EXPERIMENT NO.7

OBJECT: To determine the Compaction Factor of M20 grade (1:1.5:3) concrete with varying w/c ratio 0.5, 0.6, 0.7 and 0.8 by weight of cement.

THEORY

The workability of concrete may be defined as the ease with which the concrete is mixed, transported, placed, compacted and finished properly. It depends on the constituents of concrete such as type of aggregates, its grading and water cement ratio. The segregation and bleeding of concrete are two different parameters which affects its workability and strength. Segregation leads to separation of coarse and fine aggregates which may be due to poor grading and low water cement ratio. It reduces the workability up to great extent. The bleeding of concrete is the result of excess water which comes out on the surface of concrete after compaction. It gets evaporated leaving behind the voids. Such concrete is spongy, having less strength and durability. However, the degree of workability for various works may be different. In thin section or in R.C. work, concrete mass should be such that it easily penetrates through the reinforcements and percolates to every corner of the section. Thus concrete with high w/c ratio is needed in such cases. On the other hand, concrete used for mass concreting, the requirements are different. Here the concrete with low w/c ratio are used.

Various methods are used for determining the workability, namely

a. Slump Test

b. Compaction Factor Test

c. Vee-Bee Test

Compaction Factor TEST: It gives the measure of workability. The amount of water needed to compact a given mass of concrete is its compact ability. Practically, the compaction factor may be defined as the ratio of the weight of partially filled concrete (concrete from hoppers) to fully compacted concrete. Its value is always less than unity. This test is more accurate than slump test and its results are suitable for low and medium workability (i.e. CF: 0.8 - 0.9). The very low workable concrete (CF ≤ 0.7) can not be fully compacted and thus this test will not be suitable. The values of compaction factor for different degree of workability are as follows:

COMPACTION FACTOR VALUE	DEGREE OF WORKABILITY	SUITABILITY OF CONCRETE
0.75 – 0.80	Very Low	Concrete of shallow section with vibration
0.80 – 0.85	Low	Concrete with lightly reinforced section with vibrations
0.85 – 0.92	Medium	Concrete with lightly reinforced section without vibrations or highly reinforced section with vibrations
0.92 - above	High	Concrete with heavily reinforced section without vibrations

Apparatus Used

- Compaction Factor apparatus
- Mixing tray
- Measuring cylinder
- Trowel
- Standard Compaction rod (16mm dia, 600 mm length and bullet point ends)

Material :

i. Cement = 3.2 Kg
ii. Coarse Sand = 4.8 Kg
iii. 10 mm aggregate = 4.0 Kg
iv. 20 mm aggregate = 5.6 Kg
v. Water = as required

PROCEDURE FOR PREPARATION OF CONCRETE:

1. Weigh accurately the required quantity of materials. First spread coarse aggregate on mixing tray and fine aggregates are evenly spread over it. The cement spread in the last. The mixture is dry mixed thoroughly and uniformly with trowel till uniform mass is obtained.
2. Add measured amount of water (according to water cement ratio) slowly in the center of concrete mass such that the water get absorbed in concrete mass. The amount of water added can be computed as follows:

a) For $\frac{W}{C}$ = 0.5 , Water = 0.5 x Cement = 0.5 x 3.2 = 1.6 liters = 1600 ml

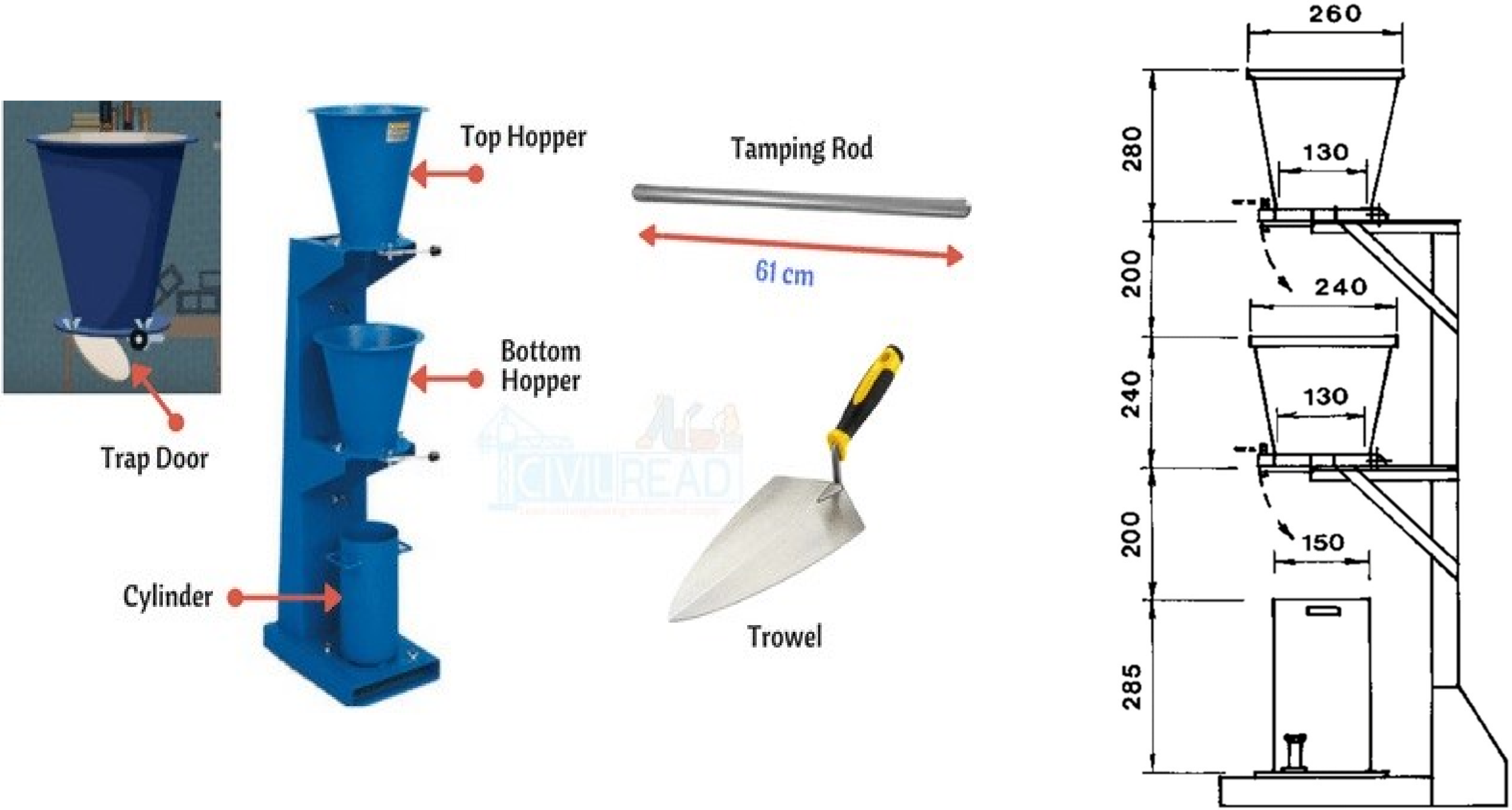
b) For $\frac{W}{C}$ = 0.6 , Water = 0.6 x Cement = 0.6 x 3.2 = 1.92 liters = 1920 ml , Therefore, for W/C = 0.5, 0.6, 0.7 and 0.8, the amount of water to be added are 1600ml, 1920ml, 2240ml and 2560ml respectively. In order to take observations for different W/C ratio, add 320ml of water in the previous concrete and note down the change in observations.

3. The calculated amount of water is added and the material mixed with trowel till uniform mix is obtained. The concrete is now ready for Compaction Factor test.

TEST PROCEDURE:

1) The Compaction Factor test equipment consists of two hoppers and a cylinder as shown in fig.
2) Take the weight of empty cylinder on a platform/ spring balance and let it be W_1.
3) The concrete as prepared above is filled in the upper hopper. While performing the test, the trap doors of both the hoppers are kept closed.
4) The trap door of the upper hopper is opened and the concrete is allowed to fall in the second hopper. This is done to bring the concrete in the "standard state of compaction". The trap door of the second hopper is also opened and the concrete is allowed to fall in the cylinder below it. Level the cylinder after removing the excess concrete over it and weigh it. The weight thus obtained is called "partially compacted concrete" and let it be W_2.
5) Take out all the concrete and refill the cylinder in four layers. Each layer is fully compacted. Level the surface and weigh it again and let it be W_3.
6) The compaction factor is defined as the ratio of weight of partially compacted concrete to fully compacted concrete and is always less than one.

$$C.F. = \frac{Weight\ of\ Partially\ compacted\ concrete}{Weight\ of\ Fully\ compacted\ concrete} = \frac{W_2 - W_1}{W_3 - W_1} < 1$$


Trap Door
Top Hopper
Bottom Hopper
Cylinder
Tamping Rod
61 cm
Trowel
260
130
240
130
150
280
200
240
200
285

OBSERVATIONS

Type of Cement = OPC/PPC

Grade of Cement = 33/43/53 Mpa

Weight of empty cylinder W_1 = 10.0 Kg

S.No.	W/C	Weight of Cylinder + Concrete from hopper W_2 Kg	Weight of Cylinder + Fully Compacted Concrete W_3 Kg	$CF = \frac{W_2 - W_1}{W_3 - W_1}$
1	0.5	20.0	23.0	
2	0.6	20.9	22.8	
3	0.7	21.5	22.9	
4	0.8	22.1	22.4	

Tests on Hardened Concrete:

Compressive Strength Test

Objective

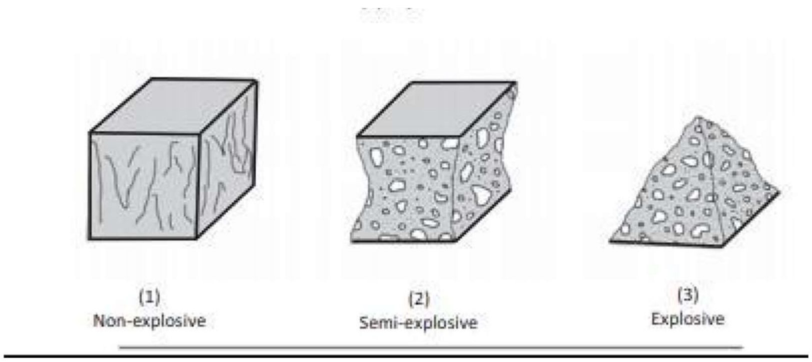
To determine the compressive strength of hardened concrete. The method is limited to concrete having a density of at least 800 kg/m3 (50 lb/ft3). The 28-day compressive strength (fc') is normally used in design.

- **Standards:** BS EN 12390-3 for cubic samples , ASTM C39 for cylindrical samples

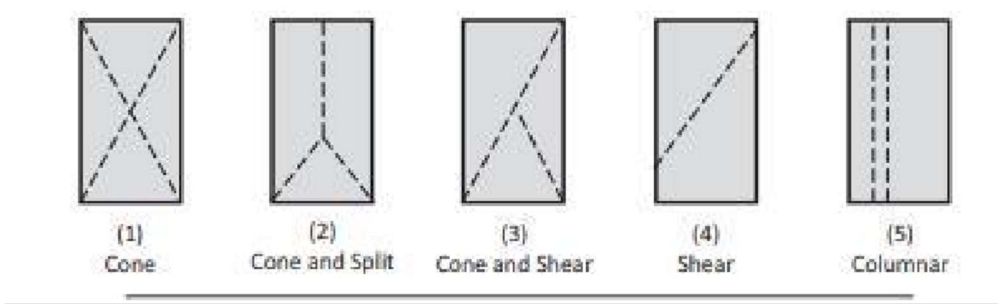
Principle:

- Strength of concrete could be defined as the ultimate load that causes failure or its resistance to rapture.
- Strength of concrete is not very directly affected by workability, but by the method of manufacture, water/cement ratio, effective water in the mix, gel/space ratio, aggregate/cement ratio, properties of coarse aggregate, curing and age of the concrete have direct effect on the strength.
- Most concrete mixes attain over 70% of their strength after 7 days and almost maximum strength after 28 days.
- Compressive strength of a concrete specimen treated in a standard manner which includes full compaction and wet curing for a specified period give results representing the potential quality of the concrete.
- The test is performed using either a concrete cube (usually 150mm × 150mm or 100mm ×100 mm) or cylinder (150mm diameter by 300mm height or 100mm diameter by 200mm height).
- Compressive strength obtained from cylinder is 0.8 times that obtained from the cube.
- There are three types of loading in compression test: *(1) Uniaxial loading* – represents the most conservative system and yields the lowest values in compression. There are three types of failure in uniaxial test; tension (splitting) failure, shear (sliding) failure, combined (tension and shear) failure. *(2) Biaxial loading* and *(3) Triaxial loading*.

