immersion the entrapped air is removed from the sample by lifting the basket 25 mm above the base of the tank and allowing it to drop, 25 times at a rate of about one drop per second.
3. The basket, with aggregate are kept completely immersed in water for a period of 24± 0.5 hour.
4. The basket and aggregate are weighed while suspended in water, which is at temperature at of 22°C to 32°C.
5. The basket and aggregates are removed from water and dried with dry absorbent cloth.
6. The surface dry aggregates are also weighed.
7. The aggregate is placed in a shallow tray and heated to about 110°c in the oven for 24 hours. Later, it is cooled in an airtight container and weighed.

PROCEDURE FOR SPECIFIC GRAVITY DETERMINATION OF AGGREGATE FINER THAN 6.3 MM

1. A clean, dry pycnometer is taken and its empty weight is determined.
2. About 1000g of clean sample is taken into the pycnometer and it is weighed.
3. Water at 27°C is filled up in the pycnometer with aggregate sample, to just immerse sample.
4. Immediately after immersion the entrapped air is removed from the sample by shaking pycnometer, placing a finger on the hole at the top of the sealed pycnometer.
5. Now the pycnometer is completely filled up with water till the hole at the top and after confirming that there is no more entrapped air in it, it is weighed.
6. The contents of the pycnometer are discharged. and it is cleaned.
7. Water is filled up to the top of the pycnometer without any entrapped air. It is then weighed.

8. For mineral filler, specific gravity bottle is used and the material is filled upto one –third of the capacity of bottle. The rest of the process of determining specific gravity is similar to the one described for aggregate finer than 6.3mm.

5. OBSERVATION AND RECORDING

Sl. No	Description	Observed Values
1	Weight of saturated aggregates and basket in water: w1 g	
2	Weight of basket in water :w2 g	
3	Weight of saturated aggregates in air : w3 g	
4	Weight of oven dry aggregates in air: w4 g	
5	Apparent specific **gravity:** W4/[W4-(W1-W2)]	
6	Bulk specific Gravity : W4/[W3-(W1-W2)]	

Table 1: Observation table for specific gravity of aggregate coarser than 6.3 mm

Sl. No	Description	Observed Values
1	Weight of Pycnometer in air : W1 g	
2	Weight of aggregates and pycnometer : W2 g	
3	Weight of aggregates , pycnometer and water: W3 g	
4	Weight of water and pycnometer in air: W4 g	
5	Apparent specific Gravity: (W2-W1)/ [(W4-W1)-(W3-W2)]	

Table 2: Observation table for specific gravity of aggregate finer than 6.3mm

6. GENERAL REMARKS

1. The specific gravity of aggregates normally used in construction ranges from about 2.5 to 3.0 with an average value of about 2.68.
2. Specific gravity of aggregates is considered as an indication of strength . Material having higher specific Gravity is generally considered as having higher strength. Water absorption of aggregate is a measure of porosity. This value is considered as a measure of resistance to frost action, and as a measure of sustaining weathering action.

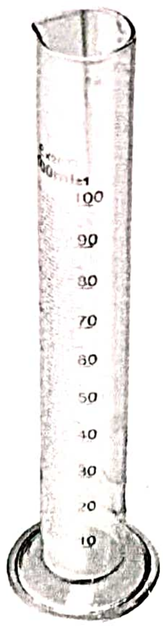
EXPERIMENT NO. – 10

AIM

The bulking of sand test should do as per IS 2386.

Apparatus

- Measuring Cylinder
- Container
- Steel Rule
- Steel Rod (6mm Dia)
- Sample sand



Procedure

1. Take a 250 ml capacity of measuring cylinder.
2. Fill the sand up to 200 ml and shake well then record the level as **a.**
3. Add 100 ml water to the cylinder to saturate the sand completely and stir well.
4. Now add the measured sand to the container and wait for some time to settle down.
5. The sand will be below the 200 ml mark. Note this level as **b**
6. Repeat the same procedure for 2 more samples

Calculation

bulking of sand = {(200-b)/b} x 100

Observation Table

S.No	DESCRIPTION	SAMPLE NO.		
		SAMPLE I	**SAMPLE II**	**SAMPLE III**
1	Volume of Loose Sand			
2	Volume of Saturated Sand			
	Bulking of Sand= {(200-b)/b}x100 %			

EXPERIMENT NO. – 11

TESTS ON AGGREGATE:

BULK DENSITY " UNIT WEIGHT" & VOIDS IN AGGREGATE

OBJECTIVE

This test method is used to determine the bulk density and voids in fine and coarse aggregate.

PRINCIPLES

- During the concrete mix design, when the aggregate is to be batched by volume or by weight , then it becomes necessary to know the mass of the aggregates that will fill the container of unit volume. If we know the bulk density of the aggregate material then we can easily determine the mass required to fill a unit volume container.
- Bulk density also indicates the percentage of voids present in the aggregate material. This percentage of voids affects the grading of the aggregates which is important in high strength concrete.
- Bulk density also indicates effort required to compact the concrete.

Bulk density of aggregates is the mass of aggregates required to fill the container of a unit volume after aggregates are batched based on volume.

