DEPARTMENT OF CIVIL ENGINEERING

CONCRETE TECHNOLOGY LABORATORY MANUAL

Subject Code: - 23CIV244L

CERTIFICATE

This is to certify that Mr./Miss_____

of Civil Branch, Sem-V, Enrollment No._____, has satisfactorily completed his/her term work for the subject **Concrete Technology (23CIV244L).**

Date :

Sign of Faculty Head of the Department

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EXPERIMENT NO. 1 **DATE: ___/___/_____**

FINENESS OF CEMENT

Aim: To determine fineness of given sample of cement.

Apparatus: Weighing balance, Trowel, Tray 30 cm X 30cm, bristle brush with 25 cm handle, Manometer fluid, Timer accurate to 0.5 sec, Thermometer, Mercury etc.

Theory: Strength development of concrete is **Result** of reaction of water with cement particles. The reaction always starts with the cement available at surface of the particles. Thus, larger the surface area available for reaction, greater is the rate of hydration. Rapid development of strength requires greater degree of fineness. However, too much fineness also requires greater degree of fineness. However, too much fineness is also undesirable, because cost of grinding cement to higher fineness is considerable. Finer cement deteriorates more quickly when exposed to air and likely to cause more shrinkage, but less prone to bleeding. Greater fineness also requires greater amount of gypsum for proper retardation. Also amount of water requirement for the paste of standard consistency is greater. It is, therefore, necessary to ensure certain amount of coarseness in cement, but maximum limit to this coarseness is prescribed by BIS to ensure minimum degree of grinding.

Procedure: **SIEVE TEST**

1. Weigh accurately 100 gm of cement and place on a standard IS sieve 90 microns.
2. Break down any air set lumps in the sample with fingers, but do not rub on the sieve.
3. Continuously sieve sample by holding tile sieve in both hands and giving a gentle wrist motion or mechanical sieve shaker may be used for this purpose. The sieving should be continuous for 15 minutes.
4. Weigh residue left after 15 minutes sieving. This residue shall not exceed the specific limits (10% of actual).

BLAINE TEST

1. Weight an amount of cement equal to that determined in the calibration.
2. Place perforated base in the permeability cell, then add a paper disk followed by the cement sample and another paper disk. Compress specimen with the plunger, pushing the plunger as far as it will go, and place the permeability cell in the socket.
3. Evacuate the air until the manometer fluid moves above the upper line, but take care not to pull it over top of tube. Close the petcock and note the amount of time it takes for fluid to drop between middle two lines. Take a reading of air temperature.
4. Cement requires a porosity of 0.50. Calculate the specific surface in cm^2/gm using following formula. The temperature at calibration and time of test must be within ±2°C of each other.

$$S = \frac{s \times \sqrt{T}}{\sqrt{T_s}}$$

Where, S = Specific surface of test sample

S_s = Specific surface of the standard used in calibration = 290 m^2/kg

T = Measured time for fluid to drop over middle interval, in seconds

T_s = Measured time required for fluid to drop over middle interval for standard sample = 28 seconds

5. Rerun test on PPC if time permits. PPC is finer and cannot be compacted to 0.50 porosity. Determine the weight of sample to produce a porosity of 0.530 by the following formula:
   W = PV (1-e)
   Where, W= Grams of sample required
   P = Specific gravity of rest sample
   V = Bulk volume of bed of cement determined calibration test
   E = Desired porosity of bed cement
6. Follow step 2 and 3 again.
7. Calculate the specific surface in, using the following formula, if the temperature at calibration and time of rest are within ±2°C of each other.

$$S = \frac{s \times \sqrt{T} \times 0.92}{\sqrt{T_s}}$$

Where, S = Specific surface of test sample

S_s = Specific surface of the standard used in calibration = 290 m^2/kg

T = Measured time for fluid to drop over middle interval, in seconds

T_s = Measured time required for fluid to drop over middle interval for standard sample = 28 seconds

Precautions

1. Cleaning of sieve should be done very gently with the help of a brush.
2. After sieving cement must be remove from bottom surface of sieve.
3. Weighing machine should be checked before use.
4. Sieve must be carried out continuously.

SIEVE ANALYSIS				
Sr. No.	Description	Sample 1	Sample 2	Sample 3
1	Weight of cement, gms			
2	I.S. sieve size, µm			
3	Sieving time, minute			
4	Weight retained, gm			
5	% weight retained			

Conclusion:

Questions:

1. Define Fineness of cement.
2. Enlist methods to find fineness of cement
3. Name the instrument used to measure fineness of cement.

Date: …… **Signature: .....**

EXPERIMENT NO. 2 **DATE: ___/___/_____**

STANDARD CONSISTENCY OF CEMENT:

Aim: To determine the standard consistencyDe of given sample of the ordinary Portland cement

Apparatus: Vicat apparatus with plunger, Trowel, Glass plate(Non-porous platform), Measuring flask (200 ml)

Theory: This test determines the quantity of water required to produce a cement paste of standard consistency for the use in other tests. The Vicat apparatus (IS 5513 – 1976) is used for this purpose. The consistency of standard cement paste is defined as that consistency which will permit the Vicat plunger (50 mm long & 10mm Φ) to penetrate to a depth of 33-35mm from the top of the mould of height of 40 mm. The Φ of the Vicat mould is 80 mm. The Vicat apparatus & its attachment are as shown in figure.

Observation Table :

Sr. No.	Weight of cement	% of water	Penetration of plunger Depth
1	400 gm		mm.
2	400 gm		mm.
3	400 gm		mm.

Result: Standard consistency of cement of given sample is =

Conclusion:

Questions:

1. Define standard consistency of cement.
2. Standard consistency of cement is .....
3. Instrument used to measure standard consistency of cement is .....

Date: …… **Signature: .....**

EXPERIMENT NO. 3 **DATE: ___/___/_____**

SETTING TIME OF CEMENT:

Aim: Given a sample of cement, determine initial and final setting time of the sample.

Apparatus: Vicat's apparatus with mould and non-porous plate (glass or metal), (i) needle, (c), (ii) needle (f), balance (with weight box) capacity 1 kg, trowel of about 210 gm weight, enamel trough, standard spatula, stop watch, thermometer centigrade (0°C to 100°C), measuring cylinder 500ml.

Relevant IS Code: IS: 4031- Part-5-1988

Theory: When water is mixed with Cement to form a paste, reaction starts. In its pure form, the finely ground Cement is extremely sensitive to water. Out of the three main compounds viz. C3A, C3S and C2S, the C3A reacts quickly with water to produce jelly-like compound, which starts solidifying. This action of changing from a fluid state to a solid state is called 'setting' and should not be confused with 'hardening'. During the next stage of hydration, Cement paste starts hardening owing to the reaction of C3S and C2S and the paste gains strength. In the first few minutes, the setting action is more predominant and after some time hardening action becomes rapid. In practice, such solidifying action or loss of plasticity is required to be delayed, because some time is needed for mixing, transporting and placing of concrete into final position before mix loses its plasticity due to setting action. It is usually specified that plastic concrete should be placed and consolidated before initial set has 'Occurred, it should not then be disturbed until concrete has hardened. This initial setting time should not be too small and therefore, the standards specify minimum initial setting time. Once initial stiffening of concrete has taken place it is desirable that it should harden or gain strength as rapidly as possible, so that there is Standards, therefore, specify maximum value of final setting time.