Failure patterns for cubic samples :



Failure patterns for cylindrical samples:



Apparatus :

1- Balance.
2- Tools and containers for mixing.
3- Tamper (16mm dia & 600mm height) for compaction or vibrating table.
4- Testing machine.
5- Cubic samples or cylindrical samples: Three cubes (150 mm side) or (100 mm side)depending on the maximum aggregate size. Or three cylinders (150*300m) or (100*200 mm).

Materials

Concrete mix (cement, sand, gravel and water)

Test Procedure

1. Prepare a concrete mix with the proportions.
2. Prepare three testing cubes; make sure that they are clean and greased or oiled thinly.
3. Metal molds should be sealed to their base plates to prevent loss of water.
4. Fill the cubes in three layers, tamping each layer with (25) strokes using a tamper or fillthe mold completely and compact concrete using vibration table.
5. Fill the molds completely, smooth off the tops evenly, and clean up any concrete outsidethe cubes.
6. Leave the specimens in the mold for 24 hours at room temperature.
7. After that open the molds and immerse the concrete cubes in a water tanks for differentcuring periods (3, 7, or 28 days).
8. Before testing, ensure that all testing machine bearing surfaces are wiped clean.
9. Carefully center the cube on the lower platen and ensure that the load will be applied totwo opposite cast faces of the cube.
10. Apply the load continuously at a nominal rate until failure (until no greater load can be besustained).
11. Record the maximum failure load and note the failure mode.

Calculations

The measured compressive strength of the cubes shall be calculated by dividing the maximum load applied to the cubes during the test by the cross-sectional area, calculated from the mean dimensions of the section and shall be expressed to the nearest 0.5 N/mm2. In determining the compressive strength, do not consider specimens that are manifestly faulty, or that give strengths differing by more than 10 percent from the average value of all the test specimens.

1. The average 3 Days Compressive Strength of given cement sample is found to be ……..
2. The average 7 Days Compressive Strength of given cement sample is found to be ……..
3. The average 28 Days Compressive Strength of given cement sample is found to be ……..

$$\text{Compressive strength} = \frac{P}{A}$$

Where:
P: maximum failure load (average of three samples), N
A: cross section area of the sample, (mm^2)

Observation and Recording

Table 1: Recordings during Compressive Test on Concrete

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					

Graph

Draw graph between Characteristics Compressive Strength of Concrete versus Time (Days).

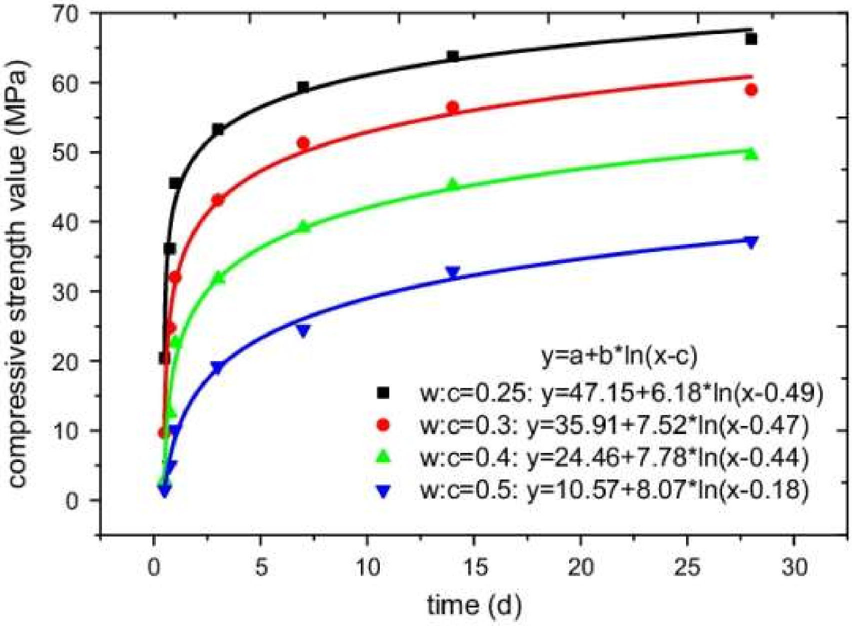


Figure: Plot of Characteristics Compressive Strength of Concrete versus Time (Days).

DETERMINATION OF AGGREGATE CRUSHING VALUE

1. AIM

1) To determine the aggregate crushing value of coarse aggregates
2) To assess suitability of aggregates for use in different types of road pavement

2. PRINCIPLE

The aggregate crushing value gives a relative measure of the resistance of an aggregate to crushing under a gradually applied compressive load. Crushing value is a measure of the strength of the aggregate. The aggregates should therefore have minimum crushing value.

3. APPARATUS

The apparatus of the aggregate crushing value test as per IS: 2386 (Part IV) – 1963 consists of:

1) A 15cm diameter open ended steel cylinder with plunger and base plate, of the general form and dimensions as shown in Fig 1.
2) A straight metal tamping rod of circular cross-section 16mm diameter and 45 to 60 cm long, rounded at one end.
3) A balance of capacity 3k, readable and accurate up to 1 g.
4) IS Sieves of sizes 12.5,10 and 2.36 mm
5) A compression testing machine capable of applying a load of 40 tonnes and which can be operated to give a uniform rate of loading so that the maximum load is reached in 10 minutes. The machine may be used with or without a spherical seating
6) For measuring the sample, cylindrical metal measure of sufficient rigidity to retain its form under rough usage and of the following internal dimensions:

   Diameter 11.5 cm

   Height 18.0 cm

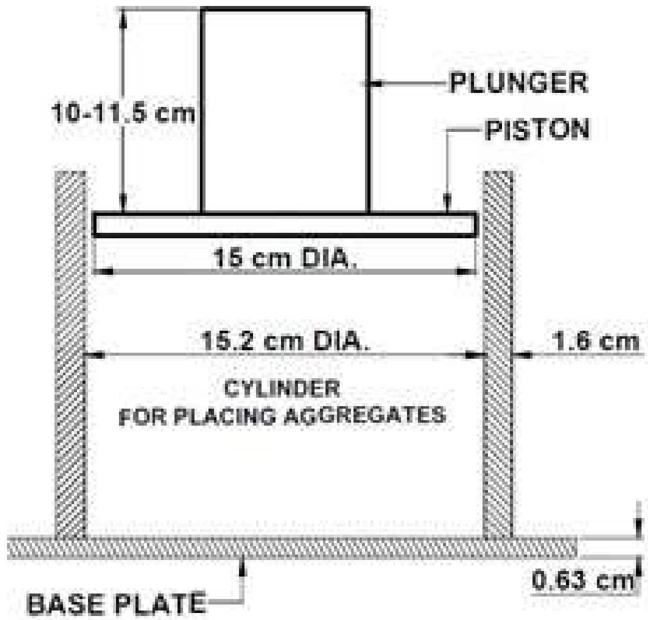


Fig 1 AGGREGATE CRUSHING TEST APPARATUS

4. PROCEDURE

The test sample: It consists of aggregates sized 12.5 mm - 10.0 mm(minimum 3kg). The aggregates should be dried by heating at 100-110° C for a period of 4 hours and cooled.

1) Sieve the material through 12.5 mm and 10.0 mm IS sieve. The aggregates passing through 12.5 mm sieve and retained on 10.0 mm sieve comprises the test material.
2) The sample shall be added to the measuring cylinder in thirds, each third being subjected to 25 strokes with the tamping rod.
3) The surface of the aggregate shall be carefully levelled.
4) Measure the sample weight W1.
5) The cylinder of the test shall be put in position on the base-plate and the test sample added in thirds, each third being subjected to 25 strokes with the tamping rod.
6) The surface of the aggregate shall be carefully levelled.
7) The plunger is inserted so that it rests horizontally on this surface, care being taken to ensure that the plunger does not jam in the cylinder
8) The apparatus, with the test sample and plunger in position, shall then be placed between the plates of the testing machine.
9) The load is applied at a uniform rate as possible so that the total load is reached in 10 minutes. The total load shall be 40 tonnes.

10) The load shall be released and the whole of the material is removed from the cylinder and sieved on 2.36mm IS Sieve.
11) The fraction passing the sieve shall be weighed and recorded W2.

5. REPORTING OF RESULTS

The mean of the two results shall be reported to the nearest whole number as the 'aggregate crushing value' of the size of the material tested.

6. RESULT

Aggregate Crushing test value =

Record of Observation

	Sample I	**Sample II**
Total weight of dry sample taken= W_1 gm		
Weight of portion passing 2.36 mm sieve= W_2 gm		
Aggregate crushing Value (per cent) = $(W_2/W_1)*100$		

Record of Observation

	Sample I	Sample II
Total weight of dry sample taken= W_1 gm		
Weight of portion passing 2.36 mm sieve= W_2 gm		
Aggregate crushing Value (per cent) = $(W_2/W_1)*100$		

Aggregate Crushing Mean Value =

DETERMINATION OF AGGREGATE IMPACT VALUE

1. AIM

1. To determine the impact value of the road aggregates
2. To assess suitability of aggregates for use in different types of road pavement

2. PRINCIPLE

The property of a material to resist impact is known as toughness. Due to movement of vehicles on the road the aggregates are subjected to impact resulting in their breaking down into smaller pieces. The aggregates should therefore have sufficient toughness to resist their disintegration due to impact. This characteristic is measured by impact value test. The aggregate impact value is a measure of resistance to sudden impact or shock, which may differ from its resistance to gradually applied compressive load.

3. APPARATUS

The apparatus of the aggregate impact value test as per IS: 2386 (Part IV) – 1963 consists of:

1. A testing machine weighing 45 to 60 kg and having a metal base with a plane lower surface of not less than 30 cm in diameter. It is supported on level and plane concrete floor of minimum 45 cm thickness. The machine should also have provisions for fixing its base.
2. A cylindrical steel cup of internal diameter 102 mm, depth 50 mm and minimum thickness 6.3 mm.
3. A metal hammer p weighing 13.5 to 14.0 kg the lower end is cylindrical in shape, is 50 mm long, 100.0 mm in diameter, with a 2 mm chamfer at the lower edge and case hardened. The hammer should slide freely between vertical guides and be concentric with the cup. The free fall of the hammer should be within 380 ± 5 mm.
4. A cylindrical metal measure having internal diameter of 75 mm and depth 50 mm for measuring aggregates.
5. Tamping rod 10 mm in diameter and 230 mm long, rounded at one end.
6. A balance of capacity not less than 500 g, readable and accurate up to 0.1 g.

