Channabasaveshwara Institute of Technology
(Affiliated to VTU, Belgaum & Approved by AICTE, New Delhi)
(NAAC Accredited & ISO 9001:2015 Certified Institution)
NH 206 (B.H. Road), Gubbi, Tumkur – 572 216. Karnataka

Department of Civil Engineering

Concrete Technology

BCV503

B.E – V Semester

Laboratory Manual 2024-25

Name: ________________________________

USN: ________________________________

Batch: ______________ **Section:** __________

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Concrete Technology

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Prepared by:

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DEPARTMENT OF CIVIL ENGINEERING

SYLLABUS

Subject code	**: BCV503**	**Exam Hours**	**: 03**
No. of Practical Hours	**: 02**	**IA Marks**	**: 50**
Teaching Hours/Week (L:T:P)	**: (0:2:2)**	**Exam Marks**	**: 50**
Credits	**: 04**	**Total Marks**	**: 100**

PART A: Concrete Lab

1. Tests on Cement:

a. Normal Consistency

b. Fineness by air permeability test

c. Setting time,

d. Specific Gravity,

e. Soundness and strength of cement

2. Testing of fine aggregate:

a. Specific Gravity

b. Sieve analysis and zoning

c. Bulking of fine aggregate

d. Bulk density,

e. Silt content.

3. Testing of coarse aggregate:

a. Specific Gravity

b. Sieve analysis

c. Flakiness index & elongation index

d. Water absorption & moisture content

e. Soundness of aggregate.

3. Concrete Mix design by IS code method as per 10262- 2019 & 456-2000, DOE method

4. Tests on Concrete:

a. Demonstration of Testing of concrete cube of specified strength

b. Demonstration of Testing of concrete beam for pure bending

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Sl. No	Name of the Experiment	Date			Record Marks (Max. 10)	Signature (Student)	Signature (Faculty)
		Conduction	Repetition	Submission of Record			
Average							

- **Note: If the student fails to attend the regular lab, the experiment has to be completed in the same week. Then the manual/observation and record will be evaluated for 50% of maximum marks.**

‘Instructions to the Candidates’

1. **Students should come with thorough preparation for the experiment to be conducted.**

2. **Students will not be permitted to attend the laboratory unless they bring the practical record fully completed in all respects pertaining to the experiment conducted in the previous class.**

3. **All the calculations should be made in the observation book. Specimen calculations for one set of readings have to be shown in the practical record.**

4. **Wherever graphs are to be drawn, A-4 size graphs only should be used and the same should be firmly attached to the practical record.**

5. **Practical record should be neatly maintained.**

6. **They should obtain the signature of the staff-in-charge in the observation book after completing each experiment.**

7. **Theory regarding each experiment should be written in the practical record before procedure in your own words.**

DEPARTMENT OF CIVIL ENGINEERING

CONTENTS

TESTS ON CEMENT

Experiment No.: 1(a) **Date:**

STANDARD CONSISTENCY OF CEMENT

(IS 4031:1991 – PART 4)

Objective:

To determine the standard consistency of a given cement sample

Scope and Significance of the test:

The purpose of the test is determining the percentage of weight of water to be added to cement to produce a cement paste of standard consistency, i.e. the paste of certain solidity, which is used to fix the quantity of water to be mixed in cement before performing tests for Initial setting time, final setting time, soundness and compressive strength of cement. Standard consistency of a cement paste is defined as that consistency which will permit a vicat plunger having 10 mm dia and 50 mm length to penetrate to a depth of 33-35 mm from top of the mould or 5-7mm from the bottom. As the fineness of cement varies from batch to batch, the quantity of water required to get a paste of standard consistency also varies.

Apparatus:

Vicat apparatus confirming to IS: 5513-1976, Balance, standard weights and gauging trowel. Gauging trowel shall have a steel blade of 100 to 150mm in length with straight edges weighing 210 ± 10gm. Fig shows vicat apparatus.