- Bulk Density = Mass of the aggregate/ Volume of aggregate particles with voids between them. This bulk density is used to convert quantities by mass to quantities by volume.
- Bulk density depends on several factors: Size distribution of aggregates , shape of particles and degree of compaction.
- There are two methods this quantity is measured by: (1) Loose method (2) Compaction method.

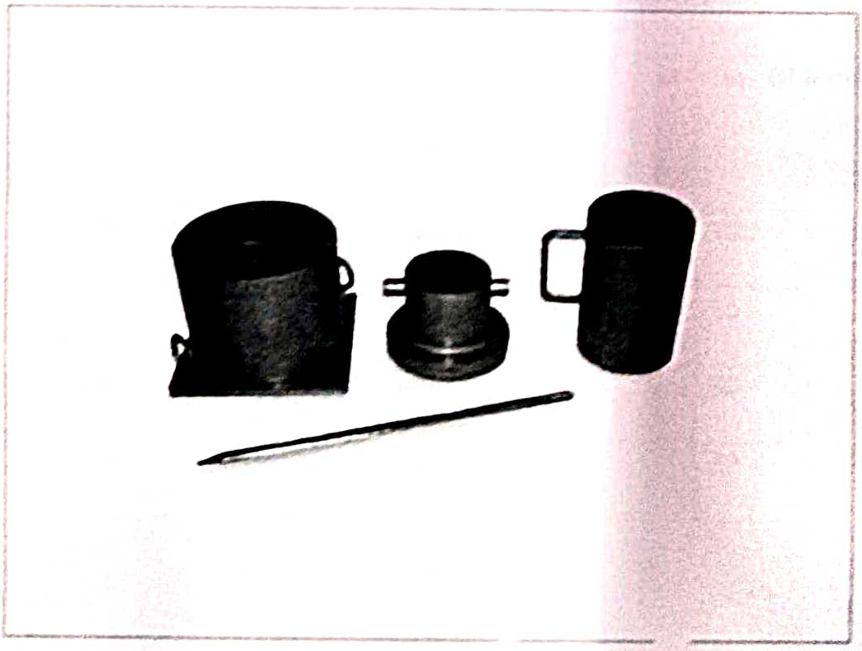
- For test purpose, the degree of compaction has to be specified. BS EN 1097-3: 1998recognizes two degrees: loose and compacted. Generally the standard conditions is a compacted aggregate in a dry state. The ratio of the loose bulk density to the compacted bulk density lies usually between 0.87 and 0.96. The bulk density is used for converting proportions by weight into the proportions by volume.

Materials:

1 . Coarse aggregate 2. Fine aggregate 3. Water

APPARATUS:

- Metal cylinder , the size depends on the maximum size of the aggregate.
- Balance
- Tamping rod: a straight metal; tamping rod of cylindrical cross section 16 mm in diameter and 600 mm long, rounded at one end.
- Shovel



TEST PROCEDURE

- **Compacted bulk density,**

  1. Weight the empty cylinder(W1)
  2. Fill the cylinder with aggregate in three stages, each one-third of the volume being ramped a number of times depending on the maximum size of the aggregate with the tamping rod.
  3. Level the surface of the cylinder by rolling the tamping rod across the top.
  4. Weigh the cylinder with the compacted aggregate (W2).
  5. Weigh the cylinder filled with water (W3)

- **Loose bulk density,**

1. Fill the cylinder with aggregate in one stage at a height not exceeding 50mm from the top of cylinder.
2. Weigh the cylinder with the loose aggregate (W4).

Note: **Details of the cylinder used in bulk density of aggregate , according to B.S**

Diameter (mm)	**Height(mm)**	**Compacted Bulk Density**	
		Max. Size of aggregate	**No. Of layers**
350	**300**	**50**	**100**
250	**300**	**28**	**50**
200	**225**	**14**	**30**
100	**150**	6	**20**

Calculations:-

Compacted bulk density = $W_2 - W_1 / ([W_3 - W_1]/1000)$ (kg/m^3)

Loose bulk density = W4-W1/([W3-W1]/1000) (kg/m^3)

% Voids = (1- [Bulk density/Specific gravity 1000])X 100

EXPERIMENT NO. – 12

FLAKINESS AND ELONGATION INDEX OF AGGREGATE

1. OBJECTIVE

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 ncreased to maintain the water –cement ratio. Generally, flat and elongated particles are avoided or are imited to about 15% by weight of the total aggregate.

2. APPARATUS REQUIRED

1: Balance

Balance should be able to weigh up to 1g.