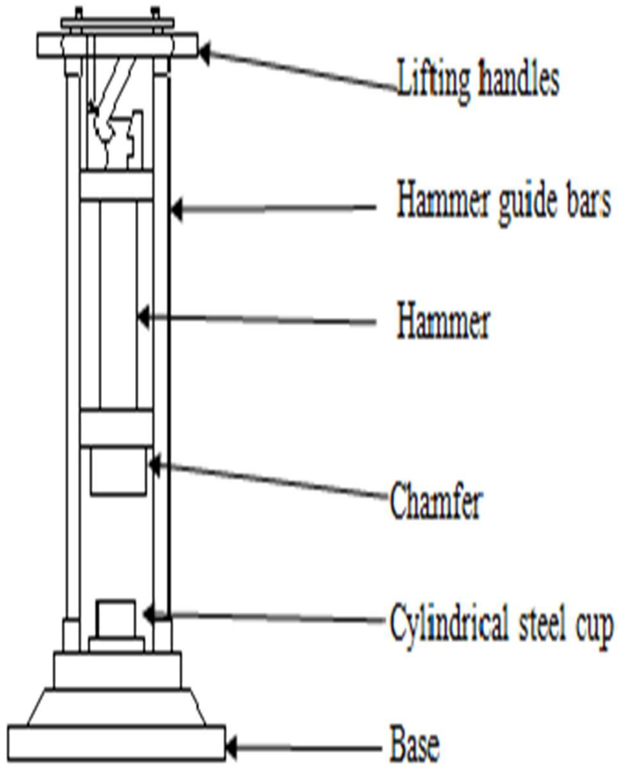


Fig 2 AGGREGATE IMPACT TESTING MACHINE

4. PROCEDURE

The test sample: It consists of aggregates sized 12.5 mm - 10.0 mm. The aggregates should be dried by heating at 100-110^{o} C for a period of 4 hours and cooled.

1. Sieve the material through 12.5 mm and 10.0 mm IS sieve. The aggregates passing through 12.5 mm sieve and retained on 10.0 mm sieve comprises the test material.
2. Pour the aggregates to fill about 1/3rd depth of measuring cylinder.
3. Compact the material by giving 25 gentle blows with the rounded end of the tamping rod.
4. Add two more layers in similar manner, so that cylinder is full.
5. Strike off the surplus aggregates.
6. Determine the net weight of the aggregates to the nearest gram (W).

7. Bring the impact machine to rest without wedging or packing up on the level plate, block or floor, so that it is rigid and the hammer guide columns are vertical.
8. Fix the cup firmly in position on the base of machine and place whole of the test sample in it and compact by giving 25 gentle strokes with tamping rod.
9. Raise the hammer until its lower face is 380 mm above the surface of the aggregate sample in the cup and allow it to fall freely on the aggregate sample.
   Give 15 such blows at an interval of not less than one second between successive falls.
10. Remove the crushed aggregate from the cup and sieve it through 2.36 mm IS sieves until no further significant amount passes in one minute. Weigh the fraction passing the sieve to an accuracy of 1 gm (W_2). Also weigh the fraction retained in the sieve.
11. Note down the observations in the Performa and compute the aggregate impact value. The mean of two observations, rounded to nearest whole number is reported as the Aggregate Impact Value.

5. PRECAUTIONS

1) Place the plunger centrally so that it falls directly on the aggregate sample and does not touch the walls of the cylinder in order to ensure that the entire load is transmitted on to the aggregates.
2) In the operation of sieving the aggregates through 2.36 mm sieve the sum of weights of fractions retained and passing the sieve should not differ from the original weight of the specimen by more than 1 gm.
3) The tamping is to be done properly by gently dropping the tamping rod and not by hammering action. Also the tampering should be uniform over the surface of the aggregate taking care that the tamping rod does not frequently strike against the walls of the mold.

6. REPORTING OF RESULTS

The mean of the two results shall be reported to the nearest whole number as the aggregate impact value of the tested material.

Aggregate impact value is used to classify the stones in respect of their toughness property as indicated below in Table 1.

Table 1: Classification of aggregate based on aggregate impact value

Aggregate impact value (%)	Quality of aggregate
< 10	Exceptionally strong
10 – 20	Strong
20 – 30	Satisfactory for road surfacing
>35	Weak for road surfacing

Table 2: Maximum allowable impact values of aggregate in different types of Pavement material/ layers

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

7. RESULT

Aggregate impact test value =

Record of Observation

	Sample I	**Sample II**
Total weight of dry sample taken= W_1 gm		
Weight of portion passing 2.36 mm sieve= W_2 gm		
Aggregate impact = $(W_2/W_1)*100$ Value (per cent)		

Aggregate Impact Mean Value =

Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregateby Abrasion and Impact in the Los Angeles Machine

ASTM C 131-03

Scope:

This test method covers a procedure for testing sizes of coarse aggregate smaller than 37.5 mm for resistance to degradation using the Los Angeles testing machine.

Apparatus

1) Los Angeles Testing Machine as shown in Figure (1).
2) Sieves
3) Balance accurate to 0.5 gm.
4) Oven.
5) Containers.
6) Abrasive charge in accordance with Table 1. The Charge must consist of steel spheres averaging (46.8mm) in diameter and each weighing between 390 to 445gm.

Procedure

1) Obtain the field sample in accordance with Practice D 75.
2) Reduce the field sample to adequate sample size in accordance with Practice C 702.
3) Wash the reduced sample and oven dry at 110±5°C to substantially constant mass.
4) Separate into individual size fractions.
5) Recombine to the grading of Table (2).
6) Record the mass of the sample prior to test to the nearest 1 g.
7) Place the test sample and the charge in the Los Angeles testing machine and rotate the machine at a speed of 30 to 33 r/min for 500 revolutions.
8) After the prescribed number of revolutions, discharge the material from the machine.
9) Make a preliminary separation of the sample on a sieve coarser than the 1.70 mm sieve.
10) Sieve the finer portion on a 1.70 mm sieve.
11) Wash the material coarser than the 1.70 mm sieve.
12) Oven-dry at 110±5°C to substantially constant mass
13) Determine the mass to the nearest 1 g.

Calculation

Calculate the difference between the original mass and that retained on the 1.7 mm sieve. Express that value as a percentage of the original mass of the sample test. This value is considered as the percent loss.

$$\%\,loss = \frac{original\ mass - \ mass\ retained\ on\ 1.7\ mm\ \ sieve}{original\ mass} \times 100$$

Note:

ASTM Specifications C33-13 requires that the abrasion percent should not exceed 50% for coarse aggregate used in concrete mixes.

TABLE (1) Abrasive Charge

Grading	Number of Spheres	Weight of Charge in Grams
A	12	5000 ± 25
B	11	4584 ± 25
C	8	3330 ± 20
D	6	2500 ± 15

TABLE (2) Grading of Test Samples

Sieve Size (Square Openings)		Mass of Indicated Sizes, g			
Passing	Retained on	Grading			
		A	B	C	D
37.5 mm (1½ in.)	25.0 mm (1 in.)	1 250 ± 25	...	...	...
25.0 mm (1 in.)	19.0 mm (¾ in.)	1 250 ± 25	...	...	...
19.0 mm (¾ in.)	12.5 mm (½ in.)	1 250 ± 10	2 500 ± 10	...	...
12.5 mm (½ in.)	9.5 mm (⅜ in.)	1 250 ± 10	2 500 ± 10	...	...
9.5 mm (⅜ in.)	6.3 mm (¼ in.)	...	...	2 500 ± 10	...
6.3 mm (¼ in.)	4.75-mm (No. 4)	...	...	2 500 ± 10	...
4.75-mm (No. 4)	2.36-mm (No. 8)	...	...	...	5 000 ± 10
Total		5 000 ± 10	5 000 ± 10	5 000 ± 10	5 000 ± 10

FIGURE (1) Los Angeles Machine

MATERIALS FINER THAN No. 200 (75 µm) SIEVE IN MINERAL AGGREGATES BY WASHING

AASHTO T 11

SCOPE

Aggregates are used in all phases of highway construction from bases, pavement mix, granular shoulders, and granular surfacing, as well as, erosion control. In order to ensure the aggregate performs as intended for the specific use, a variety of tests must be performed on the aggregate. One such test is determining materials finer than No. 200 (75 µm) sieve in mineral aggregates by washing. Fine materials such as clay particles or water soluble particles removed by washing, can cling to larger particles and do not dislodge readily. This test washes the fine particles through the No. 200 (75 µm) sieve to give an accurate determination of fine materials in the sample. The determination of minus No. 200 (75 µm) material is used to compare material performance with gradation specifications, and indirectly to gauge such properties as plasticity, permeability, and soils classifications. Such knowledge helps in determining whether a material is frost susceptible or not, and whether permeability (measurement of material capacity to allow water flow through the aggregate) will be affected.

SUMMARY OF TEST

A known amount of material is placed in a wash container and covered with water, agitated to suspend the fine size particles in the water, and then poured through a No. 200 (75 µm) sieve (Figure 1). After thorough rinsing, the portion remaining on the No. 200 (75 µm) sieve is transferred to a pan, dried and weighed. The percentage passing through the No. 200 (75 µm) sieve is then calculated.

Figure 1
Fines suspended in the water are washed over a
No. 8 (2.36 mm) and a No. 200 (75 µm) sieve

Apparatus

Balance, general purpose G_2 (AASHTO M231).

Sieves, a No. 8 (2.36 mm) or No. 16 (1.18 mm) and a No. 200 (75 µm).

Container, of sufficient size to properly agitate the sample without losing material.

Oven, capable of maintaining a temperature of 230 ± 9°F (110 ± 5°C). When tests are performed in the field where ovens are not available, test samples may be dried in suitable containers over an open flame or electric hot plates with sufficient stirring to prevent overheating.

Wetting agent, dispersing material such as dish washing soap.

Sample Preparation

Determine the proper dried sample weight from Table 1 based on the nominal maximum size of the sample to be tested. If the sample is to be tested for gradation in accordance with AASHTO T 27, the minimum weight of that test method shall apply. If the sample is not tested for gradation in accordance with AASHTO T 27 and the nominal maximum size of aggregate to be tested is not listed in Table 1, the next larger size shall be used to determine the sample size.

Table 1-Sample Weight Requirements

Nominal Maximum Size in. (mm)	Minimum Weight of Sample (gm)
No. 4 (4.75 mm)	300
3/8 in.(9.5 mm)	1000
3/4 in.(19.0 mm)	2500
1 1/2 (37.5 mm)	5000

Procedure

1. Dry sample to a constant weight. Record this as the dry weight of the material to the nearest 0.1 g. Allow sample to air cool until cool to the touch.

2. Place sample into a wash container large enough to permit mixing the sample with water (Figure 2). Cover the sample with water (and optionally, at the discretion of the technician, add a small amount of wetting agent) and agitate the sample with sufficient movement so that the particles finer than the No. 200 (75 µm) sieve become suspended in the water. Stirring and agitating the sample may be necessary and may be accomplished with any stirring or agitating instrument. Care should be taken not to lose any portion of the sample or the fines suspended in the water.

Figure 2
Washing Sample

3. Pour the water with the suspended fines through a No. 200 (75 µm) sieve (Figure 3). Occasionally inspect the No. 200 (75 µm) sieve for cracks along the seam or holes in the screen, as any imperfections will effect the final wash sieve results. Take care to pour only the water with suspended fines and not the sample itself, since samples with larger size aggregates might damage or clog the fine screen on the No. 200 (75 µm) sieve (Figure 3). Nesting sieves with larger openings a No. 8 (2.36 mm), or a No. 16 (1.18 mm) above the No. 200 (75 µm) sieve might help to prevent inadvertent clogging.

Figure 3
Pouring Water through Sieves

4. Continue washing the sample with additional water and agitate until a majority of the fines suspended in the water have been washed through. When the washed sample is near completion, the water should be relatively clear compared with the initial water color of the wash sample. If you can see the sample beneath the water, then the sample is probably adequately washed.

5. Give the sample a final rinse, pouring as much of the remaining water as possible out of the sample and into the No. 200 (75 µm) sieve. Put the sample remaining in the washing bowl into a pan for oven drying.

6. Any suspended fines remaining on the No. 200 (75 µm) sieve must be included in the sample for drying. Rinsing any suspended fines to one side of the sieve (Figure 4) and then tapping those fines into the pan is one way of accomplishing this. Be sure to include all fines suspended on the No. 200 (75 µm) sieve in the final sample for drying.