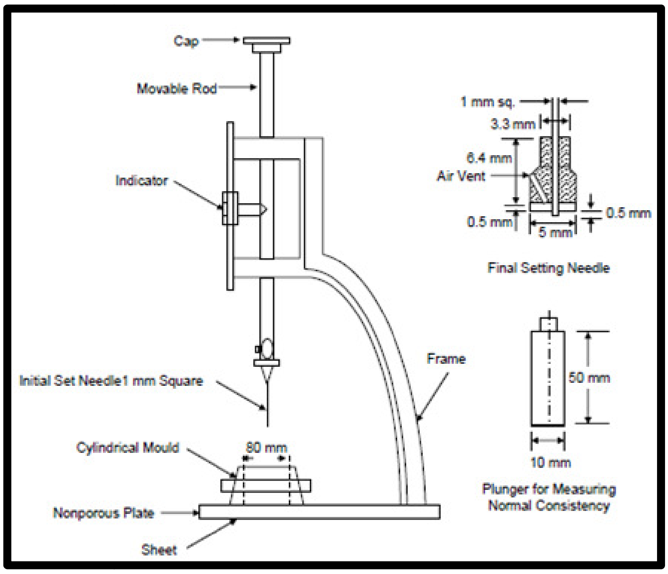


Fig: Vicat Apparatus

Procedure:

Standard consistency of a cement paste is defined as that consistency (The amount of water expressed as percentage by mass of the dry cement) which will permit the vicat plunger to penetrate to a point 5 to 7mm from the bottom of the vicat mould when the cement paste is tested as described below.

i. Take 400gms of cement and prepare a paste of cement with a weighed quantity of potable or distilled water (100ml) taking care that the time of gauging is not less than 3 minutes, not more than 5 minutes. The gauging time shall be counted from the time of adding water to the dry cement until commencing to fill the mould.

ii. Fill the mould with this paste, the mould resting upon a non-porous plate. After completely filling mould, smoothen the surface of the paste, making it level with the top of the mould. The mould may be slightly shaken to expel air.

iii. Place the test block in mould, together with the non-porous plate under the rod attached with the plunger. Lower the plungers gently to touch the surface of the test blocks and release it quickly, allowing it to sink into the paste.

iv. Prepare trial pastes with the varying percentages of water and test as described above until the amount of water necessary for the standard consistency as defined is obtained.

Observations and calculations:

Mass of the dry cement taken = 400gms

Sl. NO.	% of water	Initial Reading	Final Reading	Height not penetrated (mm)
01	26			
02				
03				
04				

Result: Standard Consistency of given cement sample is ………..

Requirement:

The standard consistency of a cement paste which permits vicat plunger to penetrate to a height of 5 to 7 mm from the bottom of the vicat mould is varies from 24% to 34% depending on the sample.

Reference Code:

IS 5513 – 1976 Specification for vicat apparatus

IS 4031 – part4 – 1988 Determination of consistency of standard cement paste.

Questions:

i. What is normal or standard consistency of a cement paste?

ii. What is the purpose of making this determination?

iii. How is the standard consistency expressed?

Technical Reference:

Name of the test	Amount of water required
Soundness (Le- Chatelier Method)	**0.78 P** (P=Consistency of standard cement paste)
Setting time	**0.85 P** (P=Consistency of standard cement paste)
Compressive strength	$(\frac{P}{4}+3)\%$ of combined mass of cement and sand.

Experiment No.: 1(b) **Date:**

SETTING TIME OF CEMENT

(IS 4031:1988 – PART 1)

Objective:

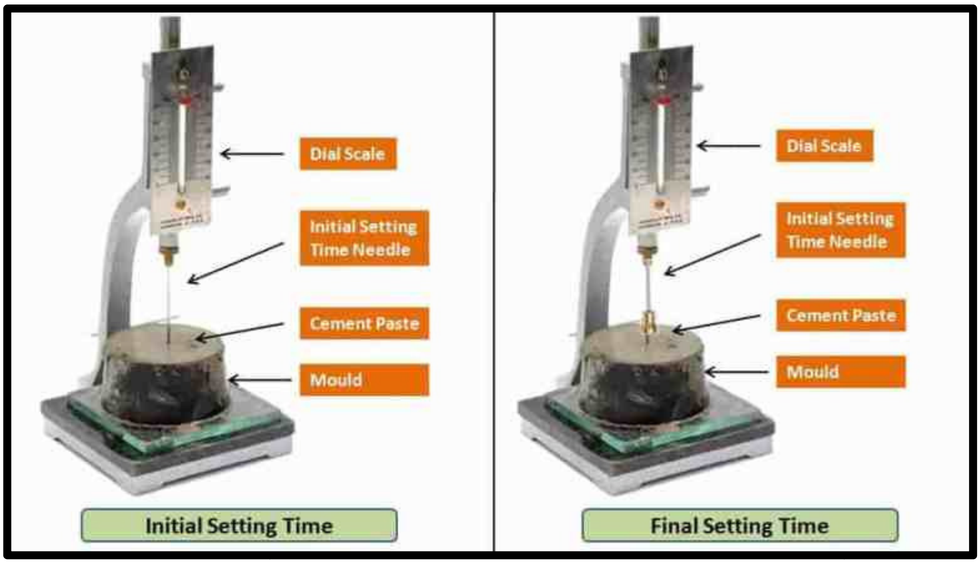
To determine the initial and final setting time of a given cement sample.