2: Sieves

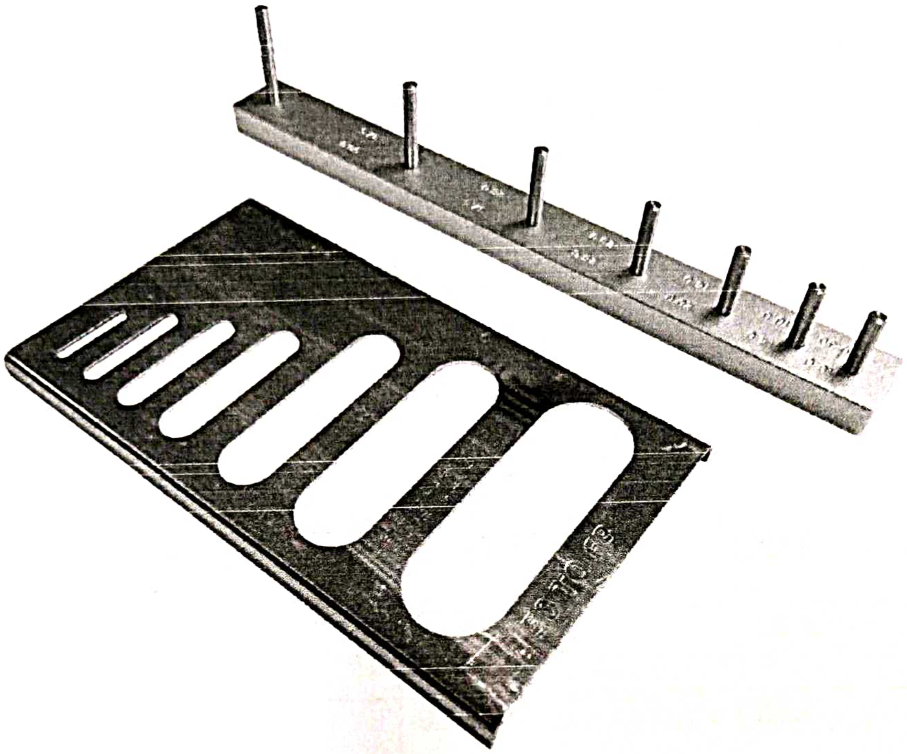
Sieves required are 63,50,40,31.5,25,20,16,12.5,10 and 6.3 mm (based on requirement and gradation of aggregate).

3:Thickness gauge-For Flakiness Index

Thickness Gauge have width equal to 0.6 times the mean dimension of the aggregate.

4: Length Gauge-For Elongation Index

Length Gauge have length equal to 1.8 times the mean dimension of the aggregate



3. **REFERENCE**

IS 2386 (part 1): 1963 methods of test for Aggregates of concrete-particle size and shape , Reaffirmed-Dec 2016

4. PROCEDURE

1. A quantity of aggregate shall be taken sufficient to provide the minimum number of 200 pieces of any fraction to be tested.
2. The sample shall be sieved with the sieves specified in table

Size of Aggregate thickness (mm)		Thickness Gauge* (mm)	Length gauge **(mm)
Passing through IS sieve	Retained on IS Sieve		
63	50	33.90	-
50	40	27.00	81.0
40	25	19.50	58.5
31.5	25	16.95	-
25	20	13.50	40.5
20	16	10.80	32.4
16	12.5	8.55	25.6
12.5	10	6.75	20.2
10.0	6.3	4.89	14.7

* This dimension is equal to 1.8 times the mean sieve size

* This dimension is equal to 0.6 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 1 for the appropriate size of material.

4. 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. Separation of elongated material- Each fraction shall be gauged individually for length on a metal length gauge of the pattern shown in fig 4. The gauge length used shall be that specified in co1.4 of table 1 for the appropriate size of material..

7. 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.

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

5. OBSERVATION AND RECORDING

Passing through IS Sieves(mm)	Retained on IS Sieves(mm)	Flakiness gauge(mm)	Weight passing on Flakiness gauge(g)	Percentage weight passing(%)
63	50	33.9		
50	40	27.00		
40	25	19.50		
31.5	25	16.95		
25	20	13.50		
20	16	10.80		
16	12.5	8.55		
12.5	10	6.75		
10	6.3	4.89		
		Total		

Recordings for flakiness Index

Passing through IS Sieves(mm)	Retained on IS Sieves(mm)	Elongation gauge (mm)	Weight retained on Elongation Gauge(g)	Percentage weight Reatained(%)
63	50	--		
50	40	81.00		
40	25	58.5		
31	25	--		
25	20	40.50		
20	16	32.4		
16	12.5	25.6		
12.5	10	20.2		
10	6.3	14.7		
		Total		

Recordings for Elongation Index

. Calculation

.. The flakiness index on an aggregate is =

Total weight passing Flakiness Gauge X 100/ Total weight of test sample= __________%

:. The elongation index on an aggregate is=

Total weight of test sample= __________%

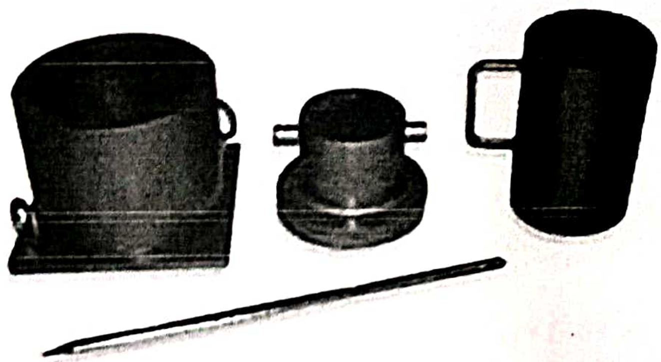
EXPERIMENT NO. – 13

AGGREGATE CRUSHING VALVE

AIM

To determine the aggregate crushing value of coarse aggregates as per IS: 2386 (part IV)-1963.