Figure 4
Material Retained on the No. 200 (75µm) sieve

A rinsing bottle (Figure 5) may be used to remove the fines sticking to the No. 200 (75 µm) sieve once the sample has been washed.

Figure 5
Rinsing Fines on No. 200 (75µm) Sieve

7. Place the washed sample into an oven set at 230 ± 9°F (110 ± 5°C), into an electric skillet, or onto an open flame and dry to a constant weight. Record the dry weight.

Calculations

Calculate the total % passing the No. 200 (75 µm) sieve (A) by dividing the difference of the original dry sample weight (B) and the weight of sample after washing and drying (C) to a constant weight by the original dry sample weight (B) and multiplying by 100.

$$A = \frac{(B - C)}{B} \times 100$$

Where: A = Total % passing No. 200 (75 µm) sieve
B = Original dry weight of sample (gms), and
C = Dry weight of sample after washing and drying to constant weight (gms)

Example

B = 532.2 gms
C = 521.6 gms
Formula: $$A = \frac{(B - C)}{B} \times 100$$

$$A = \frac{(532.3 - 521.6)}{532.3} \times 100$$

A = 2.0%

Report the percentage of material finer than the No. 200 (75 µm) sieve to the nearest 0.1%.

Standard Test Method for Slump of Hydraulic-Cement Concrete

ASTM C 143/143M-15

Scope:

This test method covers determination of slump of freshly mixed hydraulic-cement concrete, both in the laboratory and in the field.

Summary of Test Method

A sample of freshly mixed concrete is placed and compacted by rodding in a mold shaped as the frustum of a cone. The mold is raised, and the concrete allowed to subside. The vertical distance between the original and displaced position of the center of the top surface of the concrete is measured and reported as the slump of the concrete.

Apparatus:

1) Weights and weighing device.
2) Tools and containers for mixing, or concrete mixer.
3) Tamper (16 mm in diameter and 600 mm length)
4) Ruler
5) Scoop
6) Slump cone which has the shape of a frustum of a cone with the following dimensions:
   Base diameter 200 mm
   Top diameter 100 mm
   Height 300 mm
   Materials thickness at least 1.6 mm

Procedure:

1) Prepare a clean, wide, flat mixing pan.
2) Place the dampened slump cone on one side of the pan. It shall be held firmly in place during filling by the operator standing on the two-foot pieces.
3) Place the newly mixed concrete in three layers, each approximately one third the volume of the mold.
4) In placing each scoopful of concrete, move the scoop around the top edge of the mold as the concrete slides from it, in order to ensure symmetrical distribution of concrete within the mold.
5) Rod each layer with 25 strokes of the tamper, distribute the strokes in a uniform manner over the cross section of the mold, each stroke just penetrating into the underlying layer.
6) For the bottom layer this will necessitate inclining the rod slightly and making approximately half of the strokes spirally toward the center. Rod the bottom layer throughout its depth.
7) In filling and rodding the top layer, heap the concrete above the mold before rodding is

started.

8) After rodding the top layer, strike off the surface of the concrete with a trowel, leaving the mold exactly filled.
9) While filling and rodding, be sure that the mold is firmly fixed by feet and can't move.
10) Clean the surface of the base outside the cone of any excess concrete. Then immediately remove the mold from the concrete by raising it slowly in a vertical direction.
11) Measure the slump immediately by determining the difference between the height of the mold and the height of the vertical axis (not the maximum height) of the specimen.
12) Clean the mold and the container thoroughly immediately after using.
13) If the pile topples [when raising the mold out of concrete] sideways, it indicates that the materials have not been uniformly distributed in the mold and the test should be remade.

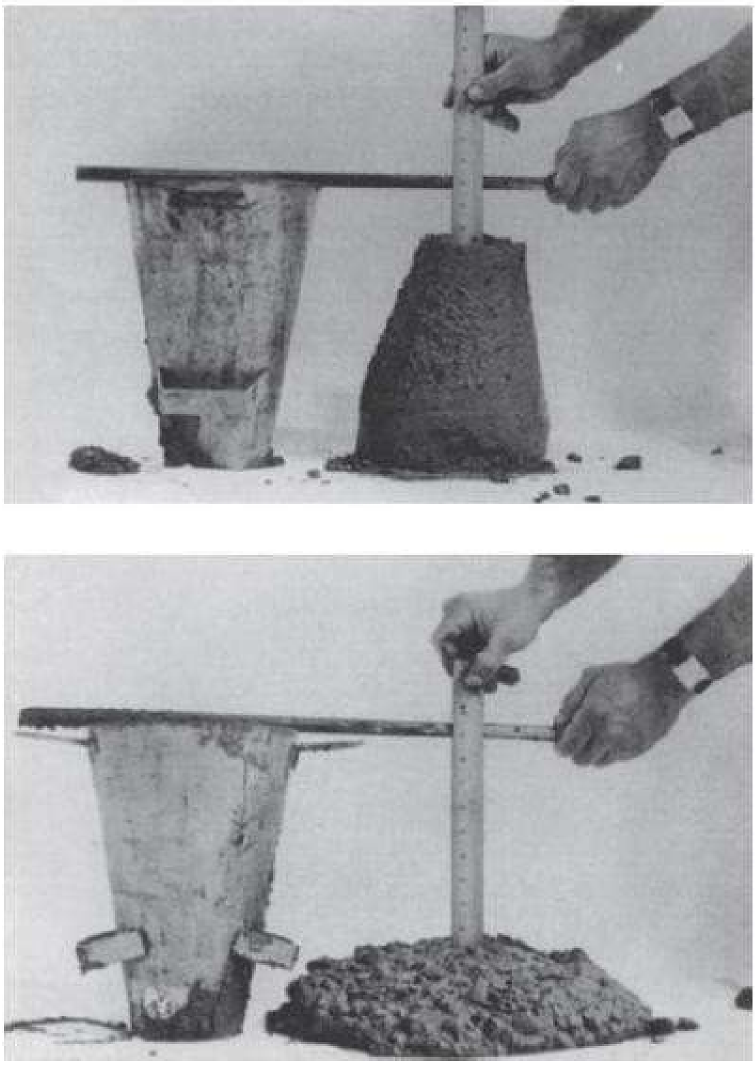
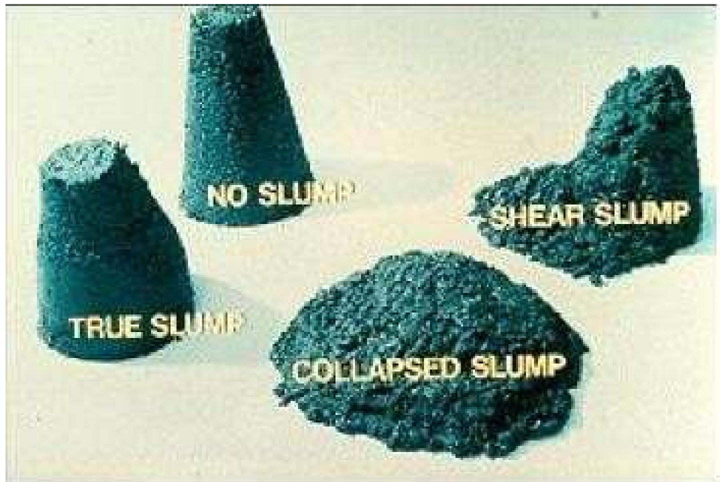


FIGURE (1): Demonstration of the use of a slump cone. The top photographillustrates a low slump and the bottom a high slump



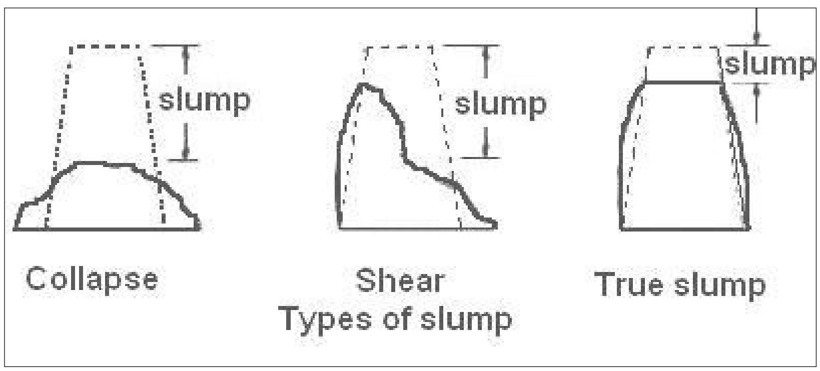


FIGURE (2): Different possible slump test results

The consistency is expressed using five descriptions due to the slump value as shown in the table below.

Slump (mm)	0-20	10-40	30-120	100-200	180-220
Consistency	Dry	Stiff	Plastic	Wet	Sloppy

Actual mixes weights

Actual Mix. No.	w/c ratio	Cement (kg)	Sand (kg)	Gravel (kg)	Water (L)
I	0.5	300	800	1200	150
II	0.5	400	800	1200	200
III	0.6	400	800	1200	240
IV	0.7	400	800	1200	280

Equivalent laboratory mixes weights

Lab. Mix. No.	w/c ratio	Cement (gm)	Sand (gm)	Gravel (gm)	Water (mL)
I	0.5	2250	6000	9000	1125
II	0.5	3000	6000	9000	1500
III	0.6	3000	6000	9000	1800
IV	0.7	3000	6000	9000	2100

Specific Gravity and Absorption of Coarse Aggregate (ASTM Designation C 127)

Scope:

This test method covers the determination of relative density (specific gravity) and the absorption of coarse aggregates. The relative density (specific gravity), a dimensionless quantity, is expressed as oven-dry (OD), saturated-surface-dry (SSD), or as apparent relative density (apparent specific gravity). The OD relative density is determined after drying the aggregate. The SSD relative density and absorption are determined after soaking the aggregate in water for a prescribed duration.

Apparatus:

1) Balance, which shall be equipped with suitable apparatus for suspending the sample container in water from the center of the platform or pan of the balance.

2) Sample Container, a wire basket of 3.35 mm (No. 6) or finer mesh, with a capacity of 4 to 7 L for 37.5-mm nominal maximum size aggregate or smaller.
3) Water Tank, into which the sample container is placed while suspended below the balance.
4) Sieves, A 4.75-mm (No. 4) sieve.
5) Oven, of sufficient size.

Materials:

5 kg of coarse aggregates where the nominal maximum size is 37.5 mm (11/2 in.) or less and all material is retained on the 4.75 mm (No.4) sieve

Procedure:

1) Select by quartering or use of a sample splitter approximately 5 kg of aggregate. Reject all material passing a No. 4 sieve.

2) Thoroughly wash the sample to remove all dust or other coatings from the particles. **3)** Dry the sample to a constant mass at a temperature of 110±5°C.

4) Cool in air at room temperature for 1 to 3h to a temperature that is comfortable to handle.

5) Immerse the aggregate in water at room temperature for a period of 24±4 h.

6) Remove the test sample from the water and roll it in a large absorbent cloth until all visible films of water are removed. Wipe the larger particles individually.

7) Determine the mass of the test sample in the saturated surface-dry condition (B) to the nearest 0.5 g.

8) After determining the mass in air, immediately place the saturated-surface-dry test sample in the sample container and determine its apparent mass (C) in water at 23±6 2.0 °C.

9) Dry the test sample in the oven to constant mass at a temperature of 110±5 °C, cool in air at room temperature 1 to 3 h to a temperature that is comfortable to handle.

10) Determine the oven-dry mass of the sample (A).

Calculations:

Bulk Specific Gravity (oven-dry) $= = \frac{A}{B-C}$

Bulk Specific Gravity (SSD) $= \frac{B}{B-C}$

Apparent Specific Gravity $= \frac{A}{A-C}$

Absorption % $= \frac{(B-A)}{A} \times 100$

Where;

A = Mass of oven-dry test sample in air, g.