Scope and Significance of the test:

Setting refers to the stiffening process which the cement paste undergoes as time elapses. The time interval for which the cement products remain in plastic condition is known as setting time. It should not be confused with hardening which refers to the gain in mechanical strength after the paste has solidified. Two periods of times are used to assess the setting behavior. These are the called the initial and final setting time. Initial setting time is regarded as the time elapsed between the moment the water is added to the cement and the time when the paste has completely lost its plasticity and has attained sufficient firmness to resist certain definite pressure. The setting time during which the cement products remain in plastic condition is required for mixing, transporting and placing cement products. Once the concrete is placed in the final position, compacted and finished, it should lose its plasticity in the earliest possible time so that it is least vulnerable to damages from external destructive agencies.

Apparatus:

Vicat's apparatus confirming to IS: 5513 – 1976, balance, standard weights, Gauging trowel, Stop watch.



Procedure:

Preparation of Test block:

Prepare a neat cement paste by gauging the cement with 0.85 times the water required to give a paste of standard consistency. Potable or distilled water shall be used in preparing the paste. The gauging time is again kept between 3 to 5 minutes. Start the stop-watch at the instant when water is added to the cement. Fill the vicat mould and smooth off the surface of the paste making it level with the top of mould. The cement block thus prepared in the mould is the test block. Immediately after moulding, place the test block in the moist closet or moist room and allow it to remain there except when determinations of time of setting are being made.

Determination of Initial setting Time:

Place the test block confined in the mould and resting on the non-porous plate, under the rod attached with the initial setting time needle. Lower the needle gently until it comes in contact with the surface of the test block and quickly release, allowing it to penetrate into the test block. In the beginning, the needle will completely pierce the test block and released as described above, fails to pierce the block beyond 5.0 ± 0.5mm measured from the bottom of the mould. The period elapsing between the time when water is added to the cement and the time at which the needle fails to pierce the test block to a point 5.0 ± 0.5mm measured from the bottom of the mould shall be initial setting time.

Determination of Final Setting Time:

Replace the initial setting time needle of the vicat apparatus by the needle with an annular attachment (i.e. setting time needle). The cement shall be considered as finally set when, upon applying the needle gently to the surface of the test block, the needle makes an impression thereon, while the attachment fails to do so, shall be the final setting time. In the event of a scum forming on the surface of the test block, use the underside of the block for determination.

Observation and Calculations:

Mass of cement taken =400 g

Mass of water taken = 0.85 x P x400 =_____ml.

Where "P" is the standard consistency (%)

Sl. No.	Reading in mm	Time in Minutes
01		
02		
03		
04		

Results:

Initial setting time = _______minutes

Final setting time =________minutes

Standard Values:

As per IS 269 (2015) specifications the initial setting time should not be less than 30 minutes and final setting time should not be more than 10 hours (600min) for ordinary Portland cement.

Questions:

1. What is normal or standard consistency of a cement paste?

2. What is the purpose of making this determination?
3. How is the standard consistency expressed?
4. What is the significance of time offset?
5. Physically what do you understand by initial and final setting times?
6. What should be the minimum initial setting time and maximum final setting time of cement according to IS specification?
7. On what factors does this time of set depend?
8. How is the rate of setting of Portland cement controlled in the manufacturing process?
9. How does fine grading affect the time offset?
10. Why gypsum is added to the clinker in the production of cement?

Experiment No.: 1(c) **Date:**

COMPRESSIVE STRENGTH OF CEMENT

(IS 4031:1988 – PART 6)

Objective: To determine the compressive strength of a given cement sample.