APPARATUS



i) Cylindrical measure and plunger

ii) Compression testing machine

IS sieve of sizes – 12.5 mm, 10mm and 2.36mm

PROCEDURE

i) The aggregates passing through 12.5 mm and retained on 10 mm IS sieve are oven-dried at a temperature of 100to 110oC for 3 to 4hrs.

ii) The cylindrical of the apparatus is filled in 3 layers, each layer tamped with 25 strokes of a tamping rod.

iii) The weight of aggregates is measured (Weight "A').

iv) The surface of the aggregates is then levelled and the plunger inserted . The apparatus is then placed in the compression testing machine and loaded at a uniform rate so as to achieve 40t load in minutes. After this, the load is released.

v) The sample is then sieved through a 2.36 mm IS Sieve and the fraction passing through the sieve is weighed (weight 'B')

vi) Two tests should be conducted.

REPORTING OF RESULTS

Aggregate crushing value = B/A X 100%

The result Should be recorded to the first decimal place and the mean of the two results reported.

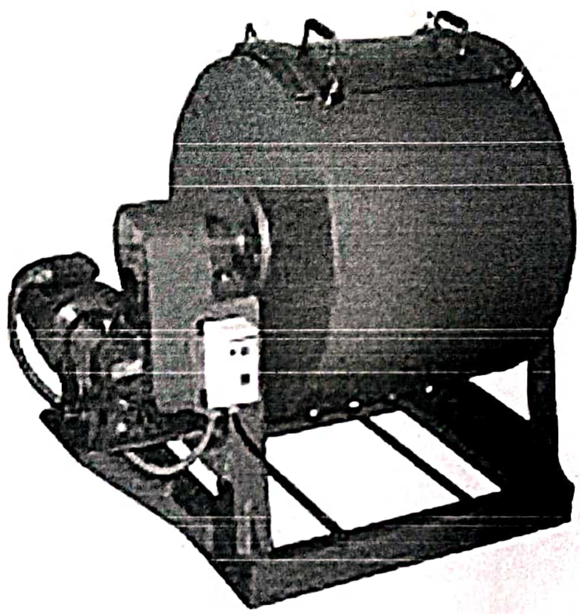
EXPERIMENT NO. – 14

AGGREGATE ABRASION VALUE

AIM

To determine the abrasion value of coarse aggregates as per IS : 2386 (part IV)-1963

APPARATUS



i) Los Angles abrasion testing machine

ii) IS sieve of size – 1.7 mm

iii) Abrasive charge- 12 nos. Cast or steel spheres approximately 48mm dia. And each weighing between 390 and 445 g ensuring that the total weight of charge is 5000 ± 25g.

iv) Oven

PREPARATION OF SAMPLE

The test sample should consists of clean aggregates which has been dried in an oven at 105 to 110°C to b substantially constant weight and should conform to one of the gradings shown in the table below:

Grading of test Samples

Sieve size (square hole)		Weight in g of test sample for grade						
		A	B	C	D	E	F	G
Passing through (mm)	Retained on (mm)							
80	63	-	-	-	-	2500*	-	--
63	50	-	-	-	-	2500*	5000*	-
50	40	-	-	-	-	5000*	5000*	5000*
40	25	1250	-	-	-	-	-	5000*
25	20	1250	-	-	-	-	-	-
20	12.5	1250	2500	-	-	-	-	-
12.5	10	1250	2500	-	-	-	-	-
10	6.3	-	-	2500	-	-	-	-
6.3	4.75	-	-	2500	-	-	-	-
4.75	2.36	-	-	-	5000	--	-	-

Tolerance of ± percent permitted

PROCEDURE

The test sample and the abrasive charge should be placed in the Los Angles abrasion testing machine rotated at a speed of 20 to 33 revolutions/minute for 1000 revolutions. At the completion of the test, the material should be discharged and sieved through 1.70 mm IS sieve.

REPORTING OF RESULTS

i) The material coarser than 1.70mm IS sieve should be washed, dried in an oven at a temperature of 100 to 110°C to a constant weight and weighed (weight 'B').

ii) The proportion of loss between weight 'A' and 'B' of the test sample should be expressed as a percentage of the original weight of the test sample. This value should be reported as,

Aggregate abrasion value = A-B/A X 100%

A sample perform for the record of the test results is given in Annexure-II.