B = Mass of saturated-surface-dry test sample in air, g.

C = Apparent mass of saturated test sample in water, g.

Example

If the following data have been obtained using specific gravity and absorption test of coarse aggregate:

Mass of oven-dry test sample in air: 2958 g.

Mass of saturated-surface-dry test sample in air: 2994 g.

Apparent mass of saturated test sample in water: 1905 g.

Calculate the following:

1) Bulk Specific Gravity (OD)
2) Bulk Specific Gravity (SSD)
3) Apparent Specific Gravity
4) Absorption %

Solution

Bulk Specific Gravity (OD) $= \frac{A}{B-C} = \frac{2958}{2994-1905} = 2.72$

Bulk Specific Gravity $(SSD) = \frac{B}{B-C} = \frac{2994}{2994-1905} = 2.75$

Apparent Specific Gravity $= \frac{A}{A-C} = \frac{2958}{2958-1905} = 2.81$

Absorption, % $= \frac{(B-A)}{A} \times 100 = \frac{2994-2958}{2958} \times 100 = 1.22\%$

EXPERIMENT NO.7

OBJECT: To determine the Compaction Factor of M20 grade (1:1.5:3) concrete with varying w/c ratio 0.5, 0.6, 0.7 and 0.8 by weight of cement.

THEORY

The workability of concrete may be defined as the ease with which the concrete is mixed, transported, placed, compacted and finished properly. It depends on the constituents of concrete such as type of aggregates, its grading and water cement ratio. The segregation and bleeding of concrete are two different parameters which affects its workability and strength. Segregation leads to separation of coarse and fine aggregates which may be due to poor grading and low water cement ratio. It reduces the workability up to great extent. The bleeding of concrete is the result of excess water which comes out on the surface of concrete after compaction. It gets evaporated leaving behind the voids. Such concrete is spongy, having less strength and durability. However, the degree of workability for various works may be different. In thin section or in R.C. work, concrete mass should be such that it easily penetrates through the reinforcements and percolates to every corner of the section. Thus concrete with high w/c ratio is needed in such cases. On the other hand, concrete used for mass concreting, the requirements are different. Here the concrete with low w/c ratio are used.

Various methods are used for determining the workability, namely

a. Slump Test
b. Compaction Factor Test
c. Vee-Bee Test

Compaction Factor TEST: It gives the measure of workability. The amount of water needed to compact a given mass of concrete is its compact ability. Practically, the compaction factor may be defined as the ratio of the weight of partially filled concrete (concrete from hoppers) to fully compacted concrete. Its value is always less than unity. This test is more accurate than slump test and its results are suitable for low and medium workability (i.e. CF: 0.8 - 0.9). The very low workable concrete (CF ≤ 0.7) can not be fully compacted and thus this test will not be suitable. The values of compaction factor for different degree of workability are as follows:

COMPACTION FACTOR VALUE	DEGREE OF WORKABILITY	SUITABILITY OF CONCRETE
0.75 – 0.80	Very Low	Concrete of shallow section with vibration
0.80 – 0.85	Low	Concrete with lightly reinforced section with vibrations
0.85 – 0.92	Medium	Concrete with lightly reinforced section without vibrations or highly reinforced section with vibrations
0.92 - above	High	Concrete with heavily reinforced section without vibrations

Apparatus Used

- Compaction Factor apparatus
- Mixing tray
- Measuring cylinder
- Trowel
- Standard Compaction rod (16mm dia, 600 mm length and bullet point ends)

Material :

i. Cement = 3.2 Kg

ii. Coarse Sand = 4.8 Kg

iii. 10 mm aggregate = 4.0 Kg

iv. 20 mm aggregate = 5.6 Kg

v. Water = as required

PROCEDURE FOR PREPARATION OF CONCRETE:

1. Weigh accurately the required quantity of materials. First spread coarse aggregate on mixing tray and fine aggregates are evenly spread over it. The cement spread in the last. The mixture is dry mixed thoroughly and uniformly with trowel till uniform mass is obtained.
2. Add measured amount of water (according to water cement ratio) slowly in the center of concrete mass such that the water get absorbed in concrete mass. The amount of water added can be computed as follows:

a) For $\frac{W}{C}$ = 0.5 , Water = 0.5 x Cement = 0.5 x 3.2 = 1.6 liters = 1600 ml

b) For $\frac{W}{C}$ = 0.6 , Water = 0.6 x Cement = 0.6 x 3.2 = 1.92 liters = 1920 ml , Therefore, for W/C = 0.5, 0.6, 0.7 and 0.8, the amount of water to be added are 1600ml, 1920ml, 2240ml and 2560ml respectively. In order to take observations for different W/C ratio, add 320ml of water in the previous concrete and note down the change in observations.

3. The calculated amount of water is added and the material mixed with trowel till uniform mix is obtained. The concrete is now ready for Compaction Factor test.

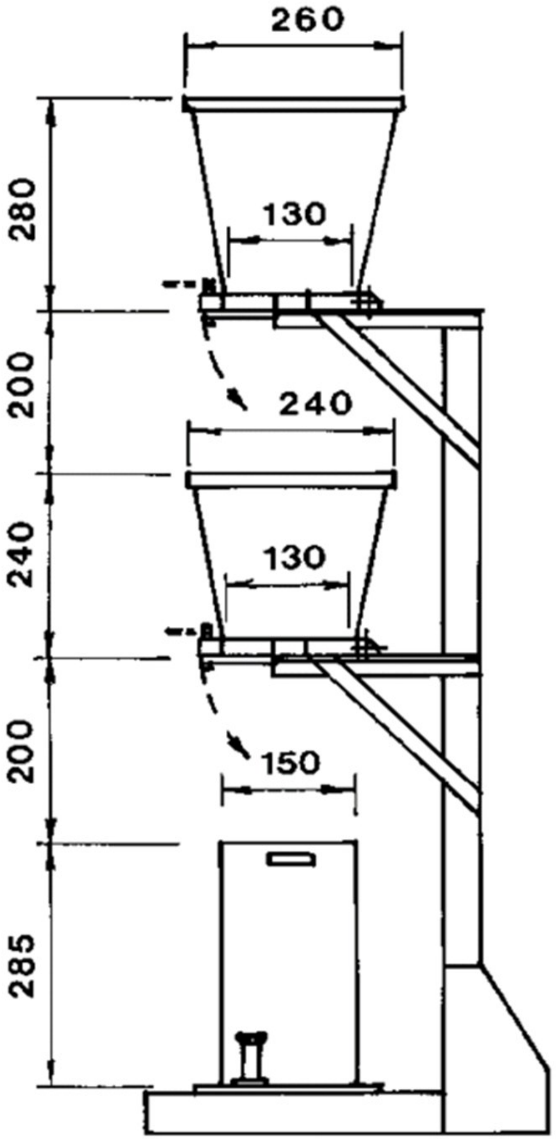
TEST PROCEDURE:

1) The Compaction Factor test equipment consists of two hoppers and a cylinder as shown in fig.
2) Take the weight of empty cylinder on a platform/ spring balance and let it be W_1.
3) The concrete as prepared above is filled in the upper hopper. While performing the test, the trap doors of both the hoppers are kept closed.
4) The trap door of the upper hopper is opened and the concrete is allowed to fall in the second hopper. This is done to bring the concrete in the "standard state of compaction". The trap door of the second hopper is also opened and the concrete is allowed to fall in the cylinder below it. Level the cylinder after removing the excess concrete over it and weigh it. The weight thus obtained is called "partially compacted concrete" and let it be W_2.
5) Take out all the concrete and refill the cylinder in four layers. Each layer is fully compacted. Level the surface and weigh it again and let it be W_3.
6) The compaction factor is defined as the ratio of weight of partially compacted concrete to fully compacted concrete and is always less than one.

$$C.F. = \frac{Weight\ of\ Partially\ compacted\ concrete}{Weight\ of\ Fully\ compacted\ concrete} = \frac{W_2 - W_1}{W_3 - W_1} < 1$$


Top Hopper
Bottom Hopper
Trap Door
Cylinder


Tamping Rod
61 cm
Trowel


260
130
240
130
150
280
200
240
200
285

OBSERVATIONS

Type of Cement = OPC/PPC

Grade of Cement = 33/43/53 Mpa

Weight of empty cylinder W_1 = 10.0 Kg

S.No.	W/C	Weight of Cylinder + Concrete from hopper W_2 Kg	Weight of Cylinder + Fully Compacted Concrete W_3 Kg	$CF = \frac{W_2 - W_1}{W_3 - W_1}$
1	0.5	20.0	23.0	
2	0.6	20.9	22.8	
3	0.7	21.5	22.9	
4	0.8	22.1	22.4	

Tests on Hardened Concrete:

Compressive Strength Test

Objective

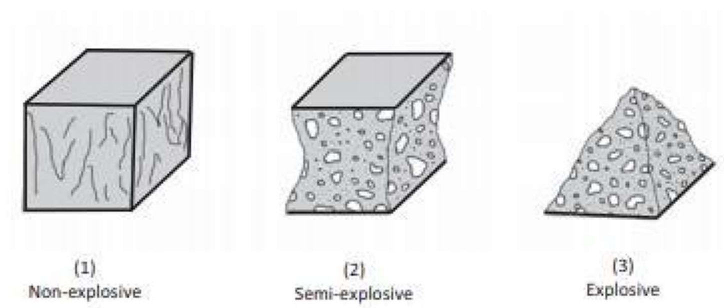
To determine the compressive strength of hardened concrete. The method is limited to concrete having a density of at least 800 kg/m3 (50 lb/ft3). The 28-day compressive strength (fc') is normally used in design.

- **Standards:** BS EN 12390-3 for cubic samples , ASTM C39 for cylindrical samples

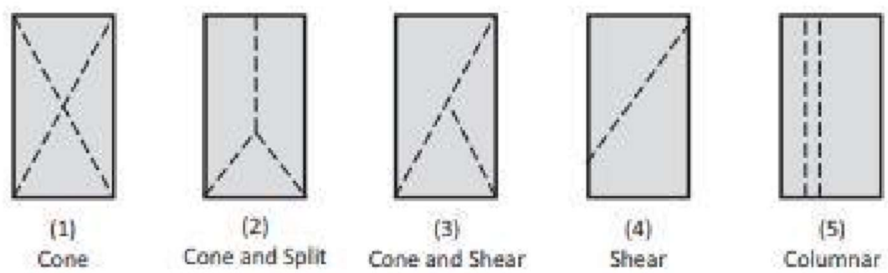
Principle:

- Strength of concrete could be defined as the ultimate load that causes failure or its resistance to rapture.
- Strength of concrete is not very directly affected by workability, but by the method of manufacture, water/cement ratio, effective water in the mix, gel/space ratio, aggregate/cement ratio, properties of coarse aggregate, curing and age of the concrete have direct effect on the strength.
- Most concrete mixes attain over 70% of their strength after 7 days and almost maximum strength after 28 days.
- Compressive strength of a concrete specimen treated in a standard manner which includes full compaction and wet curing for a specified period give results representing the potential quality of the concrete.
- The test is performed using either a concrete cube (usually 150mm × 150mm or 100mm ×100 mm) or cylinder (150mm diameter by 300mm height or 100mm diameter by 200mm height).
- Compressive strength obtained from cylinder is 0.8 times that obtained from the cube.
- There are three types of loading in compression test: *(1) Uniaxial loading* – represents the most conservative system and yields the lowest values in compression. There are three types of failure in uniaxial test; tension (splitting) failure, shear (sliding) failure, combined (tension and shear) failure. *(2) Biaxial loading* and *(3) Triaxial loading*.

Failure patterns for cubic samples :



Failure patterns for cylindrical samples:



Apparatus :

1- Balance.
2- Tools and containers for mixing.
3- Tamper (16mm dia & 600mm height) for compaction or vibrating table.
4- Testing machine.
5- Cubic samples or cylindrical samples: Three cubes (150 mm side) or (100 mm side)depending on the maximum aggregate size. Or three cylinders (150*300m) or (100*200 mm).