Scope and significance of the test:

The compressive strength of cement is determined from tests on cement mortar (1:3) cubes. The standard sand confirming to IS: 650 – 1956 is used for preparing the cubes. Strength tests are not made on neat cement paste because of difficulties of excessive shrinkage and subsequent cracking of neat cement. Strength of cement is indirectly found from cement mortar. There is also a good correlation between the compressive strength of cement mortar test cubes and strength of concrete made with same cement. The mechanical strength of hardened cement is the property of the material that is needed in structural design.

Apparatus:

Universal testing machine or Compression testing machine, cube moulds (70.71mm), vibrating machine, crucible for mixing cement and sand, measuring cylinder, trowels, non-porous plate and balance with weight box.

Procedure:

i. The material for each cube shall be mixed separately by taking quantities of cement: standard sand and water are as follows;

Cement: 200gms, standard sand: 600gms,

Water: P/4 + 3% of combined weight of cement and sand (Where 'P' is standard consistency)

ii. Place on a non-porous plate a mixture of cement and ennore sand in the proportion of 1:3 by weight as given above.

iii. Mix it dry with a trowel for one minute and then add water until mix is of uniform colour.

iv. Gauging time should not be less than 3 minutes and should not exceed 4 minutes. If it exceeds, mixture is rejected and operation is repeated.

v. Oil the interior faces of the mould.

vi. Place the assembled mould on the table of the vibrating machine and firmly hold it in position by means of suitable clamps. Securely attach the hopper at the top of the mould to facilitate filling and this hopper shall not be removed until completion of vibration period.

vii. Immediately after mixing the mortar as explained above, fill the entire quantity of mortar in the hopper of the cube mould and vibrated. The period of vibration shall be two minutes at the specified speed of 12,000±400 cycles per minute.

viii. Remove the mould from the machine and keep it at a temperature of 27±2 °C in an atmosphere of at least 90% relative humidity for 24 hours after completion of vibrations.

ix. At the end of this period, remove the cube from the mould and immediate submerge it in clean and fresh water and keep them until taken out just prior to breaking. The water in which the cubes are submerged shall be releaved after every 7 days and be maintained at a temperature of 27 ± 2°C. Keep the cubes wet till they are placed in machine for testing.

x. Test all three specimens after three days. The periods are being record from the completion of vibration. The compressive strength shall be the average of the strengths of three cubes for each period. The cubes shall be tested on their sides, the load being applied at the rate of 35 N/mm^2/minute.

Observations and calculations:

Sl. No.	3 Days Compressive Strength		7 Days Compressive Strength		28 Days Compressive Strength	
	Load in kN	**Strength in N/mm^2**	**Load in kN**	**Strength in N/mm^2**	**Load in kN**	**Strength in N/mm2**
01						
02						
03						
AVG						

Mass of cement taken =200 gms Mass of sand taken = 600 gms

Percentage of water = (P/4) + 3= ________

Mass of water taken = __________ml.

Results:

The mean three days compression strength of cement = ________MPa

Type of grade and Ref., code properties {Compressive strength in MPa IS:4031 (Part- 6)-1988}	**IS:269- 2015**		
	OPC 33	**OPC 43**	**OPC 53**
3 Days	16	23	27
7 Days	22	33	37
28 Days	33	43	43

Questions:

1. What is the significance of this test?
2. What are ultimate strengths of cement, sand, mortar cubes after 3 days and 7days?
3. What is the percentage of water (by mass of dry materials) added in preparation of 1/3 cement standards and mortar for compressive strength tests?
4. How can you be sure that the cement and sand are thoroughly mixed?
5. What is the rule for mixing water to the sand cement mix for preparing test specimens for compressive strength of cement?
6. What are the requirements for the moulds, including base and cover plates?
7. What is the minimum no. of specimens of a kind to be made for each age attesting?
8. What are the requirements concerning the removal of the cubes from the moulds?
9. How is the curing of test specimen done?

Experiment No.: 1(d) **Date:**

TEST FOR FINENESS OF CEMENT

(IS 4031:1988 – Part 2)

Objective:

To determine the specific surface of cements, pozzolanas, etc.

Scope and Significance:

The degree of fineness of cement is a measure of the mean size of the grains in the cement. The rate of hydration and hydrolysis and consequent development of strength depends upon the fineness of cement. To have the same rate of hardening in different brands of cement, the fineness has been standardized. The finer cement has quicker action with water and gains early strength through its ultimate strength remains unaffected. However, the shrinkage and cracking of cement will increase with fineness of cement.