It is not possible, however, in practice, to exactly locate the initial setting time and final setting time. The Indian Standard has selected two arbitrary points, which relate strength of cement to time from adding water.

Initial setting time (IST) is defined as the period elapsing between the time when the water is added to the cement and the time at which the needle of 1mm square section frails to pierce test block to a depth of about 5 mm from the bottom of mould. 30 minutes is minimum initial setting time specified by BIS for ordinary and rapid hardening cement.

The final setting time (FST) is defined as the period elapsing between the time when the water is added to the cement and the time at which needle of 1mm square with 5mm diameter attachment makes an impression on the test block, while the attachment fails to make an impression on the test block. 600 minutes is the

maximum time specified for final set for all above mentioned Portland cement

Procedure: **Determination of Initial setting time**

1. Weigh about 400 gm of neat cement.
2. Prepare a neat cement paste by adding 0.85 times the percentage of water required for standard consistency
3. Start the stop watch at the instant when water is added to the cement.
4. Fill the Vicat's mould with the cement paste prepared with the mould resting on the non-porous plate. Gauging time should not be less than 3 minutes and more than 5 minutes.
5. Place the test block confined in the mould and resting on the non-porous plate under the rod bearing the needle.
6. Lower the needle gently till it comes in contact with the surface of the test block and quickly release, allowing it to penetrate into the test block and note penetration, after every two minutes.
7. Repeat this procedure until the needle fails to pierce the block for about 5mm measured from the bottom of the mould. Stop the stopwatch and note the time, which is the initial setting time.

Determination of final setting time

1. Needle must be cleaned each time before use.
2. Go on releasing the needle as described earlier till the needle makes an impression thereon, while the attachment fails to do so.
3. The time that elapses between the moment the water is added to the cement and when the needle makes only an impression is considered as final setting time for the cement under test.

Precautions:

1. Needle must be cleaned each time before use.
2. Shift the position of the mould after recording the penetration reading so that the penetration may not be at the same place.
3. Check up the stop watch for accuracy.
4. Clean appliances shall be used for gauging.
5. Test block should be kept in 90% relative humidity and at 27°C±2°C and away from draught.

Observation

Sr. No.	Measurements	
1.	Weight of cement, gm	
2.	Weight of water, gm (0.85 X P)	
3.	Initial setting time, minutes	
4.	Final setting time, minutes	

Conclusion:

Questions:

1. Define Initial and final setting time of cement.
2. Initial and Final setting time of OPC is ..... and .....
3. Name the instrument for measurement of Initial and final setting time of cement.

Date: …… **Signature: .....**

EXPERIMENT NO. 4 **DATE: ___/___/_____**

SOUNDNESS OF CEMENT:

Aim: To find given sample of cement is sound.

Apparatus: Le-chatelier apparatus, glass sheets, trowel, measuring cylinder, blow lamp or stove or water bath with electric heating arrangement, enamel tray, thermometer, stop watch, balance and weight box and Autoclave apparatus, length comparator, mould etc.

Theory: It is essential that cement concrete does not undergo large change in volume after it has hardened. Limiting the quantities of free lime (CaO) and magnesia (MgO) in cement ensure this. During manufacture of cement, free lime is produced. Free-lime reacts with water and increases in volume considerably. Magnesia also has the same effect but its rate of reaction is slow. Larger percentage of free lime and magnesia, if present, tends to increase the volume of the hardened concrete, thus causing disintegration. The cement is, therefore, said to be unsound when the percentage of free lime and magnesia is more than that specified by BIS. Unsoundness is measured with the help of Le-chatelier mould and Autoclave tests as explained in procedure.

It must be specially mentioned here that in the event of the cement failing to comply with the above requirement, a further test should e made by the "Le-chatelier method" from another portion of the sample after aeration by spreading it out to a depth of 75mm at a relative humidity of 50 to 80 percent for a total period of 7 days. The process is repeated and the expansion of each of the three types of cement mentioned above shall not be more than 5mm.

Autoclave test is said to be more comprehensive as it also includes the effect of MgO on the soundness of hydrating cement paste in addition to the effect of CaO. Effect of CaO on hydrating cement paste with respect to soundness is measured by Le-chatelier method, which fails to measure the effect of MgO due to its very slow rate of hydration, which some time may take more than 5-10 years. Autoclave hastens the hydration process of MgO due to very high temperature and pressure.

Procedure: **Le-chatelier test (unsoundness due to free lime)**

1. Place the mould on a glass sheet and fill it with cement paste formed by gauging cement with 0.78 p. Care should be exercised to keep the edges of the mould gently together, while this operation is being performed.
2. 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 of 27° C to 32° C and keep there for 24 hours.
3. Measure the distance separating the indicating points to an accuracy of a mm.
4. Submerge the mould again in water at a temperature prescribed above.

5. Bring the water to boiling, with the mould kept submerged in 25 to 30 minutes, and keep it boiling for three hours.
6. Remove the mould from the water, allow it to cool and measure the distance between the indicator points.
7. The difference between these two measurement represent the expansion of the cement (<10mm).

Autoclave test (unsoundness due to excess magnesia)

1. Cover the mould with thin layer of mineral oil and set reference point.
2. Take 500 gm of Cement an mix with water equal to 'p' to form a paste of standard consistency.
3. Fill the mould in two layers with cement paste by pressing into corners by thumb Finish the top level by trowel.
4. Store the mould in a moist room and take out the specimens after 24 hours.
5. After 24 ± 0.5 hours after moulding the specimens, the specimens are removed from moist atmosphere, measured for the length and are placed into Autoclave at room temperature in racks so that all four sides of each specimens are exposed to saturated steam, Autoclave should have water of about 10% of its volume for the test.
6. Start the Autoclave, keeping the vent valve open in the beginning till steam starts escaping. Close the vent valve and raise the temperature so that the gauge pressure of the steam is 2.1 MPa in 1.5 hour from the time the heat is turned on.
7. Maintain the pressure to 2.0 ± 0.1 MPa for three hours and then switch off the Autoclave. Allow the machine to cool off at a rate of 0.1 MPa / hour. Bring the pressure to atmospheric level by opening the vent valve.
8. Remove the specimens immediately to a water bath of temperature 90° C. Cool the water to 27 ± 2° C In 15 minutes.
9. Dry the surface of the specimens and measure the length.

Precautions

1. All the measurements of quality of cement and water should be done accurately by weight.
2. Le-chatelier apparatus should be handled by pressing indicator arms.
3. Oil the Autoclave mould with very thin layer of mineral oil.
4. Lengths should be measured accurately.
5. Temperature of Autoclave should be raised & lowered gradually.

Observation Table : Le-chatelier Apparatus

Sr. No.	Measurements	
1.	Weight of cement, gm	
2.	Weight of water, gm (0.78 * p)	
3.	Distance between pointer before boiling. mm	
4.	Distance between pointer after boiling. mm	
5.	Difference, mm	

Conclusion:

Questions:

1. Define Soundness of cement.
2. How soundness of cement is important?

Date: …… **Signature: .....**

EXPERIMENT NO. 5 **DATE: ___/___/_____**

COMPRESSIVE STRENGTH OF CEMENT MORTAR CUBES:

Aim: To determine the Compressive Strength of given sample of Ordinary Portland Cement

Apparatus: 12 nos of 70.6 mm X 70.6 mm X 70.6 mm size cubes, Trowel, Tamping Rod, Measuring cylinder, IS Sieve-2mm, 90µ

Theory: The compressive strength of cement is one of the most important property of cement. Strength test is not made on the neat cement paste because of excessive shrinkage and cracking of neat cement. Hence, strength of cement is found on cement & sand mortar cubes. For this, the standard sand is used. The procedure for this test is described in IS 4031 (part-VI), 1988.