Materials

Concrete mix (cement, sand, gravel and water)

Test Procedure

1. Prepare a concrete mix with the proportions.
2. Prepare three testing cubes; make sure that they are clean and greased or oiled thinly.
3. Metal molds should be sealed to their base plates to prevent loss of water.
4. Fill the cubes in three layers, tamping each layer with (25) strokes using a tamper or fillthe mold completely and compact concrete using vibration table.
5. Fill the molds completely, smooth off the tops evenly, and clean up any concrete outsidethe cubes.
6. Leave the specimens in the mold for 24 hours at room temperature.
7. After that open the molds and immerse the concrete cubes in a water tanks for differentcuring periods (3, 7, or 28 days).
8. Before testing, ensure that all testing machine bearing surfaces are wiped clean.
9. Carefully center the cube on the lower platen and ensure that the load will be applied totwo opposite cast faces of the cube.
10. Apply the load continuously at a nominal rate until failure (until no greater load can be besustained).
11. Record the maximum failure load and note the failure mode.

Calculations

The measured compressive strength of the cubes shall be calculated by dividing the maximum load applied to the cubes during the test by the cross-sectional area, calculated from the mean dimensions of the section and shall be expressed to the nearest 0.5 N/mm2. In determining the compressive strength, do not consider specimens that are manifestly faulty, or that give strengths differing by more than 10 percent from the average value of all the test specimens.

1. The average 3 Days Compressive Strength of given cement sample is found to be ……..
2. The average 7 Days Compressive Strength of given cement sample is found to be ……..
3. The average 28 Days Compressive Strength of given cement sample is found to be ……..

$$\text{Compressive strength} = \frac{P}{A}$$

Where:
P: maximum failure load (average of three samples), N
A: cross section area of the sample, (mm^2)

Observation and Recording

Table 1: Recordings during Compressive Test on Concrete

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					

Graph

Draw graph between Characteristics Compressive Strength of Concrete versus Time (Days).

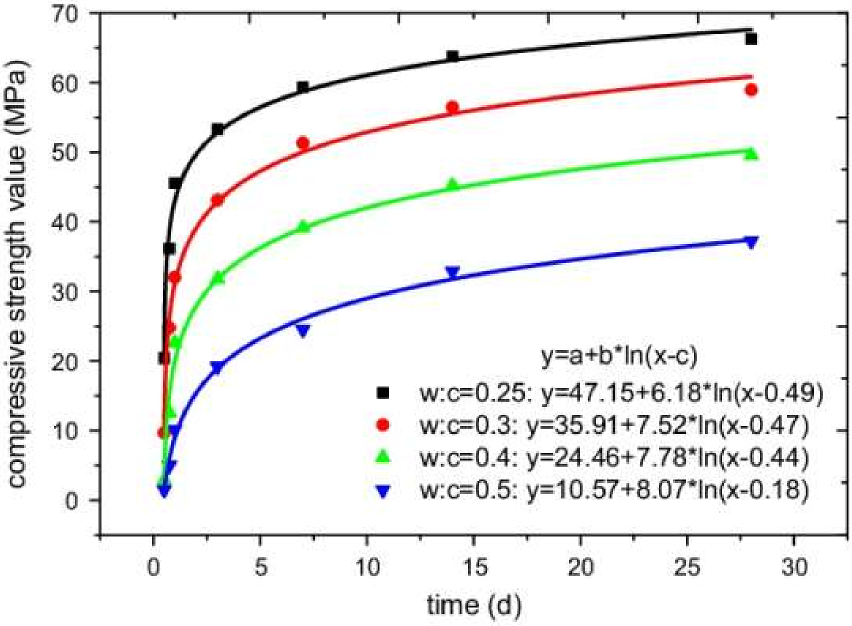


Figure: Plot of Characteristics Compressive Strength of Concrete versus Time (Days).

DETERMINATION OF AGGREGATE CRUSHING VALUE

1. AIM

1) To determine the aggregate crushing value of coarse aggregates
2) To assess suitability of aggregates for use in different types of road pavement

2. PRINCIPLE

The aggregate crushing value gives a relative measure of the resistance of an aggregate to crushing under a gradually applied compressive load. Crushing value is a measure of the strength of the aggregate. The aggregates should therefore have minimum crushing value.

3. APPARATUS

The apparatus of the aggregate crushing value test as per IS: 2386 (Part IV) – 1963 consists of:

1) A 15cm diameter open ended steel cylinder with plunger and base plate, of the general form and dimensions as shown in Fig 1.
2) A straight metal tamping rod of circular cross-section 16mm diameter and 45 to 60 cm long, rounded at one end.
3) A balance of capacity 3k, readable and accurate up to 1 g.
4) IS Sieves of sizes 12.5,10 and 2.36 mm
5) A compression testing machine capable of applying a load of 40 tonnes and which can be operated to give a uniform rate of loading so that the maximum load is reached in 10 minutes. The machine may be used with or without a spherical seating
6) For measuring the sample, cylindrical metal measure of sufficient rigidity to retain its form under rough usage and of the following internal dimensions:

   Diameter 11.5 cm

   Height 18.0 cm

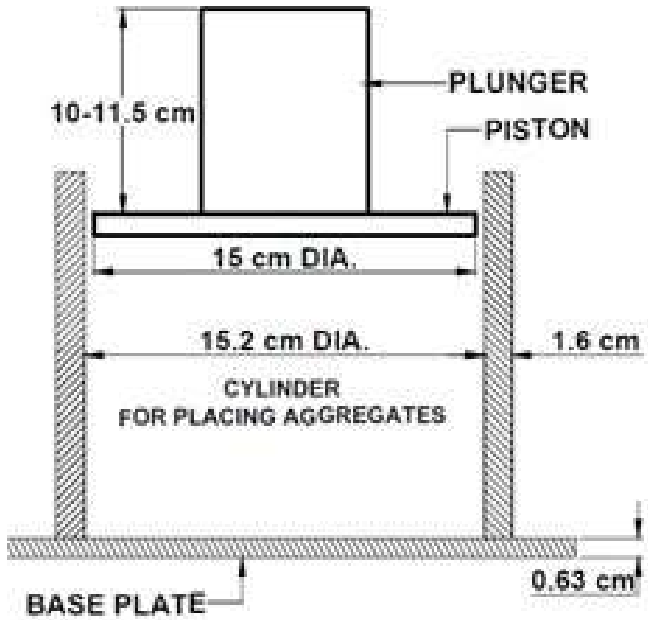


Fig 1 AGGREGATE CRUSHING TEST APPARATUS

4. PROCEDURE

The test sample: It consists of aggregates sized 12.5 mm - 10.0 mm(minimum 3kg). The aggregates should be dried by heating at 100-110^{o} C for a period of 4 hours and cooled.

1) Sieve the material through 12.5 mm and 10.0 mm IS sieve. The aggregates passing through 12.5 mm sieve and retained on 10.0 mm sieve comprises the test material.
2) The sample shall be added to the measuring cylinder in thirds, each third being subjected to 25 strokes with the tamping rod.
3) The surface of the aggregate shall be carefully levelled.
4) Measure the sample weight W1.
5) The cylinder of the test shall be put in position on the base-plate and the test sample added in thirds, each third being subjected to 25 strokes with the tamping rod.
6) The surface of the aggregate shall be carefully levelled.
7) The plunger is inserted so that it rests horizontally on this surface, care being taken to ensure that the plunger does not jam in the cylinder
8) The apparatus, with the test sample and plunger in position, shall then be placed between the plates of the testing machine.
9) The load is applied at a uniform rate as possible so that the total load is reached in 10 minutes. The total load shall be 40 tonnes.

10) The load shall be released and the whole of the material is removed from the cylinder and sieved on 2.36mm IS Sieve.
11) The fraction passing the sieve shall be weighed and recorded W2.

5. REPORTING OF RESULTS

The mean of the two results shall be reported to the nearest whole number as the 'aggregate crushing value' of the size of the material tested.

6. RESULT

Aggregate Crushing test value =

Record of Observation

	Sample I	**Sample II**
Total weight of dry sample taken= W_1 gm		
Weight of portion passing 2.36 mm sieve= W_2 gm		
Aggregate crushing Value (per cent) = $(W_2/W_1)*100$		

Record of Observation

	Sample I	Sample II
Total weight of dry sample taken= W_1 gm		
Weight of portion passing 2.36 mm sieve= W_2 gm		
Aggregate crushing Value (per cent) = $(W_2/W_1)*100$		

Aggregate Crushing Mean Value =

DETERMINATION OF AGGREGATE IMPACT VALUE

1. AIM

1. To determine the impact value of the road aggregates
2. To assess suitability of aggregates for use in different types of road pavement

2. PRINCIPLE

The property of a material to resist impact is known as toughness. Due to movement of vehicles on the road the aggregates are subjected to impact resulting in their breaking down into smaller pieces. The aggregates should therefore have sufficient toughness to resist their disintegration due to impact. This characteristic is measured by impact value test. The aggregate impact value is a measure of resistance to sudden impact or shock, which may differ from its resistance to gradually applied compressive load.

3. APPARATUS

The apparatus of the aggregate impact value test as per IS: 2386 (Part IV) – 1963 consists of:

1. A testing machine weighing 45 to 60 kg and having a metal base with a plane lower surface of not less than 30 cm in diameter. It is supported on level and plane concrete floor of minimum 45 cm thickness. The machine should also have provisions for fixing its base.
2. A cylindrical steel cup of internal diameter 102 mm, depth 50 mm and minimum thickness 6.3 mm.
3. A metal hammer p weighing 13.5 to 14.0 kg the lower end is cylindrical in shape, is 50 mm long, 100.0 mm in diameter, with a 2 mm chamfer at the lower edge and case hardened. The hammer should slide freely between vertical guides and be concentric with the cup. The free fall of the hammer should be within 380 ± 5 mm.
4. A cylindrical metal measure having internal diameter of 75 mm and depth 50 mm for measuring aggregates.
5. Tamping rod 10 mm in diameter and 230 mm long, rounded at one end.
6. A balance of capacity not less than 500 g, readable and accurate up to 0.1 g.

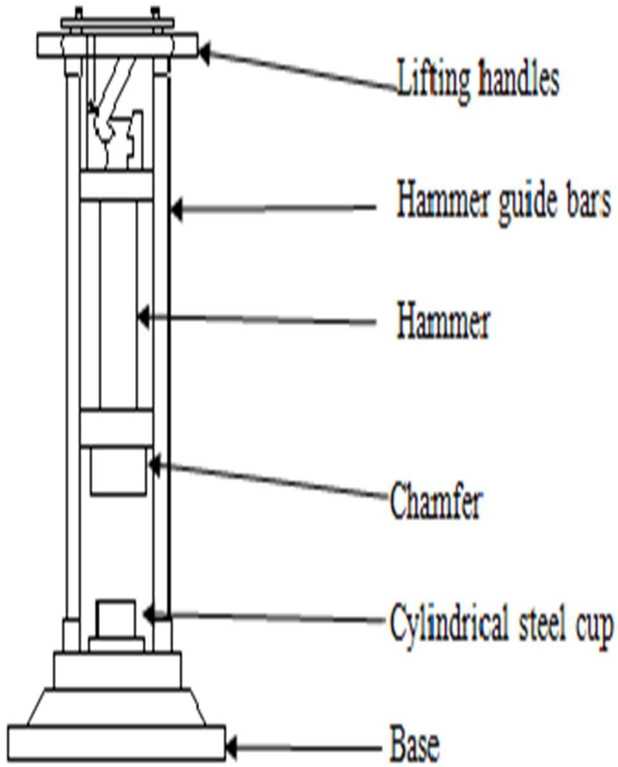


Fig 2 AGGREGATE IMPACT TESTING MACHINE

4. PROCEDURE

The test sample: It consists of aggregates sized 12.5 mm - 10.0 mm. The aggregates should be dried by heating at 100-110° C for a period of 4 hours and cooled.