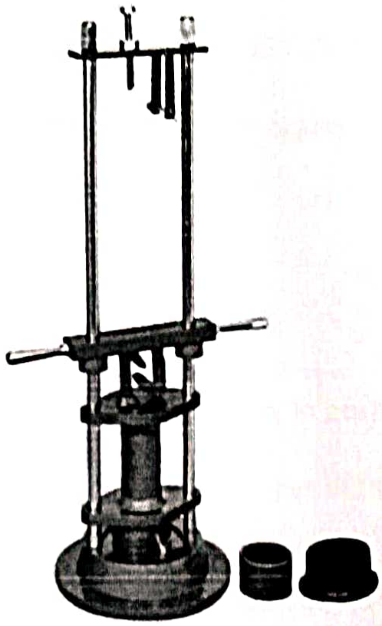
EXPERIMENT NO. – 15

AGGREGATE IMPACT VALUE

AIM

To determine the aggregate impact value of coarse aggregates as per IS: 2386 (part IV)-1963

APPARATUS



i) Impact testing machine conforming to IS: 2386 (part IV)-1963

ii) IS sieves of sizes -12.5 mm, 10mm and 2.36mm

iii) A cylindrical metal measure of 75mm dia. And 50mm depth

iv) A tamping rod of 10mm circular cross section and 230mm length, rounded at one end

v) Oven

PREPARATION OF SAMPLE

i) The test sample should conform to the following grading:

- Passing through 12.5mm IS sieve 100%
- Retention on 10mm IS sieve 100%

ii) The sample should be oven –dried for 4 hrs. At a temperature of 100 to 110°C and cooled.

iii) The measure should be about one-third full with the prepared aggregates and tamped with 25 strokes of the tamping rod. A further similar quantity of aggregates should be added and a further tamping of 25 strokes given. The measure should finally be filled to overflow , tamped 25 times and the surplus aggregates struck off, using a tamping rod as a straight edge. The net weight of the aggregates in the measure should be determined to the nearest gram (weight 'A')

PROCEDURE

i) The cup of the impact testing machine should be fixed firmly in position on the base of the machine and the whole of the test sample placed in it and compacted by 25 strokes of the tamping rod.

ii)The hammer should be raised to 380mm above the upper surface of the aggregates in the cup and allowed to fall freely onto the aggregates. The test sample should be subjected to a total of 15 such blows, each being delivered at an interval of not less than one second.

REPORTING OF RESULTS

i) The sample should be removed and sieved through a 2.36mm IS sieve. The fraction passing through should be weighed (weight 'B'). The fraction retained on the sieve should also be weighed (weight 'C') and if the total weight(B+C) is less than the initial weight (A) by more than one gram, the result should be discarded and a fresh test done.

ii) The ratio of the weight of the fines formed to the total sample weight should be expressed as a percentage.

Aggregate impact value= B/A X 1005

iii) Two such tests should be carried out and the mean of the results should be reported.

A sample perform for the record of the test results is given in Annexure-III

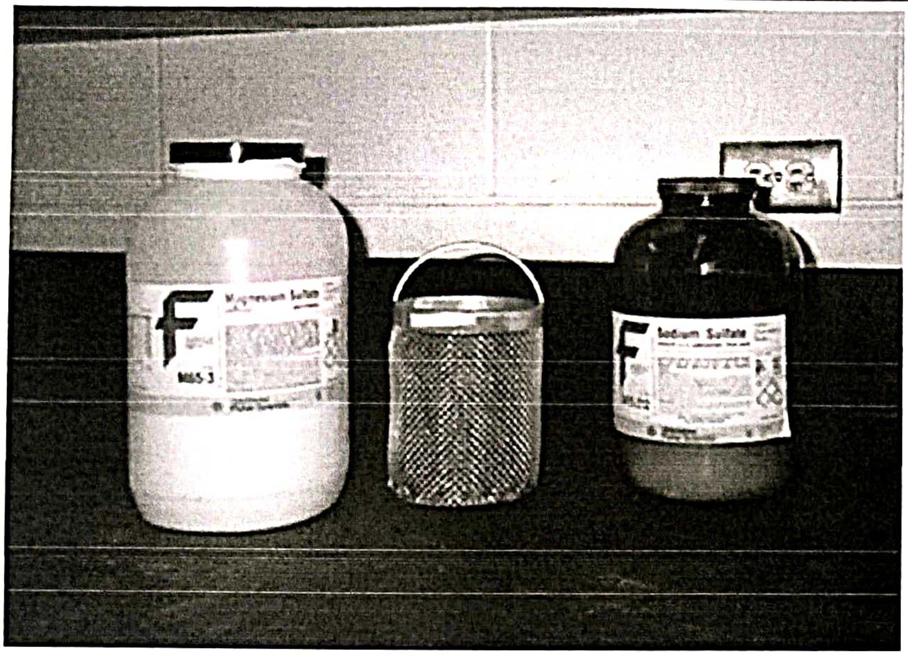
EXPERIMENT NO. – 16

OBJECTIVE

This test is intended to study the resistance of coarse and fine aggregates to weathering action and to judge the durability of the coarse aggregate.

APPARATUS

Name	Capacity	Least count
Balance	500 g	0.1 g
Balance	5000 g	1 g
Oven	105 to 110^{0}C	
Sieves	80 mm, 63 mm, 40 mm, 31.5 mm, 25 mm, 20 mm, 16 mm, 12.5 mm, 10 mm, 8.0 mm, 4.75 mm, 4.0 mm, 2.36 mm, 1.18 mm, 600 micron, 300 micron, 150 micron	
Wire mesh basket		
container		



Chemicals and wire mesh basket

CHEMICAL SOLUTION

- Sodium Sulphate Solution
- Magnesium Sulphate Solution

PREPARATION OF TEST SAMPLE FOR FINE AGGREGATE

- Wet sieve the sample through a nest of IS sieves, the lower being 300 micron and the upper being 10 mm size.
- The material passing 10 mm sieve and retained on 300 micron sieve is then dried and taken for the test.
- The sample collected as above is again sieved through a series of sieves such as 10 mm, 4.75 mm, 2.36 mm, 1.18 mm, 600 micron and 300 micron.
- The amount of sample to be taken for sieving is such that, it will yield not less than 100 g of each of the following sizes.