Apparatus: Blaine's variable air permeability apparatus.

Fig: Blain's Air Permeability apparatus

Procedure:

1. Calibration of the Blaine's Apparatus.
2. Calculate the bulk volume of the compacted bed of cement (V) by the following formula; V = (Wa – Wb) /p

   Where; Wa = mass of the mercury required to fill the permeability cell.

   Wb = mass of the mercury to fill the proportion of the cell not occupied by the bed of cement formed by 2.8gms of the standard cement sample.

   p = density of mercury at the temperature of test.
3. The masses Wa and Wb are obtained by weighing mercury in the crucible.
4. Determine the mass of sample, w required to produce a bed having porosity of 0.500 (=e) as follows:

   w = 3.15 v (1 – e)
5. Evacuate the air until the fluid moves above the upper line without pulling it over the top of the side outlet. Close the valve and note the time Ts taken by manometer liquid to fall from second mark (from top) to the third mark on the manometer when the air is allowed to permeate through the compacted bed of standard cement sample. Note the air temperature.

Specific surface Determination:

1. Weigh an amount of cement sample equal to that determined in step 2, in the calibration.
2. Place the perforated disc in the permeability cell, and then add a filter paper, followed by the sample and another filter paper. Compress the specimen with plunger, remove the plunger and couple the permeability cell with the manometer.
3. Evacuate the air until the fluid moves above the upper line without pulling it over the top of side tube. Close the valve of manometer and note the time T it takes for the fluid to drop from the second mark to the third mark on the manometer when the air is allowed to permeate through the compacted bed of cement obtained in step 5. Note the air temperature.
4. Calculate the specific surface S in square centimeters per gram of the tested cement by using the following formula, if the temperature at calibration and at the time of test is

within ± 3% of each other

$$S = Ss \frac{\sqrt{T}}{\sqrt{Ts}}$$

Where Ss = specific surface of the standard cement used in calibration in cm2 / gm

Ts = measured time in seconds required for the fluid to fall the middle interval for standard sample, and

T = measured time in seconds required for the fluid to drop over the middle interval.

Compare the test values with specified values of the cement sample used.

Observations and calculations:

Apparatus identification	
Mass of empty crucible, gms	
Mass of crucible + mercury required to fill the cell, gms	
Mass of Mercury required to fill the cell Wa, gm.	
Mass of crucible + mercury required to fill the portion of the cell above the cement bed, gm.	
Mass of mercury required to fill portion of cell above the cement bed, Wb gm.	
Bulk volume of compacted bed of cement, v, cm^3	
Mass of ample, w, gm	
Average time taken by manometer liquid to fall from second to third line Ts, sec	
Air temperature, ^0C	
Specific surface of standard cement, Ss, cm^2/g	

Standard values:

The specific surface by air permeability method for different should not be less than;

Ordinary Portland cements = 2250 cm^2/g

Rapid hardening cement = 3250 cm^2/g

Low heat cement= 3200cm^2/g

Questions:

1. What does the fineness of cement indicate?
2. What is the maximum or minimum value of fineness of cement?
3. What effect does additional fineness of grading have upon the strength of concrete and on the rate of development of strength?
4. Define specific surface of cement, name the popular methods to determine the specific surface, explain the basic theory behind the air permeability method for determining the fineness. Why is the fineness an important characteristic of cement?
5. Is the Blaine's apparatus suitable for measuring the fineness of all particles?
6. Give several other possible methods for getting particle size and its distribution. What precautions do you take while performing the experiment?
7. What precautions do you take transporting and storing in cement?
8. Elaborate the statement in relation to the arrival of cement at the construction site, first arrived first used. Correct the statements: (a) Finer the cement, lesser the surface area.
9. (b) Finer the cement, lesser the strength it will attain.
10. What does the test of sieving the cement through 90-micron IS sieve indicate?
11. Does it give any idea of the particle's sizes present in the sample?
12. What is the object of this test?

Experiment No.: 1(e) **Date:**

SPECIFIC GRAVITY OF CEMENT

Objective: To determine the specific gravity of cement sample.