The materials used for this test, should be having good quality. As the test is to be carried for a cement property, the sand & water should be of classified quality. The water should be clean & crystalline. The sand used shall be standard sand as Ennore sand. In scare of this sand local available sand also can be used.

Procedure:

a) Get ready the moulds of size 70.7 mm X 70.7 mm X 70.7 mm having area of face equal to 5000 mm^2 by oiling the inside.
b) Take 185 gm of cement & 555 gm of standard sand. Prepare 12 such sample. Total weight of each sample will be 740 gm and proportion 1:3.
c) Take water (P/4 + 3.5) percent to the total weight of the sample. I.e. 740 gm.
d) Place the mixture of cement & sand on non-porous plate and mix dry and add water as specified in (C). Mix it till the uniform colour of mixture appears. This mixing shall be complete between 3 to 4 minutes.
e) Place the mortar in the mould firmly held in vibrating table.
f) The period of vibration shall be 2 min.
g) Prepare all the six cubes in above manner.
h) Keep the filled moulds at a temperature of 27 ± 2° C in atmosphere of 90 % relative humidity for 24 hours.
i) After 24 hours remove the cubes from the moulds and immediately immerse in clean fresh water and keep it for required period of curing.
j) Test it for required period of testing.

Observation Table :

Sr. No.	Strength after 3 days of curing	Strength after 7 days of curing	Strength after 28 days of curing
1.			
2.			
3.			
Avg.			

Results: The average compressive strength of given sample after

3 days of curing period is …….
7 days of curing period ……..
28 days of curing period is ……..

Conclusion :

Questions:

1. Define compressive strength of cement.
2. Define Curing.
3. List methods of curing.

Date: …… **Signature: .....**

EXPERIMENT NO. 6 **DATE: ___/___/_____**

SIEVE ANALYSIS OF AGGREGATES

Aim: To determine the fineness modulus of aggregates by sieve analysis method.

Apparatus: Set of sieve size 40 mm, 20 mm, 10 mm, 4.75 mm, 2.36 mm, 1.18mm, 600µ and 150µ.

Theory: Sieve analysis is the operation of dividing sample of aggregates into various functions each consisting of particles of same size. The sieve analysis is conducted to determine the particle size distribution in the sample of aggregates. This is known as graduation. The aggregates generally used for making concrete are of maximum 50 mm, 40 mm, 20 mm, 10 mm, 4.75 mm, 2.36 mm, 1.18 mm, 600µ , 150µ . The aggregate fractions from 80 mm to 4.75 mm are termed as coarse aggregates. Those fractions from 4.75 mm to 150m are termed as fine aggregates. The **Result**s of sieve analysis can be grasped much more easily if represented graphically and for this reason grading charts are used extensively.

Procedure : Before sieve analysis is performed the aggregate sample has to be air dried. Grading
pattern of a sample of coarse aggregate and fine aggregate is assessed by sieving the sample successively through all sieves mounted one over the another keeping larger size on the top. The material retained on each sieve after shaking represents the function of aggregates coarser than sieve below and finer than sieve above. Weight of the particles is 5 kg for coarse aggregates and 2 kg for fine aggregates. In manual operations the sieve is shaken giving movements in all directions so that the particles pass through the sieves and is continued for such a time so that no further movement of particles is possible. The time for sieve shaking is 15 minutes.

Observation:

Sieve Size	**Coarse Aggregate**				**Fine Aggregate**			
	Wt. Retain	% Wt. Retain	Cum % retain	% passing	Wt. Retain	% Wt. Retain	Cum % retain	% passing
40mm								
20mm								
10mm								
4.75mm								
2.36mm								
1.18mm								
600µ								
300µ								
150µ								
Pan								
	∑ =				∑ =			
	F.M. =				**F.M.** =			

Results:

Conclusion:

Date: …… **Signature: .....**

EXPERIMENT NO. 7 **DATE: __/__/_____**

SPECIFIC GRAVITY & BULK DENSITY OF AGGREGATES

Aim: To determine the specific gravity and bulk density of aggregates.

Apparatus materials: Specific gravity bottles, metallic measures for bulk density
(1) Coarse aggregate samples
(2) Fine aggregate samples
(3) Water

Theory: The Specific gravity is defined as the ratio of the mass of the solid in a given volume of sample to the mass of an equal volume o water at he same temperature. Specific gravity of aggregates is properly which mainly depends upon the original compaction of parent rock. Higher specific gravity indicates better strength, more durability and less water absorption by aggregate. It is mainly important for gravity structures such as dam, retaining wall etc. As in such structure better mechanical performance such as absorption and attrition resistance and other mechanical properties of aggregates. The determination of specific gravity is important step in mix design of concrete. Specific gravity also influences the bulk density of aggregates to some extent.

Procedure:
1. Take the bottle of a known volume.
2. For the coarse aggregate weight of sample is 1000 gm. and for the fine aggregate the weight of sample is 500 gm.
3. Pour both the samples in two bottles separately and then fill it with water completely.
4. Packed weight of both bottles individually say it is "A".
5. Take the weight of the bottle.
6. Let the sample to be dried in the atmosphere and take its weight named it "C".
7. Now place the sample in oven for drying and take its weight D.

$$\text{Sp. gravity} = \frac{D}{C-(A-B)}$$

A = wt. of bottle + sample + water
B = wt. of bottle + water
C = wt. of surface saturated sample in water
D = wt. of oven dried sample

BULK DENSITY SIGNIFICANCE:

Bulk density of aggregate is defined as the density of aggregates including the voids in the aggregate. The bulk density depends upon the particle size present in the given batch of aggregates. If the volume of voids in aggregate batch is considerable, the bulk density of that sample will be lower. Coarser aggregate has lower bulk density compared to finer aggregates. The bulk density of aggregate is used to convert the weight batching of concrete to volume batching for field mixes.

Observation :

Sr. No	Weight	Sand	Coarse Aggregate
1	Wt. of container (w_1)		
2	Wt. of container + sample (w_2)		
3	Volume of container (m^3)		
4	Bulk density = $\frac{w_2 - w_1}{V}$		

Conclusion:

Questions:

1. Define specific gravity.
2. Define Bulk density.

Date: …… Signature: .....

EXPERIMENT NO. 8 **DATE: ___/___/_____**

AGGREGATE CRUSHING STRENGTH TEST

OBJECTIVE

To determine crushing strength of a given aggregates.

APPARATUS

A steel cylinder of internal diameter 15.2 cm (Steel cylinder with open ends), a square base plate, plunger having a piston diameter of 15 cm, A cylindrical measure of internal diameter of 11.5 and height 18 cm, Steel tamping rod having diameter of 1.6 cm length 45 to 60 cm. Balance of capacity 3 kg with accuracy up to 1 gm, Compression testing machine capable of applying load of 40 tonnes at a loading rate of 4 tonnes per minute.