Passing	Retained
10 mm	4.75 mm
4.75 mm	2.36 mm
2.36 mm	1.18 mm
1.18 mm	600 micron
600 micron	300 micron

- Weigh 100 g of sample from each of the separated fraction and place it in separate containers for the test.
- Note- Fine aggregates sticking in the meshes of the sieves is not used in preparing the sample.

PREPARATION OF TEST SAMPLE FOR COARSE AGGREGATE

- Wash the coarse aggregate through 4.75 mm IS sieve and dry the material retained on the sieve in an oven maintained at a temp of 105 to 110^{0}C, till it attains a constant mass.
- Sieve the dried sample to separate it into different size fractions using sieves of sizes 80 mm, 63 mm, 40 mm, 20 mm, 10 mm, 4.75 mm.
- The sample should be of such an amount that it will yield not less than the following amount of the different sizes, which shall be available in amounts of 5 percent or more.

Size	Yield
10 mm to 4.75 mm	300 g
20 mm to 10 mm	1000 g (consisting of 12.5 mm to 10 mm = 33% and 20 mm to 12.5 mm = 67%)
40 mm to 20 mm	1500 g (consisting of 25 mm to 20 mm = 33% and 40 mm to 25 mm = 67%)
63 mm to 40 mm	3000 g (consisting of 50 mm to 40 mm = 50% and 63 mm to 50 mm = 50%)
80 mm and larger	3000 g

- Take proper weight of sample from each fraction and place it in separate containers for the test.

PROCEDURE

1. Take individual samples in a wire mesh basket and immerse it in the solution of sodium sulphate or magnesium sulphate for not less than 16 hours nor more than 18 hours, in such a manner that the solution covers them to a depth of at least 15 mm.
2. After completion of the immersion period, remove the samples from solution and allow it to drain for 15 minutes and place it in drying oven.

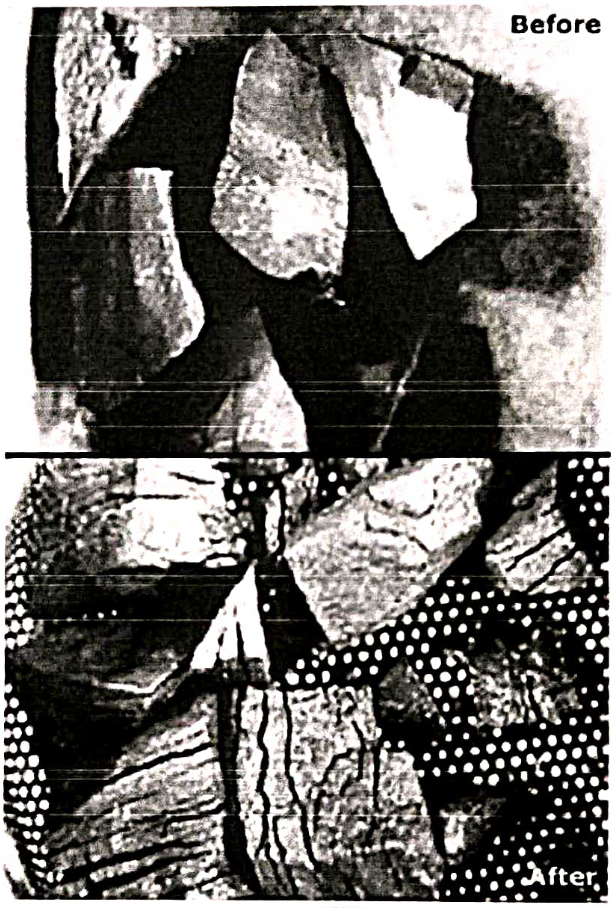
3. Dry the sample until it attains a constant mass and then remove it from oven and cool it to room temperature.
4. After cooling again immerse it in the solution as described in step-1.
5. The process of alternate immersion and drying is repeated until the specified number of cycles as agreed between the purchaser and the vendor is obtained.
6. After completion of the final cycle and after the sample has been cooled, wash it to free from sodium sulphate or magnesium sulphate solution. This may be determined when there is no reaction of the wash water with barium chloride.
7. Then dry each fraction of the sample to constant temp of 105 to 110^{0}C and weigh it.
8. Sieve the fine aggregates over the same sieve on which it was retained before test.
9. Sieve the coarse aggregate over the sieve shown below for the appropriate size of particles.

Size of Aggregate	Sieve used to determine loss
63 mm to 40 mm	31.5 mm
40 mm to 20 mm	16.0 mm
20 mm to 10 mm	8.0 mm
10 mm to 4.75 mm	4.0 mm

REPORT

The result should be reported giving the following particulars

- Type of solution used for the test
- Weight of each fraction of sample before the test.
- Material from each fraction of the sample passing through the specified IS sieve, expressed as a percentage by weight of the fraction.
- In the case of particles coarser than 20 mm size before the test, the number of particles in each fraction before the test and the number of particles affected classified as to the number disintegrating, splitting, crumbling , cracking, flaking etc.