Significance:

Specific gravity is made use of in design calculations of concrete mixes. It is required in calculating the compacting factor in connection with the workability measurements. It is also considered when dealing with light weight and heavy weight concrete. Fig shows Specific gravity bottle (Le-chatelier's flask).

Apparatus: Specific gravity bottle, electronic weighing machine.

Procedure:

As the cement reacts with water its specific gravity is determined using non-reactive liquid like kerosene.

1. The specific gravity bottle is cleaned and weight (W1) is noted.
2. The bottle is filled about 1/3rd of cement and the weight (W2) is noted.
3. This is again filled with kerosene and the weight (W3) is noted.
4. The specific gravity bottle is cleaned and it is filled with kerosene and the weight (W4) is noted.
5. This is again filled with water and the weight (W5) is noted.

Observation and calculations:

1. The Le-chatelier's flask should be free from moisture content, that mean flask is thoroughly dried.
2. Now, weigh the empty flask and note it as **W1**.
3. Take 50gm of cement and add it in Flask. Now weight the Flask with the stopper as **W2**
4. Now pour kerosene in the sample up to the neck of the bottle. Mix thoroughly and see that no air bubbles left in the flask. Note down the weight as **W3**
5. Empty the flask and fill the bottle with kerosene up to the tip of the bottle and record the

weight as **W4**.

Specific gravity of cement = $\frac{(W2-W1)}{(W2-W1)-(W3-W4)*G}$

Where, G = Specific Gravity of Kerosene

Results:

Specific gravity of cement = ______

Standard value:

Specific gravity of cement should be between 3.0 to 3.5.

Experiment No.: 1(e) **Date:**

SOUNDNESS OF CEMENT

Objective: To determine the soundness of cement sample.

Soundness of cement can be defined as its ability to retain its volume after it gets hardened. This means that a properly sound cement will undergo minimum volume change after it converts into the hardened state. In the soundness test of cement, we determine the amount of excess lime. This test can be conducted by Le-chatelier's method and Autoclave Method. Here we will discuss Le- chatelier's method of determining the soundness of cement.

Significance of Soundness Test on Cement

Cement is a composition of lime, silica, alumina, magnesia, alkaline, sulfur trioxide, iron oxide, and calcium sulfate. Among which, lime constitutes 60 to 70%. Hence, a cement deficient in lime will set quickly and will affect the property of the cement. Lime content in higher amount will make the cement unsound. An unsound cement will affect the quality of the cement work performed. This demand of soundness test of cement before using it. Through this test, it is ensured that the cement won't undergo any sort of expansion due to the presence of excess amount of lime.

Procedure:

1. The Le- chatlier mould and the glass plates are lightly oiled before conducting the test
2. Prepare a cement paste as in consistency test with 0. 78 times the water required to give a paste of standard consistency
3. Fill the cement paste in the Le- chatelier's mould taking care to keep the edges of the mould gently together during the operation.
4. Cover the mould with another piece of a glass plate and place a small weight over the cover plate.
5. Submerge the whole assembly immediately in water at a temperature of 27 ± 2 °C and keep it there for 24 hours.
6. Take out the assembly again in water at 27+/- 2 °C. The distance between the indicator points are measured as A.
7. Submerge assembly again in water at 27 + /- 2 °C

8. Bring the water to boiling in 25 to 30 minutes and keep at boiling for 3 hours. The assembly should be immersed in water during this process.
9. Remove the mould from water and allow it to cool to 27 +/- 2 °C
10. Measure the distance between the indicator points as B.

Observation & Calculations:

Expansion= B - A =

Here, A = The measurement taken after 24hours of immersion in water at 27 ± 2 °Celsius B = The measurement taken after 3hours of immersion in water at boiling temperature

Standard value:

- The value of soundness of cement obtained for Ordinary Portland Cement (OPC), Low heat cement, high alumina cement and rapid hardening cement must not exceed 10mm (by Le-chatelier's Method).
- The Le-chatelier's Method helps us to determine the lime present in the cement in excess. This is the excess lime that causes expansion of cement.

TESTS ON FINE AGGREGATES

(As per IS 2386: 1963 – Reaffirmed in 2012: Part I to IV

and specifications as per IS 383:2016)

Experiment No.: 2 (a) **Date:**

SPECIFIC GRAVITY OF FINE AGGREGATE

Aim: To determine the specific gravity of the fine aggregate.