MATERIAL

Aggregates in surface dry condition and passing 12.5 mm sieve and retained on 10 mm sieve.

RELATED I.S. CODE

IS-2386 Part- IV

FIGURE

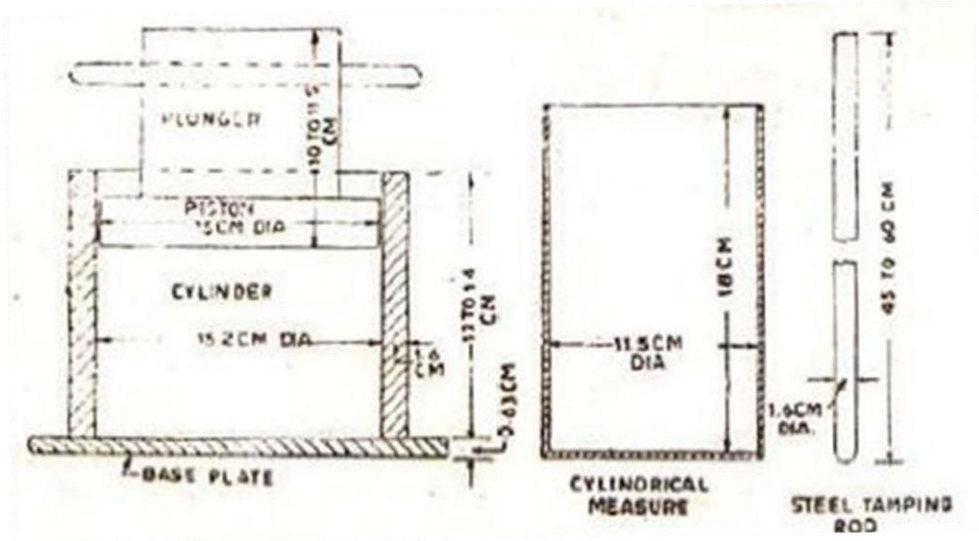

Fig 3.1 AGGREGATE CRUSHING TEST APPARATUS

PROCEDURE

1. The aggregate in surface-dry condition before testing and passing 12.5 mm sieve and retained on 10 mm sieve is selected.
2. The cylindrical measure is filled by the test sample of the aggregate in three layers of approximately equal depth, each layer being tamped 25 times by the rounded end of the tamping rod.
3. After the third layer is tamped, the aggregates at the top of the cylindrical measure are leveled off by using the tamping rod as a straight edge.
4. Then the test sample is weighed. Let that be W_1 gm.
5. Then the cylinder of test apparatus is kept on the base plate and one third of the sample from cylindrical measure is transferred into cylinder and tamped 25 times by rounded end of the tamping rod.
6. Similarly aggregate in three layers of approximately equal depth, each layer being tamped 25 times by rounded end of the tamping rod.
7. Then the cylinder with test sample and plunger in position is placed on compression testing machine.
8. Load is then applied through the plunger at a uniform rate of 4 tonnes per minute until the total load is 40 tonnes and the load is released.
9. Aggregates including the crushed position are removed from the cylinder and sieved on a 2.36mm IS. sieve and material which passes this sieve is collected and weighed. Let this be W_2 gm.
10. The above step is repeated with second sample of the same aggregate. The two tests are made for the same specimen for taking an average value.
11. Total weight of dry sample taken is w1 gm weight of the portion of crushed material passing 2.36mm IS sieve be W_2 gm.
12. Then the aggregate crushing value is defined as the ratio of weight of fines passing the specified IS sieve to the total weight of the sample (W_1).

Aggregate crushing value = (W_2/W_1) 100 in %

OBSERVATION TABLE

Trials	Total Weight of Dry Aggregate sample 10 gm	Weight of fines passing 2.36 mm IS sieve, w_2 gm	Aggregate Crushing Value %	Avg. Aggregate Crushing Strength Value
1				
2				

CALCULATIONS

RESULT

The mean (average) of the crushing value aggregate is _____%

Conclusion:

Questions:

1. Define crushing strength.
2. What is the important of crushing value for aggregates?

Date: …… Signature: ……

EXPERIMENT NO. 9 **DATE: ___/___/_____**

LOS ANGELES ABRASION TEST

OBJECTIVE

To determine the abrasion value of given aggregate sample by conducting Los Angeles Abrasion test.

APPARATUS

Los Angeles machine with inside diameter 70cm and inside length of 50%.Abrasive charges, I.S. Sieve with 1.7mm opening, Weighting Balance of 0.1gm accuracy.

MATERIAL

Dry aggregate sample confirming to one of the grading A to G (Refer Table 3.1)

RELATED I.S.CODE

I.S.-2386 part-IV

FIGURE

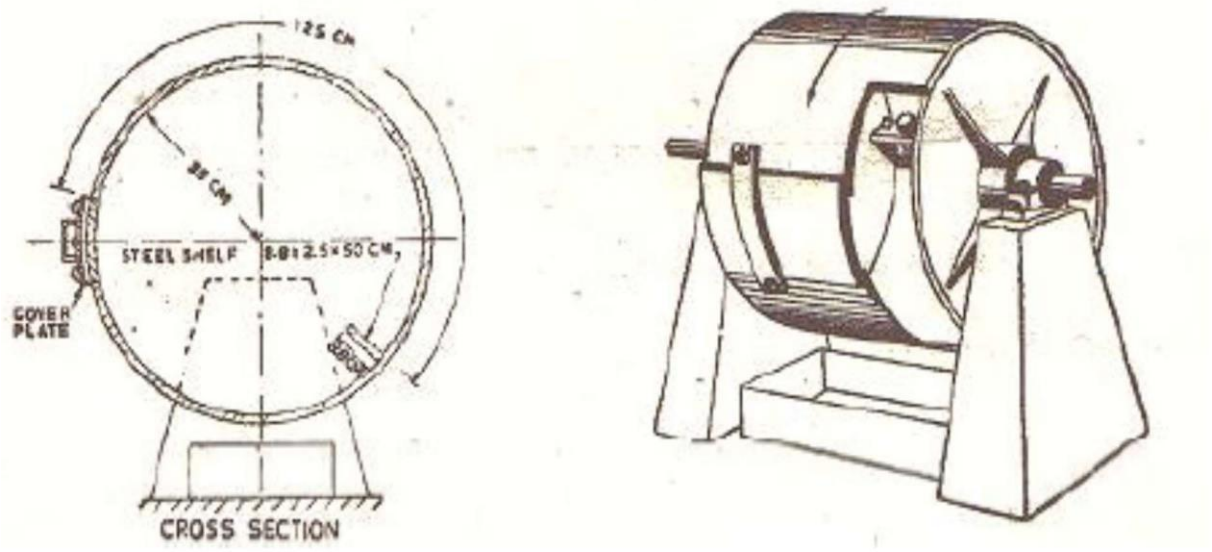

Fig 4.1 SCHEMATIC DIAGRAM OF LOS ANGELES ABRASION TESTING MACHINE

THEORETICAL BACKGROUND

Abrasion is a measure of resistance to wear or hardness. It is an essentially property for road aggregates especially when used in wearing coarse. Due to the movements of traffic, the road stones used in the surfacing course are subjected to wearing actions at the top. When traffic moves on the road the soil particle (sand) which comes between the wheel and road surface causes abrasion on the road stone. The abrasion test on aggregate is found as per I.S.-2386 part-IV.