Before and After Soundness Test

REFERENCE

- IS-2386 (Part-5)-Methods Of Test For Aggregates For Concrete (Part-5-Soundness)

EXPERIMENT NO. – 17

TESTS ON FRESH CONCRETE

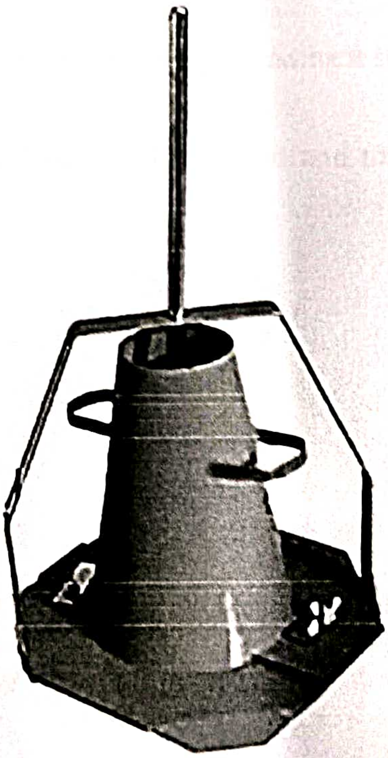
WORKABILITY

SLUMP

Aim

To determine the workability of fresh concrete by slump test as per IS : 1199- 1959

APPARATUS



i) Slump

ii) Tamping rod

PROCEDURE

i) The internal surface of the mould is thoroughly cleaned and applied with a light coat of soil.

ii) The mould is placed on a smooth, horizontal , rigid and non-absorbent surface.

iii) The mould is then filled in four layers with freshly mixed concrete, each approximately to one-fourth of the height of the mould.

iv) Each layer is tamped 25 times by the rounded end of the tamping rod (strokes are distributed evenly over the cross-section).

v) After the top layer is rodded, the concrete is struck off the level with a trowel.

Vi) The mould is removed from the concrete immediately by raising it slowly in the vertical direction.

vii) The difference in level between the height of the mould and that of the highest point of the subsided concrete is measured.

vii) The difference in height in mm is the slump of the concrete.

REPORTING OF RESULTS

The slump measured should be recorded in mm of subsidence of the specimen during the test. Any slump specimen, which collapses or shears off laterally gives incorrect result and if this occurs , the test should be repeated with another sample. If, in the repeat test also , the specimen sheared, should be recorded.

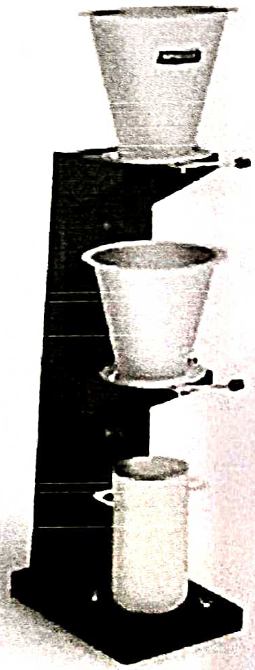
EXPERIMENT NO. – 18

COPMPACTING FACTOR

AIM

To determine the workability of fresh concrete by compacting factor test as per IS: 1199-1959.

APPARATUS



i) Compacting factor apparatus

PROCEDURE

i) The sample of concrete is placed in the upper hopper up to the brim.

ii) The trap –door is opened so that the concrete falls in to the lower hopper.

iii) The trap-door of the lower hopper is opened and the concrete is allowed to fall in to the cylinder.

iv) The excess concrete remaining above the top level of the cylinder is then cut off with the help of plane blades.

v) The concrete in the cylinder is weighed. This is known as weight of partially compacted concrete.

vi) The cylinder is filled with a fresh sample of concrete and vibrated to obtain full compaction. The concrete in the cylinder is weighed again. The weight is known as the weight of fully compacted concrete.

REPORTING OF RESULTS

$$\text{Compacting factor} = \frac{\text{Weight of partially compacted concrete}}{\text{Weight of fully compacted concrete}}$$

It should normally be stated to the nearest second decimal place.

EXPERIMENT NO. – 19

TESTS ON HARDENED CONCRETE

NON-DESTRUCTIVE TESTS

REBOUND HAMMER

AIM

To assess the likely compressive strength of concrete by using rebound hammer as per IS : 13311 (part 2) -1992

PRINCIPLE

The rebound of an elastic mass depends on the hardness of the surface against which its mass strikes. When the plunger of the rebound hammer is pressed against the surface of the concrete, the spring –controlled mass rebounds and the extent of such a rebound depends upon the surface hardness of the concrete. The surface hardness and therefore the rebound is taken to be related to the compressive strength of the concrete. The rebound value is read from a graduated scale and is designated as the rebound number or rebound index. The compressive strength can be read directly from the graph provided on the body of the hammer.