Apparatus:

1. Balance,
2. Pycnometer
3. Metal tray,
4. Conical mould.

Theory: Specific gravity of an aggregate is defined as ratio of the mass of a given volume of a sample to the mass of a equal volume of water at the same temperature. The specific gravity of fine aggregate is generally required for calculations related to concrete mix designs, for determination of moisture content and for calculations of volume yield of concrete. The specific gravity also gives information on quality and properties of aggregates.

Specific gravity also indicates the change in shape and grading of aggregates used in mix design

Procedure:

1. Take the empty weight of the pycnometer, let the weight be W1
2. Take the sample of fine aggregate for which the specific gravity has to be found out (note: the sample must be saturated and surface dry i.e. free from surface moisture) and transfer that to the empty flask and then it is weighed let the weight be W2
3. The pycnometer with the sample is filled with water up to a mark (made on the flask) and its weight is taken. The flask should be completely dry on the outer surface W3
4. Fill the flask with water to the top cone, Roll the flask in an inclined position to eliminate the air bubble and replace with water by means of wash bottleW4.
5. Calculate the specific gravity of the fine aggregate by using the formula

$$\text{Specific Gravity} = \frac{Dry\ weight\ of\ aggregate}{Weight\ of\ equal\ volume\ of\ water}$$

Observation and calculation:

1. Mass of empty pycnometer W_1 ________g
2. Mass of Pycnometer + 1/3 volume of fine aggregates W_2 ________g
3. Mass of pycnometer + 1/3 volume of fine aggregates W_2 + 2/3 volume of water W_3 ________g
4. Mass of pycnometer+ full of water W_4_____________ g

$$\text{Specific Gravity} = \frac{W2-W1}{(W4-W1)-(W3-W2)}$$

Result: The Specific Gravity of given Fine Aggregate is_______

Experiment No.: 2 (b) **Date:**

BULKING OF FINE AGGREGATES

Aim: To determine the bulking of fine aggregates and to draw curve between water content and bulking.

Apparatus: Balance, Cylindrical container, graduated cylinder, Beaker, Metal tray, Steel rule and Oven.

Theory and scope: In concrete mix design, the quantity of fine aggregates used in each batch should be related to know the volume of cement. The difficulty with measurement of fine aggregate by volume is the tendency of sand to vary s in bulk according to moisture content. The extent of this variation is given by this test.

If sand is measured by volume and no allowance is made for bulking the mix will be richer than specified because for given mass, moist sand occupies a considerable larger volume than the same mass of dry sand, as the particles are less closely packed when the sand is moist. If as usual the sand is measured by loose volume, it is necessary in such a case to increase the measured volume of the sand, in order that the amount of sand put into concrete may be the amount intended for the nominal mix used (based on the dry sand). It will be necessary to increase the volume of sand by the best, but a correction of the right order can easily be determined and should be applied in order to keep the concrete uniform.

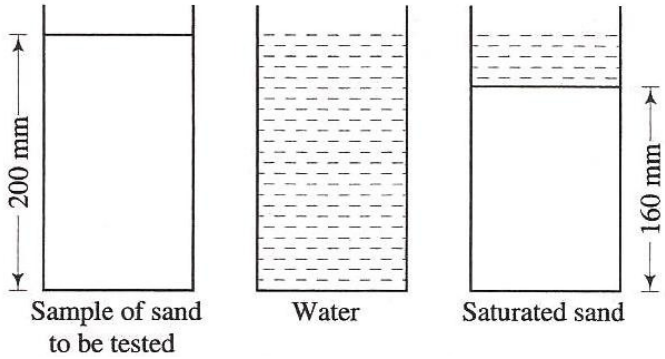
This experiment is intended to cover the field method of determining the necessary adjustment for bulking of the aggregate.