1. Sieve the material through 12.5 mm and 10.0 mm IS sieve. The aggregates passing through 12.5 mm sieve and retained on 10.0 mm sieve comprises the test material.
2. Pour the aggregates to fill about 1/3rd depth of measuring cylinder.
3. Compact the material by giving 25 gentle blows with the rounded end of the tamping rod.
4. Add two more layers in similar manner, so that cylinder is full.
5. Strike off the surplus aggregates.
6. Determine the net weight of the aggregates to the nearest gram (W).

7. Bring the impact machine to rest without wedging or packing up on the level plate, block or floor, so that it is rigid and the hammer guide columns are vertical.
8. Fix the cup firmly in position on the base of machine and place whole of the test sample in it and compact by giving 25 gentle strokes with tamping rod.
9. Raise the hammer until its lower face is 380 mm above the surface of the aggregate sample in the cup and allow it to fall freely on the aggregate sample.
   Give 15 such blows at an interval of not less than one second between successive falls.
10. Remove the crushed aggregate from the cup and sieve it through 2.36 mm IS sieves until no further significant amount passes in one minute. Weigh the fraction passing the sieve to an accuracy of 1 gm (W_2). Also weigh the fraction retained in the sieve.
11. Note down the observations in the Performa and compute the aggregate impact value. The mean of two observations, rounded to nearest whole number is reported as the Aggregate Impact Value.

5. PRECAUTIONS

1) Place the plunger centrally so that it falls directly on the aggregate sample and does not touch the walls of the cylinder in order to ensure that the entire load is transmitted on to the aggregates.
2) In the operation of sieving the aggregates through 2.36 mm sieve the sum of weights of fractions retained and passing the sieve should not differ from the original weight of the specimen by more than 1 gm.
3) The tamping is to be done properly by gently dropping the tamping rod and not by hammering action. Also the tampering should be uniform over the surface of the aggregate taking care that the tamping rod does not frequently strike against the walls of the mold.

6. REPORTING OF RESULTS

The mean of the two results shall be reported to the nearest whole number as the aggregate impact value of the tested material.

Aggregate impact value is used to classify the stones in respect of their toughness property as indicated below in Table 1.

Table 1: Classification of aggregate based on aggregate impact value

Aggregate impact value (%)	Quality of aggregate
< 10	Exceptionally strong
10 – 20	Strong
20 – 30	Satisfactory for road surfacing
>35	Weak for road surfacing

Table 2: Maximum allowable impact values of aggregate in different types of Pavement material/ layers

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

7. RESULT

Aggregate impact test value =

Record of Observation

	Sample I	Sample II
Total weight of dry sample taken= W_1 gm		
Weight of portion passing 2.36 mm sieve= W_2 gm		
Aggregate impact = $(W_2/W_1)*100$ Value (per cent)		

Aggregate Impact Mean Value =

Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregateby Abrasion and Impact in the Los Angeles Machine

ASTM C 131-03

Scope:

This test method covers a procedure for testing sizes of coarse aggregate smaller than 37.5 mm for resistance to degradation using the Los Angeles testing machine.

Apparatus

1) Los Angeles Testing Machine as shown in Figure (1).
2) Sieves
3) Balance accurate to 0.5 gm.
4) Oven.
5) Containers.
6) Abrasive charge in accordance with Table 1. The Charge must consist of steel spheres averaging (46.8mm) in diameter and each weighing between 390 to 445gm.

Procedure

1) Obtain the field sample in accordance with Practice D 75.
2) Reduce the field sample to adequate sample size in accordance with Practice C 702.
3) Wash the reduced sample and oven dry at 110±5°C to substantially constant mass.
4) Separate into individual size fractions.
5) Recombine to the grading of Table (2).
6) Record the mass of the sample prior to test to the nearest 1 g.
7) Place the test sample and the charge in the Los Angeles testing machine and rotate the machine at a speed of 30 to 33 r/min for 500 revolutions.
8) After the prescribed number of revolutions, discharge the material from the machine.
9) Make a preliminary separation of the sample on a sieve coarser than the 1.70 mm sieve.
10) Sieve the finer portion on a 1.70 mm sieve.
11) Wash the material coarser than the 1.70 mm sieve.
12) Oven-dry at 110±5°C to substantially constant mass
13) Determine the mass to the nearest 1 g.

Calculation

Calculate the difference between the original mass and that retained on the 1.7 mm sieve. Express that value as a percentage of the original mass of the sample test. This value is considered as the percent loss.

$$\%\,loss = \frac{original\ mass - mass\ retained\ on\ 1.7\ mm\ \ sieve}{original\ mass} \times 100$$

Note:

ASTM Specifications C33-13 requires that the abrasion percent should not exceed 50% for coarse aggregate used in concrete mixes.

TABLE (1) Abrasive Charge

Grading	Number of Spheres	Weight of Charge in Grams
A	12	5000 ± 25
B	11	4584 ± 25
C	8	3330 ± 20
D	6	2500 ± 15

TABLE (2) Grading of Test Samples

Sieve Size (Square Openings)		Mass of Indicated Sizes, g			
		Grading			
Passing	Retained on	A	B	C	D
37.5 mm (1½ in.)	25.0 mm (1 in.)	1 250 ± 25	...	...	...
25.0 mm (1 in.)	19.0 mm (¾ in.)	1 250 ± 25	...	...	...
19.0 mm (¾ in.)	12.5 mm (½ in.)	1 250 ± 10	2 500 ± 10	...	...
12.5 mm (½ in.)	9.5 mm (⅜ in.)	1 250 ± 10	2 500 ± 10	...	...
9.5 mm (⅜ in.)	6.3 mm (¼ in.)	...	...	2 500 ± 10	...
6.3 mm (¼ in.)	4.75-mm (No. 4)	...	...	2 500 ± 10	...
4.75-mm (No. 4)	2.36-mm (No. 8)	...	...	...	5 000 ± 10
Total		5 000 ± 10	5 000 ± 10	5 000 ± 10	5 000 ± 10

FIGURE (1) Los Angeles Machine

MATERIALS FINER THAN No. 200 (75 µm) SIEVE IN MINERAL AGGREGATES BY WASHING

AASHTO T 11

SCOPE

Aggregates are used in all phases of highway construction from bases, pavement mix, granular shoulders, and granular surfacing, as well as, erosion control. In order to ensure the aggregate performs as intended for the specific use, a variety of tests must be performed on the aggregate. One such test is determining materials finer than No. 200 (75 µm) sieve in mineral aggregates by washing. Fine materials such as clay particles or water soluble particles removed by washing, can cling to larger particles and do not dislodge readily. This test washes the fine particles through the No. 200 (75 µm) sieve to give an accurate determination of fine materials in the sample. The determination of minus No. 200 (75 µm) material is used to compare material performance with gradation specifications, and indirectly to gauge such properties as plasticity, permeability, and soils classifications. Such knowledge helps in determining whether a material is frost susceptible or not, and whether permeability (measurement of material capacity to allow water flow through the aggregate) will be affected.

SUMMARY OF TEST

A known amount of material is placed in a wash container and covered with water, agitated to suspend the fine size particles in the water, and then poured through a No. 200 (75 µm) sieve (Figure 1). After thorough rinsing, the portion remaining on the No. 200 (75 µm) sieve is transferred to a pan, dried and weighed. The percentage passing through the No. 200 (75 µm) sieve is then calculated.

Figure 1
Fines suspended in the water are washed over a
No. 8 (2.36 mm) and a No. 200 (75 µm) sieve

Apparatus

Balance, general purpose G_2 (AASHTO M231).

Sieves, a No. 8 (2.36 mm) or No. 16 (1.18 mm) and a No. 200 (75 µm).

Container, of sufficient size to properly agitate the sample without losing material.

Oven, capable of maintaining a temperature of 230 ± 9°F (110 ± 5°C). When tests are performed in the field where ovens are not available, test samples may be dried in suitable containers over an open flame or electric hot plates with sufficient stirring to prevent overheating.

Wetting agent, dispersing material such as dish washing soap.

Sample Preparation

Determine the proper dried sample weight from Table 1 based on the nominal maximum size of the sample to be tested. If the sample is to be tested for gradation in accordance with AASHTO T 27, the minimum weight of that test method shall apply. If the sample is not tested for gradation in accordance with AASHTO T 27 and the nominal maximum size of aggregate to be tested is not listed in Table 1, the next larger size shall be used to determine the sample size.

Table 1-Sample Weight Requirements

Nominal Maximum Size in. (mm)	Minimum Weight of Sample (gm)
No. 4 (4.75 mm)	300
3/8 in.(9.5 mm)	1000
3/4 in.(19.0 mm)	2500
1 1/2 (37.5 mm)	5000

Procedure

1. Dry sample to a constant weight. Record this as the dry weight of the material to the nearest 0.1 g. Allow sample to air cool until cool to the touch.

2. Place sample into a wash container large enough to permit mixing the sample with water (Figure 2). Cover the sample with water (and optionally, at the discretion of the technician, add a small amount of wetting agent) and agitate the sample with sufficient movement so that the particles finer than the No. 200 (75 µm) sieve become suspended in the water. Stirring and agitating the sample may be necessary and may be accomplished with any stirring or agitating instrument. Care should be taken not to lose any portion of the sample or the fines suspended in the water.

Figure 2
Washing Sample

3. Pour the water with the suspended fines through a No. 200 (75 µm) sieve (Figure 3). Occasionally inspect the No. 200 (75 µm) sieve for cracks along the seam or holes in the screen, as any imperfections will effect the final wash sieve results. Take care to pour only the water with suspended fines and not the sample itself, since samples with larger size aggregates might damage or clog the fine screen on the No. 200 (75 µm) sieve (Figure 3). Nesting sieves with larger openings a No. 8 (2.36 mm), or a No. 16 (1.18 mm) above the No. 200 (75 µm) sieve might help to prevent inadvertent clogging.

Figure 3
Pouring Water through Sieves

4. Continue washing the sample with additional water and agitate until a majority of the fines suspended in the water have been washed through. When the washed sample is near completion, the water should be relatively clear compared with the initial water color of the wash sample. If you can see the sample beneath the water, then the sample is probably adequately washed.

5. Give the sample a final rinse, pouring as much of the remaining water as possible out of the sample and into the No. 200 (75 µm) sieve. Put the sample remaining in the washing bowl into a pan for oven drying.

6. Any suspended fines remaining on the No. 200 (75 µm) sieve must be included in the sample for drying. Rinsing any suspended fines to one side of the sieve (Figure 4) and then tapping those fines into the pan is one way of accomplishing this. Be sure to include all fines suspended on the No. 200 (75 µm) sieve in the final sample for drying.

Figure 4
Material Retained on the No. 200 (75µm) sieve

A rinsing bottle (Figure 5) may be used to remove the fines sticking to the No. 200 (75 µm) sieve once the sample has been washed.

Figure 5
Rinsing Fines on No. 200 (75µm) Sieve

7. Place the washed sample into an oven set at 230 ± 9°F (110 ± 5°C), into an electric skillet, or onto an open flame and dry to a constant weight. Record the dry weight.

Calculations

Calculate the total % passing the No. 200 (75 µm) sieve (A) by dividing the difference of the original dry sample weight (B) and the weight of sample after washing and drying (C) to a constant weight by the original dry sample weight (B) and multiplying by 100.

$$A = \frac{(B - C)}{B} \times 100$$

Where:
A = Total % passing No. 200 (75 µm) sieve
B = Original dry weight of sample (gms), and
C = Dry weight of sample after washing and drying to constant weight (gms)

<u>Example</u>

B = 532.2 gms
C = 521.6 gms
Formula: $A = \frac{(B - C)}{B} \times 100$

$$A = \frac{(532.3 - 521.6)}{532.3} \times 100$$

A = 2.0%

Report the percentage of material finer than the No. 200 (75 µm) sieve to the nearest 0.1%.