Abrasion tests on aggregates are generally carried out by any one of the following methods:

1. Los Angeles abrasion test.
2. Deval abrasion test.
3. Dorry attrition test.

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. Maximum Allowable Los Angeles Abrasion Values of Aggregates in Different types of pavement layers as per Indian Road Congress (IRC) are:

For sub-base course a value of 60%. For base course such as WBM, Bituminous Macadam (BM), Built-Up spray grout base course and etc. value of 50%. For surface course such as WBM, BM, Bituminous Penetration Macadam, Built-Up spray grout binder course and etc. a value of 40%. If aggregates are used in surface course as bituminous carpet, bituminous surface dressing, single or two coats, cement concrete surface coarse and etc. a value of 35%. If aggregates are used for bituminous concrete, Cement concrete pavement as surface coarse than aggregate abrasion value of 30% maximum.

Table 4.1 Grading of Aggregates

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	No. of Spheres	Weight of charge, g
A	-	-	-	1250	1250		1250	-	-	-	12	5000± 25
B	-	-	-	-	-	2500	2500	-	-	-	11	4584± 25
C		-	-	-		-	-	2500	2500	-	8	3330± 20
D		-	-	-		-		-	-	5000	6	2500± 15
E	2500	2500	5000	-		-		-	-	-	12	5000± 25
F		-	5000	5000		-		-	-	-	12	5000± 25
G		-	-	5000	5000	-		-	-	-	12	5000± 25

PROCEDURE

1. Clean and dry aggregate sample confirming to one of the grading A to G is used for the test. (Refer table no. 1)
2. Aggregates weighing 5Kg 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 no.1 and placed in the cylinder of the machine, and cover is fixed to make dust tight.
4. The machine is rotated at a speed of 30 to 33 revolutions per minute.
5. The machine is rotated for 500 revolutions for gradings A, B, C and D, for gradings E, F and G, it shall be rotated for 1000 revolutions.
6. 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.
7. Using a sieve of size larger than 1.70mm I.S sieve, the material is first separated into two parts and the finer position is taken out and sieved further on a 1.7mm I.S sieve.
8. Let the original weight of aggregate be W_1 gm, weight of aggregate retained on 1.70mm I.S sieve after the test be W_2 gm.

OBSERVATION TABLE

Sr. No.	Details of Sample	Trial 1	Trial 2	Average
1	Weight of Specimen = W_1 gm			
2	Weight of Specimen after abrasion test, coarser than 1.70 mm IS sieve = W_2 gm			
3	Percentage Wear =$((W_1-W_2)/W_1)*100$			

CALCULATIONS

RESULT

The average value of two Los Angeles Abrasion test is _____%.

Conclusion:

Questions:

1. Define abrasion value.
2. What is the important of abrasion value for aggregates?
3. List role of abrasive charges added in aggregate.

Date: …… Signature: ……

EXPERIMENT NO. 10 **DATE: ___/___/_____**

AGGREGATE IMPACT VALUE TEST

OBJECTIVE

To determine the aggregate impact value of given aggregate as per I.S-2386 Part IV.

APPARATUS

Impact testing machine: The machine consists of a metal base. A detachable cylindrical steel cup of internal diameter 10.2cm and depth 5cm. A metal hammer of weight between 13.5 to 14Kg, 10cm in diameter and 5cm long. An arrangement for raising the hammer and allow it to fall freely between vertical guides from a height of 38cm on the test sample in the cup. A cylindrical metal measure having 7.5cm and depth of 5cm for measuring aggregates, A tamping rod of circular cross section, 1cm in diameter and 23cm long, rounded at one end, I.S. sieve of sizes 12.5mm, 10mm and 2.36mm. Balance of capacity not less than 500gm to weigh accurate up to 0.01gm.

MATERIAL

Surface dried aggregates passing 12.5 sieve and retained on 10 mm sieve.

RELATED I.S.CODE

IS-2386 Part IV

FIGURE

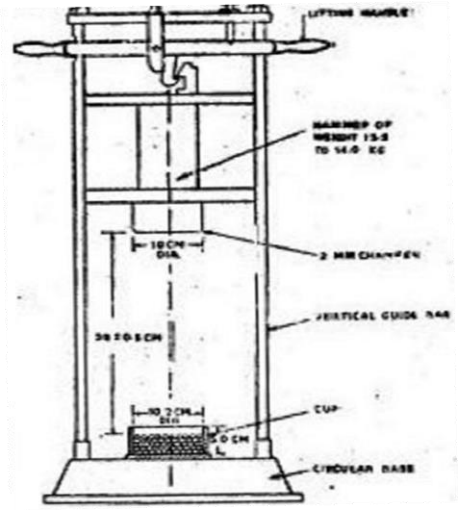

Fig 5.1 AGGREGATE IMPACT TESTING MACHINE

THERORETICAL BACKGROUND

Toughness is the property of a material to easiest impact. Due to moving loads the aggregates are subjected to pounding action or impact and there is possibility of stones breaking into smaller pieces. Therefore a test designed to evaluate the toughness of stones i.e., the resistance of the stones to fracture under repeated impacts may be called Impact test on aggregates. The test can also be carried on cylindrical stone specimen known as Page Impact test. The aggregate Impact test has been standardized by Indian Standard Institution. The aggregate impact test is conducted as per IS-2386 Part IV.

The aggregate Impact value indicates a relative measure of the resistance of aggregate to a sudden shock or an Impact, which in some aggregates differs from its resistance to a slope compressive load in crushing test. A modified Impact test is also often carried out in the case of soft aggregates to find the wet Impact value after soaking the test sample.

Various agencies have specified the maximum permissible aggregate Impact values for the different types of pavements. IRC has specified the following values.

The maximum allowable aggregate Impact value for water bound Macadam; Sub-Base coarse 50% where as cement concrete used in base course is 45%. WBM base course with Bitumen surface in should be 40%. Bituminous Macadam base course should have A.I.V. of 35%. All the surface courses should possess an A.I.V. below 30%.

PROCEDURE

1. The test sample consists of aggregates passing 12.5mm sieve and retained on 10mm sieve and dried in an oven for 4 hours at a temperature of 100 ºC to 110 ºC.
2. The aggregates are filled upto about 1/3 full in the cylindrical measure and tamped 25 times with rounded end of the tamping rod.
3. The rest of the cylindrical measure is filled by two layers and each layer being tamped 25 times.
4. The overflow of aggregates in cylindrically measure is cut off by tamping rod using it has a straight edge.
5. Then the entire aggregate sample in a measuring cylinder is weighted nearing to 0.01gm.

6. The aggregates from the cylindrical measure are carefully transferred into the cup which is firmly fixed in position on the base plate of machine. Then it is tamped 25 times.
7. The hammer is raised until its lower face is 38cm above the upper surface of aggregates in the cup and allowed to fall freely on the aggregates.
8. The test sample is subjected to a total of 15 such blows each being delivered at an interval of not less than one second.
9. The crushed aggregate is then removed from the cup and the whole of it is sieved on 2.366 mm sieve until no significant amount passes.
10. The fraction passing the sieve is weighed accurate to 0.1gm. Repeat the above steps with other fresh sample.
11. Let the original weight of the oven dry sample be w1gm and the weight of fraction passing 2.36mm I.S. sieve be W_2 gm.
12. Then aggregate Impact value is expressed as the % of fines formed in terms of the total weight of the sample.