APPARATUS

i) Rebound hammer

PROCEDURE

i) Before commencement of a test, the rebound hammer should be tested against the test anvil, to get reliable results, for which the manufacturer of the rebound hammer indicates the range of readings on the anvil suitable for different types of rebound hammer.

ii) Apply light pressure on the plunger – it will release it from the locked position and allow it to extend to the ready position for the test.

iii) Press the plunger against the surface of the concrete, keeping the instrument perpendicular to the test surface, Apply a gradual increase in pressure until the hammer impacts. (Do not touch the button while depressing the plunger. Press the button after impact, in case it is not convenient to note the rebound reading in that position.)

iv) Take the average of about 15 readings.

INTERPRETATION OF RESULTS

The rebound reading on the indicator scale has been calibrated by the manufacturer of the rebound hammer for horizontal impact, that is, on a vertical surface, to indicate the compressive strength When used in any other position , appropriate correction as given by the manufacturer is to be taken in to account.

EXPERIMENT NO. – 20

ULTRASONIC PULSE VELOCITYAIM

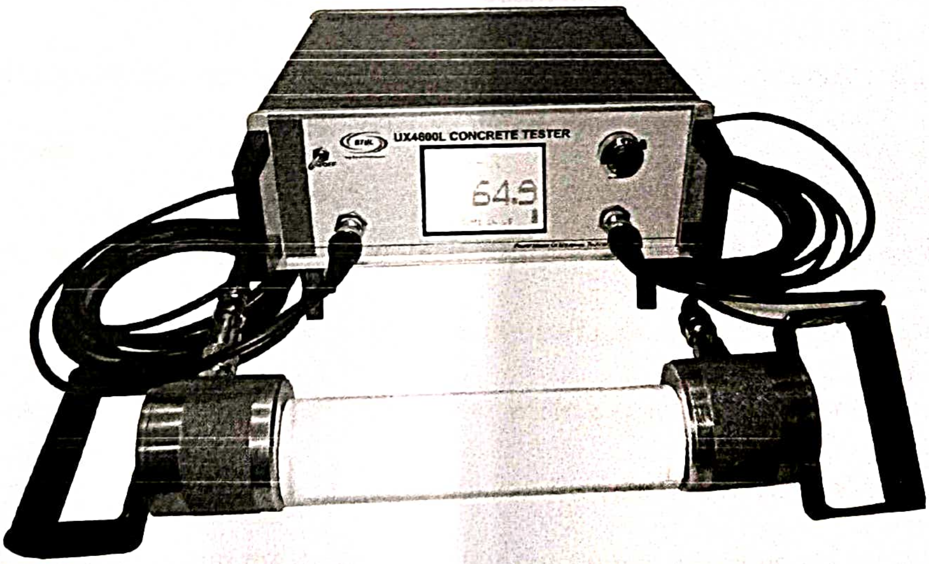
AIM

To assess the quality of concrete by ultrasonic pulse velocity method as per IS: 13311 (part 1) -1992

PRINCIPLE

The method consists of measuring the time of travel of an ultrasonic pulse passing through the concrete being tested. Comparatively higher velocity is obtained when concrete quality is good in terms of density , uniformly , homogeneity etc.

APPARATUS



i) Ultrasonic pulse velocity meter

PROCEDURE

i) Preparing for use: Before switching on the 'V' meter, the transducers should be connected to the sockets marked "TRAN" and "REC".

The 'V' meter may be operated with either:

a) the internal battery

b) an external battery or

c) the A.C line

ii) Set reference: A reference bar is provided to check the instrument zero. The pulse time for the bar is engraved on it. Apply a smear of grease to the transducer faces before placing it on the opposite ends of the bar. Adjust the 'SET REF' control until the reference bar transit time is obtained on the instrument read-out.

iii) range selection: For maximum accuracy , it is recommended that the 0.1 microsecond range be selected for path length up to 400mm.

iv) Pulse velocity: Having determined the most suitable test points on the material to be tested, make careful measurement of the path length 'L' . Apply couplant to the surfaces of the transducer and press it hard on to the surface of the material. Do not move the transducer while a reading is being taken, as this can generate noise signals and errors in measurements. Continue holding the transducer on to the surface of the material until a consistent reading appears on the display, which is the time in microsecond for the ultrasonic pulse to travel the distance 'L'.

The mean value of the display readings should be taken when the units digit hunts between two values.

Pulse velocity= Path length/Travel time

v) Separation of transducer leads: It is advisable to prevent the two transducer leads from coming into close contact with each other when the transit time measurements are being taken. If this is not done , the receiver lead might pick-up unwanted signals from the transmitter lead and this would result in an incorrect display of the transit time .

INTERPRETATION OF RESULTS

The quality of concrete in terms of uniformly , incidence or absence of internal flaws , cracks and segregation, etc., indicative of the level of workmanship employed, can thus be assessed using the guidelines given below, which have been evolved for characterising the quality of concrete in structures in terms of the ultrasonic pulse velocity.

Pulse velocity (km/second)	Concrete Quality (Grading)
Above 4.5	Excellent
3.5 to 4.5	Good
3.0 to 3.5	Medium
Below 3.0	Doubtful