Standard Test Method for Slump of Hydraulic-Cement Concrete

ASTM C 143/143M-15

Scope:

This test method covers determination of slump of freshly mixed hydraulic-cement concrete, both in the laboratory and in the field.

Summary of Test Method

A sample of freshly mixed concrete is placed and compacted by rodding in a mold shaped as the frustum of a cone. The mold is raised, and the concrete allowed to subside. The vertical distance between the original and displaced position of the center of the top surface of the concrete is measured and reported as the slump of the concrete.

Apparatus:

1) Weights and weighing device.
2) Tools and containers for mixing, or concrete mixer.
3) Tamper (16 mm in diameter and 600 mm length)
4) Ruler
5) Scoop
6) Slump cone which has the shape of a frustum of a cone with the following dimensions:
   Base diameter 200 mm
   Top diameter 100 mm
   Height 300 mm
   Materials thickness at least 1.6 mm

Procedure:

1) Prepare a clean, wide, flat mixing pan.
2) Place the dampened slump cone on one side of the pan. It shall be held firmly in place during filling by the operator standing on the two-foot pieces.
3) Place the newly mixed concrete in three layers, each approximately one third the volume of the mold.
4) In placing each scoopful of concrete, move the scoop around the top edge of the mold as the concrete slides from it, in order to ensure symmetrical distribution of concrete within the mold.
5) Rod each layer with 25 strokes of the tamper, distribute the strokes in a uniform manner over the cross section of the mold, each stroke just penetrating into the underlying layer.
6) For the bottom layer this will necessitate inclining the rod slightly and making approximately half of the strokes spirally toward the center. Rod the bottom layer throughout its depth.
7) In filling and rodding the top layer, heap the concrete above the mold before rodding is

started.

8) After rodding the top layer, strike off the surface of the concrete with a trowel, leaving the mold exactly filled.
9) While filling and rodding, be sure that the mold is firmly fixed by feet and can't move.
10) Clean the surface of the base outside the cone of any excess concrete. Then immediately remove the mold from the concrete by raising it slowly in a vertical direction.
11) Measure the slump immediately by determining the difference between the height of the mold and the height of the vertical axis (not the maximum height) of the specimen.
12) Clean the mold and the container thoroughly immediately after using.
13) If the pile topples [when raising the mold out of concrete] sideways, it indicates that the materials have not been uniformly distributed in the mold and the test should be remade.

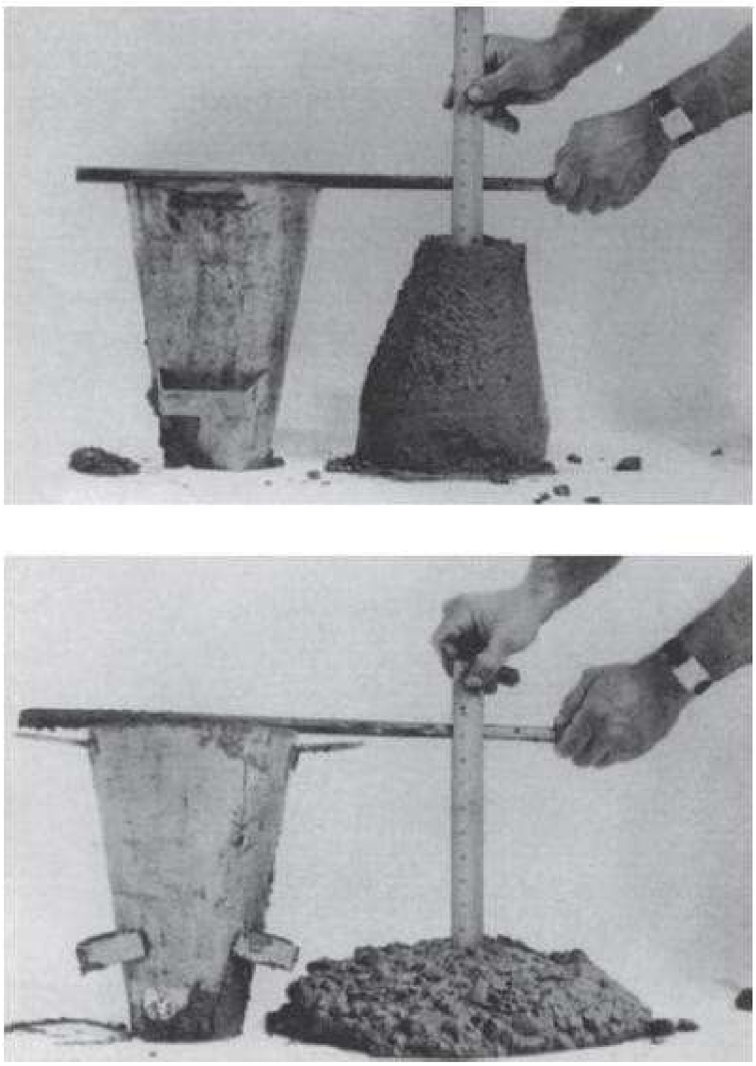
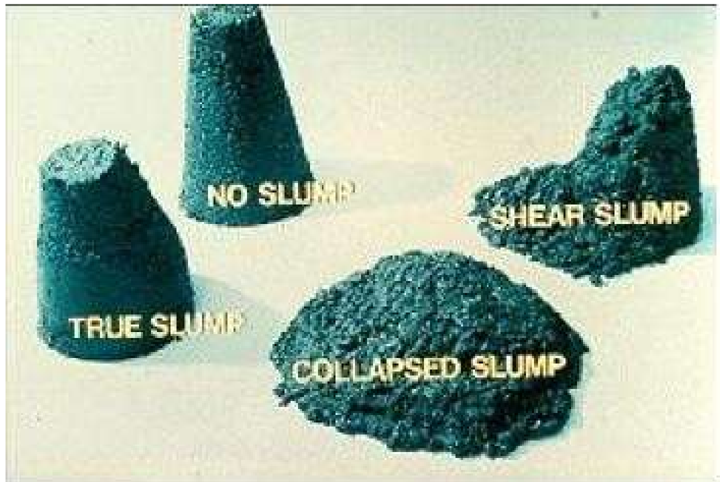


FIGURE (1): Demonstration of the use of a slump cone. The top photographillustrates a low slump and the bottom a high slump



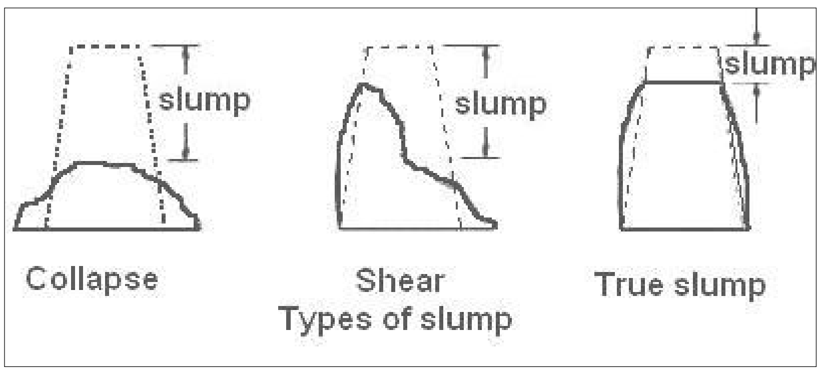


FIGURE (2): Different possible slump test results

The consistency is expressed using five descriptions due to the slump value as shown in the table below.

Slump (mm)	0-20	10-40	30-120	100-200	180-220
Consistency	Dry	Stiff	Plastic	Wet	Sloppy

Actual mixes weights

Actual Mix. No.	w/c ratio	Cement (kg)	Sand (kg)	Gravel (kg)	Water (L)
I	0.5	300	800	1200	150
II	0.5	400	800	1200	200
III	0.6	400	800	1200	240
IV	0.7	400	800	1200	280

Equivalent laboratory mixes weights

Lab. Mix. No.	w/c ratio	Cement (gm)	Sand (gm)	Gravel (gm)	Water (mL)
I	0.5	2250	6000	9000	1125
II	0.5	3000	6000	9000	1500
III	0.6	3000	6000	9000	1800
IV	0.7	3000	6000	9000	2100

Specific Gravity and Absorption of Coarse Aggregate
(ASTM Designation C 127)

Scope:

This test method covers the determination of relative density (specific gravity) and the absorption of coarse aggregates. The relative density (specific gravity), a dimensionless quantity, is expressed as oven-dry (OD), saturated-surface-dry (SSD), or as apparent relative density (apparent specific gravity). The OD relative density is determined after drying the aggregate. The SSD relative density and absorption are determined after soaking the aggregate in water for a prescribed duration.

Apparatus:

1) Balance, which shall be equipped with suitable apparatus for suspending the sample container in water from the center of the platform or pan of the balance.

2) Sample Container, a wire basket of 3.35 mm (No. 6) or finer mesh, with a capacity of 4 to 7 L for 37.5-mm nominal maximum size aggregate or smaller.
3) Water Tank, into which the sample container is placed while suspended below the balance.
4) Sieves, A 4.75-mm (No. 4) sieve.
5) Oven, of sufficient size.

Materials:

5 kg of coarse aggregates where the nominal maximum size is 37.5 mm (11/2 in.) or less and all material is retained on the 4.75 mm (No.4) sieve

Procedure:

1) Select by quartering or use of a sample splitter approximately 5 kg of aggregate. Reject all material passing a No. 4 sieve.

2) Thoroughly wash the sample to remove all dust or other coatings from the particles. **3)** Dry the sample to a constant mass at a temperature of 110±5°C.

4) Cool in air at room temperature for 1 to 3h to a temperature that is comfortable to handle.

5) Immerse the aggregate in water at room temperature for a period of 24±4 h.

6) Remove the test sample from the water and roll it in a large absorbent cloth until all visible films of water are removed. Wipe the larger particles individually.

7) Determine the mass of the test sample in the saturated surface-dry condition (B) to the nearest 0.5 g.

8) After determining the mass in air, immediately place the saturated-surface-dry test sample in the sample container and determine its apparent mass (C) in water at 23±6 2.0 °C.

9) Dry the test sample in the oven to constant mass at a temperature of 110±5 °C, cool in air at room temperature 1 to 3 h to a temperature that is comfortable to handle.
10) Determine the oven-dry mass of the sample (A).

Calculations:

$$\text{Bulk Specific Gravity (oven-dry)} = = \frac{A}{B-C}$$

$$\text{Bulk Specific Gravity (SSD)} = \frac{B}{B-C}$$

$$\text{Apparent Specific Gravity} = \frac{A}{A-C}$$

$$\text{Absorption \%} = \frac{(B-A)}{A} \times 100$$

Where;

A = Mass of oven-dry test sample in air, g.

B = Mass of saturated-surface-dry test sample in air, g.

C = Apparent mass of saturated test sample in water, g.

Example

If the following data have been obtained using specific gravity and absorption test of coarse aggregate:

Mass of oven-dry test sample in air: 2958 g.

Mass of saturated-surface-dry test sample in air: 2994 g.

Apparent mass of saturated test sample in water: 1905 g.

Calculate the following:

1) Bulk Specific Gravity (OD)
2) Bulk Specific Gravity (SSD)
3) Apparent Specific Gravity
4) Absorption %

Solution

$$\text{Bulk Specific Gravity (OD)} = \frac{A}{B-C} = \frac{2958}{2994-1905} = 2.72$$

$$\text{Bulk Specific Gravity } (SSD) = \frac{B}{B-C} = \frac{2994}{2994-1905} = 2.75$$

$$\text{Apparent Specific Gravity} = \frac{A}{A-C} = \frac{2958}{2958-1905} = 2.81$$

$$\text{Absorption, \%} = \frac{(B-A)}{A} \times 100 = \frac{2994-2958}{2958} \times 100 = 1.22\%$$