Aggregate Impact Value = (W_2/W_1) 100 in %

OBSERVATION TABLE

Sr. No.	Details of Sample	Trial 1	Trial 2	Average
1	Total weight of aggregate sample filling the cylinder measure = W_1 gm			
2	Weight of aggregate passing 2.36 mm sieve after the test = W_2 gm			
3	Weight of aggregate retained 2.36 mm sieve after the test = W_3 gm			
4	W_1-W_2+W_3			
5	Aggregate Impact Value = (W_2/W_1)*100 %			

CALCULATIONS

RESULT

The mean Aggregate Impact Value of the aggregate is _____%.

Conclusion:

Questions:

1. Define Impact value.
2. What is the important of impact value for aggregates?

Date: …… Signature: ……

EXPERIMENT NO. 11 **DATE: ___/___/_____**

SHAPE TEST
PART- A: FLAKINESS INDEX

OBJECTIVE

To determine the flakiness Index of a given aggregates sample.

APPARATUS

The apparatus consists of a standard thickness gauge, I.S. sieves of sizes 63, 50, 40, 31.5, 25, 20, 16, 12.5, 10 and 6.3mm and a balance to weigh the samples.

MATERIAL

Aggregates of different sizes

RELATED I.S.CODE

IS-2386 (PART- I)

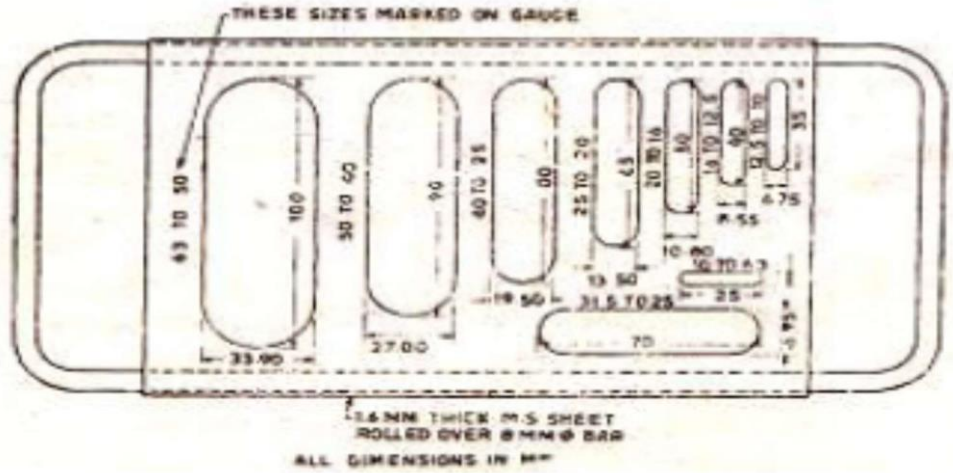

Fig 6.1 THICKNESS GAUGE

THEORETICAL BACKGROUND

Flakiness and Elongation tests are conducted on coarse aggregates to assess the shape of aggregates.

Aggregates which are flaky or elongated are detrimental to the higher workability and stability of mixes. They are not conducive to good interlocking and hence the mixes with an excess of such particles are difficult to compact to the required degree. For base coarse and construction of bituminous and cement concrete types, the presence of flaky and elongated particles are considered undesirable as they may cause inherent weakness with probabilities of breaking down under heavy loads. Rounded aggregates are preferred in cement concrete road construction as the workability of concrete improves. Angular shape of particles are desirable for granular base coarse due to increased stability derived from the better interlocking when the shape of aggregates deviates more from the spherical shape, as in the case of angular, flaky and elongated aggregates, the void content in an aggregate of any specified size increases and hence the grain size distribution of the graded aggregates has to be suitably altered in order to obtain minimum voids in the dry mix or the highest dry density. It is determined according to the procedure laid down in IS-2386 (PART- I).

FLAKINESS INDEX

The flakiness index of aggregates is the percentage by particles whose least dimension (thickness) is less than 3/5th (0.6) of their mean dimension. The test is not applicable to sizes smaller than 6.3mm.

PROCEDURE

1. The sample is sieved with the sieves mentioned in the table. A minimum of 200 pieces of each fraction to be tested are taken and weighed ($w_1$gm).

2. In order to separate flaky materials, each fraction is then gauged for thickness on thickness gauge, or in bulk on sieve having elongated slots as specified in the table.

3. Then the amount of flaky material passing the gauge is weighed to an accuracy of atleast 0.1% of test sample.

4. Let the weight of the flaky materials passing the gauge be w1gm. Similarly the weights of the fractions passing and retained on the specified sieves be w_1, w_2, w_3, etc. are weighed and the total weight $w_1+w_2+w_3+\ldots\ldots = wg$ is found. Also the weights of the

materials passing each of the specified thickness gauge are found = W_1, W_2, W_3…. and the total weight of the material passing the different thickness gauges = $W_1+W_2+W_3+$…. = W grams is found.

5. Then the flakiness index is the total weight of the flaky material passing the various thickness gauges expressed as a percentage of the total weight of the sample gauged

Flakiness Index = $(w_1+w_2+w_3+……..) /(W_1+W_2+W_3+……..) \times 100$

OBSERVATION TABLE

Size of Aggregate		Thickness Gauge (0.6 times the mean sieve), mm	Weight of the fraction consisting of atleast 200 pieces, gm	Weight of aggregates in each fraction passing thickness gauge, gm
Passing Through I.S. Sieve, mm	Retained on I.S. Sieve, mm			
63	50	33.90		
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		

CALCULATIONS

RESULT

The flakiness index of the given sample of aggregates is _____%

Conclusion:

Questions:

1. Define Flakiness Index.
2. Define Elongation Index.
3. Name the instruments used to measure them.

Date: …… Signature: ……

EXPERIMENT NO. 11 **DATE: ___/___/_____**

SHAPE TEST
PART- B: ELONGATION INDEX

OBJECTIVE

To determine the Elongation index of a given aggregates sample.

APPARATUS

Length gauge, I.S-sieves as given in the table and a balance of accuracy 0.01 gm

MATERIAL

Aggregates of different sizes

RELATED I.S.CODE

IS-2386 (PART- I)

FIGURE

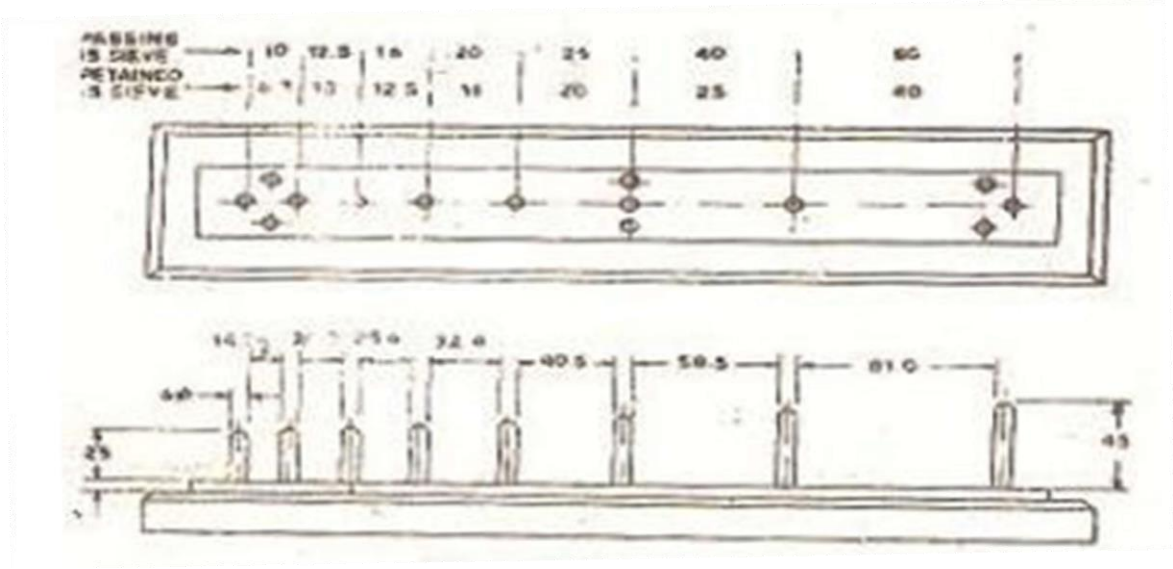

Fig 6.2 LENGTH GAUGE

THEORETICAL BACKGROUND

Refer Experiment 6 Part-A.

ELONGATION INDEX

The elongation index of an aggregate is the percentage by weight of particles whose greatest dimension (length) is greater than 1 and 4/5th times (1.8 times) their mean dimensions. The elongation test is not applicable to sizes smaller than 6.3mm.

PROCEDURE

1. The sample is sieved through I.S-sieves specified in the table. A minimum of 200 aggregate pieces of each fraction is taken and weighed.
2. Each fraction is thus gauged individually for length in a length gauge. The gauge length is used should be those specified in the table for the appropriate material.
3. The pieces of aggregates from each fraction tested which could not pass through the specified gauge length with its long side are elongated particles and they are collected separately to find the total weight of aggregate retained on the length gauge from each fraction.
4. The total amount of elongated material retained by the length gauge is weighed to an accuracy of atleast 0.1% of the weight of the test sample.
5. The weight of each fraction of aggregate passing and retained on specified sieves sizes are found W_1, W_2, W_3,…….And the total weight of sample determined = $W_1+W_2+W_3+$……..= Wg. Also the weights of material from each fraction retained on the specified gauge length are found = x_1, x_2, x_3….. and the total weight retained determined = $x_1+x_2+x_3+$ ……. = x gm.
6. 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.

$$\textbf{Elongation Index} = (x_1+x_2+x_3+\ldots\ldots..) / (W_1+W_2+W_3+\ldots\ldots..) \times 100$$

OBSERVATION TABLE

Size of Aggregate		Thickness Gauge (1.8 times the mean sieve), mm	Weight of the fraction consisting of atleast 200 pieces, gm	Weight of aggregates in each fraction retained on length gauge, gm
Passing Through I.S. Sieve, mm	Retained on I.S. Sieve, mm			
63	50	-		
50	40	81.00		
40	25	58.50		
31.5	25	-		
25	20	40.50		
20	16	32.40		
16	12.5	25.60		
12.5	10	20.20		
10	6.3	14.70		

CALCULATIONS

RESULT

The elongation index of a given sample of aggregate is _____%.

Conclusion:

Date: …… Signature: ……

EXPERIMENT NO. 11 **DATE: ___/___/_____**

SHAPE TEST
PART-C : ANGULARITY NUMBER

OBJECTIVE

To determine the Angularity Number of the given aggregate sample

APPARATUS

The apparatus consists of a metal cylinder closed at one end and of about 3 liter capacity. The diameter and height of this being approximately equal i.e., about 15.64 cm diameter and 15.64 cm height, A metal tamping rod of circular cross section 1.6 cm in diameter and 60 cm in length rounded at one end, I.S. sieves of sizes 20, 16, 5, 10, 6.3 and 4.75 mm and balance of capacity 10 kg to weigh upto 0.1 gm.

THEORETICAL BACKGROUND

The particle shape of aggregate is determined by the percentages of flaky and elongated particles contained in it. In case of gravel it is determined by its Angularity Number.

Refer Experiment 6 Part-A.

ANGULARITY NUMBER

The angularity number of an aggregate is the amount by which the percentage voids exceeds 33 after being compacted in a prescribed manner. The minimum allowable combined index of aggregates used in surface course in different types of pavement is 30%.

PROCEDURE

1. Metal cylinder is calibrated by determining the weight of water at 27ºC required filling it, so that no meniscers is present above the rim of the container.
2. The sample of single size aggregate retained between the specified pair of sieves is dried in an oven at a temperature 100ºC to 110ºC for 24 hours and cooled prior to testing.

3. The aggregates are placed in the cylinder and subjected to 100 blows of the tamping rod at a rate of about 2 blows per second.
4. Each blow is applied by holding the rod vertically with its rounded end 5cms above the surface of the aggregates and releasing it so that it falls vertically and no force is applied to the rod.
5. The process of filling and tamping is repeated exactly as described above with a second and third layer of aggregate.
6. After the third layer is tamped, the cylinder is filled to over flowing and the aggregates are struck off level with the top using a tamping rod as a straight edge.
7. The aggregate with cylinder is then weighed accurately.
8. All the above steps are repeated on another sample and averages of two are represented.
9. The angularity number is calculated from the formula,

Angularity Number = 67 – (100 W/CG)

W = Mean weight of aggregates in the cylinder, gm

C = Weight of water required in the cylinder, gm

G = Specific gravity of aggregate

OBSERVATION TABLE

Details of Sample	Trial 1	Trial 2	Average
Weight of aggregates filling the cylinder to the nearest five grams			

CALCULATIONS

RESULT

The angularity number of given aggregate sample = _____.

Conclusion:

Questions:

1. Define angularity number.
2. State role of angularity number in aggregate.

Date: …… Signature: ……

EXPERIMENT NO. 12 **DATE: ___/___/_____**

WORKABILITY OF CONCRETE

Aim: To measure the workability by slump test and compacting factor test for various w/c ratio of identical concrete mix

[A] WORKABILITY BY SLUMP TEST

Apparatus: Slump mould, steel foot rule, mixing platform, balance, taping rod

Procedure:

1. Prepare concrete mix with specified w/c ratio.
2. Place slump mould on smooth non porous plate with inside and base mould moistened to minimize the surface friction.
3. Fill the mould as 3layers of equal weight tamping each layer by 25 strokes.
4. Level the top level.
5. Lift the mould vertically so unsupported concrete will new slump.
6. Decrease in the height of highest part is known as the slump and measured to the nearest of slump.

Importance:

a) Slump test is most commonly used in construction site.
b) It does not measure all factors contributing about uniformity.
c) Too high or too low slump gives immediate warning and enable the site engineers to remedy situation.

Observation

Sr. No	W/C ratio	Slump in mm
1.	0.5	
2.	0.55	
3.	0.6	
4.	0.65	

[B] WORKABILITY BY COMPACTING FACTOR TEST

Apparatus: Balance & weight compacting factor apparatus, vibrating machine, concrete mixing machine.

Procedure:

1. Prepare the concrete mix with specified w/c ratio.
2. Fill the hopper with concrete.
3. Release the bottom door of hopper &let the concrete fall in lower hopper.
4. Now release bottom door of lower hopper & let the concrete fall in the cylinder.
5. Cut excess concrete by two flat slides cross the top.
6. Calculate the net weight of concrete is of known cylinder weight
7. Refill the sample with same amount
8. Compact it heavily is means of vibrating machine.
9. Struck of excess concrete by trowel.
10. Take Weight of the compacted concrete
11. Calculate net weight of compacted concrete in same known volume of cylinder.

Observation Table :

Sr. No.	W/C ratio	Wt. of Part. Comp. Conc. W_p (Kg)	Wt. of Fully Comp. Conc. W_f (Kg)	Comp. Factor $= \frac{W_P}{W_F}$
1.	0.5			
2.	0.55			
3.	0.6			
4.	0.65			

Conclusion :

Date: ……. Signature: .....

EXPERIMENT NO. 13 **DATE: ___/___/_____**

[A] COMPRESSIVE STRENGTH OF CONCRETE

Aim: To measure the compressive strength of concrete cube

Apparatus: Weight balance, non-porous enamel tray, compression testing machine and cube mould of size 15 cm X 15cm X 15cm

Theory: The compressive strength of the concrete is the most important and useful property. Compressive strength of concrete is also used as a qualitative measure for other properties of hardened concrete. Compressive strength increases as the specimen size decreases, whereas the modulus of elasticity decreases. Concrete containing about 6% of entrained air which is relatively weaker in strength is found to be more durable then dense and strong concrete. Strength of concrete is its resistance to rupture. It may be measured in a number of ways such as strength in compression, in tension, in shear or in flexure.

Procedure:

1. Fill concrete into the mould in layers approximately 5 cm deep by moving the scoop around the top edge of the mould as the concrete slides from it, in order to ensure a symmetrical distribution of the concrete within HIS mould
2. Compaction: If compaction is done by hand, tamp the concrete with the standard rod strokes uniformly distributed over the cross-section of the mould. For 15cm cube, no. of strokes shall not be less than 35% and 25. For cylindrical specimens no of strokes shall not be less than 30 per layer. Strokes should penetrate into the underlying layer Tamp sides of the mould to close the voids left by tamping bars.
3. If compaction is done by vibration, then each layer is compacted by means of suitable vibrating hammer or vibrator. Mode and quantum of vibration of laboratory specimen shall be as nearly same as those adopted ill actual operations.
4. Curing: Storing the specimen in a place at temperature 27°C±2°C for 24±1/2 hour from the time of addition of water to dry ingredients. Remove the specimen from the mould and keep it immediately submerged in clean, fresh water and keep there until taken out just prior to test. Water in which specimen is submerged shall be renewed every seven days.
5. Placing specimen in the machine: Place the specimen in such a manner that the load shall be applied to opposite sides of cubes as cast, i.e. not to the top and bottom. Align carefully the centre of thrust of the spherically seated platen. Apply load slowly and at the rate of 140 kg/cm^2/min. Till the cube breaks. Note down the maximum load and appearance of the concrete failure i.e. whether aggregate has broken or cement paste has separated from the aggregate.

ObservationTable:

Conclusion:

Questions:

1. Write importance of Compressive strength of concrete.
2. List instrument used to measure compressive strength.

Date: …… Signature: .....

EXPERIMENT NO. 13 **DATE: ___/___/_____**

[B FLEXURAL STRENGTH OF CONCRETE

Aim: To determine flexural strength of concrete

Apparatus: Beam mould of size 50 cm x 10 cm x 10 cm, testing machine with loading apparatus

Theory:

1. Direct tensile strength of concrete is difficult to measure.
2. Neither specimen nor testing apparatus have been designed which assume uniform distribution of the pull applied to concrete.
3. Beam tests are found to be dependable.
4. The value of modulus of rupture depends on the dimensions of beam & manner of loading.

Procedure:

1. Concrete specimen of size 50 cm x 10 cm x 10 cm is cast in metal mould. The metal should be of sufficient
2. Test specimens are stored in water before testing.
3. The bearing surface of support & rollers are wiped, cleared & any loose sand or other material is removed.
4. The specimen is placed in machine in such a manner that the load is applied to the appear most surface as cast mould along 2-lines apart at 133 mm.
5. The flexural strength of specimen is expressed as modulus of rupture (fb)

Observation Table:

Sr. No	Applied Load (kg)	Flexural Strength (kg/cm^2)	W/C ratio
1.a			
b			
c			
2.a			
b			
c			
3.a			
b			
c			

Calculation: Load P =

Moment of inertia $I = \frac{bd^3}{12}$, Now, $M = \frac{PL}{4}$, Flexural strength: $f = \frac{M \times Y}{I}$

Y = (100/2)

Results:

Conclusion:

Date: …… Signature: .....

EXPERIMENT NO. 13 **DATE: ___/___/_____**

[C] TENSILE STRENGTH OF CONCRETE

Aim: To determine tensile strength of concrete mix by Split Cylinder tensile test.

Apparatus:
1) Cylindrical mound 15 cm and 30 cm height.
2) Universal testing machine.
3) Plywood strip 25 mm wide, 3 mm thick and 300 mm long.

Theory: The test is carried out by placing a cylindrical specimen horizontally between loading surface of compressive testing machine and load is applied until failure of the cylinder along the vertical diameter takes place. The figure shows the test specimen and the stress pattern in the cylinder respectively. When the load is applied along the generation an element on the vertical diameter of the cylinder is subjected to vertical compressive stress of

$$\frac{2P}{\pi LD}\left[\frac{D^2}{r(D-r)}-1\right]$$

And horizontal compressive strength = $\frac{2p}{\pi LD}$

Where
P = Compressive load on cylinder
L = Length of cylinder
D = Diameter of cylinder r & (D-r) are the diameter of elements from two loads respectively.

The loading condition produces a high compressive stress immediately below the tow generators to which the load is applied but the larger portion corresponding to depth is subjected to uniform tensile stress acting horizontally for about 1/6 depth & remaining 5/6 depth is subjected to tension.
In order to reduce the magnitude of the high compressive stress near the point of application of load, narrow packing strip of suitable material such as plywood are placed between the specimen and loading plains of testing machine. The main advantage of this method is that the same type of specimen and same testing machine as are used for the compressive test can be employed for this test. That's why this test is gaining popularity. The splitting test is simple to perform and gives more uniform **Result** than other tension test. Determined Strength of the splitting test is believed to be closer to the true tensile strength of concrete than the rupture splitting test.

Procedure:
1. Prepare the concrete mix in proportion of---------- with designed w/c ratio_____
2. Fill the concrete mix in standard cylinder in three layers.
3. After the concrete sets, cure it for 28 days.
4. Test cylindrical specimen is placed horizontal between loading surfaces of machine and the load is applied until failure, of cylinder along vertical diameter.
5. The packing strips should be smooth enough to allow the distribution.

Observation Table:

Sr. No.	W/C ratio	Cube tensile load	Tensile strength of cube	Cylinder flexural load in kg.	Cylinder tensile strength Kg./cm^2
1.					
2.					
3.					

Calculation:

Split tensile strength $\sigma = \frac{2P}{\pi LD}$

Conclusion:

Date: …… Signature: .....