Procedure:

1. Put sufficient of the oven dry sand loosely into the container until it is about two third full. Level off the top of sand and weigh the container. Calculate the mass of sand by deducting the mass of container.
2. Push a steel rule vertically down through the sand at the middle to the bottom and measure the height of the sand. Let it be **V1** mm^3
3. Empty the sand out into a clean metal tray without any loss.
4. Add 1 percent of water by mass of sand. Mix the sand and water thoroughly by hand (1).
5. Put the wet sand loosely into the container without tamping it.
6. Smooth and level the top surface of the moist sand and measure its depth at the middle with the steel rule. Let it be **V2** mm^3 (2)
7. Repeat the steps (1) and (2) of the above procedure with 1% of water by mass. Go on increasing the percentage by one till bulking is maximum and a start falling down

ultimately bulking is Zero. i.e. saturated sand occupies the same volume as dry sand

$$\textbf{Percentage Bulking} = \frac{V2-V1}{V1} \times 100$$



Observations and calculations

Sand	% of Water Added	Initial Volume (V1)	Final Volume (V2)	**% Bulking =** $\frac{V2-V1}{V1}$ **x 100**

Result: Bulking of fine aggregate = ____________________%

Experiment No.: 2 (c) **Date:**

BULK DENSITY OF FINE AGGREGATES

Objective: To determine the bulk density of given sample of fine aggregate.

Apparatus: Cylindrical container, Weighing Balance, vibrator.

Theory: The bulk density is the weight of material in a given volume, and for the purpose of this standard it is measured in kilograms per litre. The bulk density of an aggregate is affected by several factors, including the amount of moisture present and the amount of effort introduced in filling the measures. t is emphasized that this is a laboratory test intended for comparing properties of different aggregates. It is not generally suitable for use as a basis for quoting mix design conversion factors.

Procedure:

1. The diameter and height of the container measured to calculate the volume.
2. The container is weighed and its mass is noted.

   The container is filled with aggregate in loose state. The measure shall be filled to overflowing by means of a shovel or scoop, the aggregate being discharged from a height not exceeding 5 cm above the top of the measure. Care shall be taken to prevent, as far as possible, segregation of the particle sizes of which the sample is composed. The surface of the aggregate shall then be levelled with a straightedge. The net mass of the aggregate in the measure shall then be determined and the bulk density calculated in kilogram per litre.
3. The container is placed on the vibrating machine. The vibrating machine is started and fine aggregate is added till the container is filled with aggregates up to the brim. The weight of the container with aggregate in densest state is noted down.
4. Bulk density is calculated in both loose and compacted state.

Diameter of cylinder = d =_______cm

Height of cylinder = h = _______cm

Sl.No.	Details	Trail 1	Trail 2	Trail 3
1	Volume of cylinder, V, m^3			
2	Mass of empty cylinder, M_1, g			
3	Mass of empty cylinder + Sand in Loosest state, M_2, g			
4	Mass of empty cylinder + Sand in densest state, M3, g			
5	Bulk Density in loosest state, $\rho_{loosest}$, kg/m^3			
6	Bulk Density in densest state, $\rho_{densest}$, kg/m^3			

$$\rho_{loosest} = \frac{(M2 - M1)}{M1}$$

$$\rho_{Densest} = \frac{(M3 - M1)}{M1}$$

Experiment No.: 2 (d) **Date:**

SIEVE ANALYSIS: FINENESS MODULUS OF FINE AGGREGATE.

Aim: To determine fineness modulus and grain size distribution of the given fine aggregates

Apparatus:

I.S. Sieve Set (4.75mm,2.36mm,1.18mm.600mm,300mm,150mm), Sieve Shaker., Balance.

Theory:

The sieve analysis is a simple test consisting of sieving a measured quantity of material through successively smaller sieves. The weight retained on each sieve is expressed as a percentage of the total sample. The sedimentation principle has been used for finding the grain size distribution of fine soil fraction: two methods are commonly used. Viz, Pipette method and Hydrometer method of distribution of soil particles. Most of the methods for soil identification and classification are based on certain physical properties of the aggregate. The commonly used properties for classification are the grain size distribution.

Grain size analysis also known as mechanical analysis. It determines the percentages of individual grain size present in the sample. The result of the test is of great value in soil classification. In mechanical stabilization of soil and for designing soil aggregate mixture the result of the gradation tests is used. Conclusions have also been made between the grain size distribution of soil and the general soil behaviors as sub grade material and the performance such as susceptibility to frost action. Pumping of rigid pavements etc. Sand is the fine aggregate used in mortar. Coarse aggregate that is the broken stone or gravel and the mixed aggregate which is the combination of coarse and fine aggregates are used in concrete. The coarse aggregate unless mixed with fine aggregates does not produce good quality concrete for construction works.

Fineness Modulus Fineness modulus is only a numerical index of fineness giving some idea of the mean size of particles in the entire body of aggregate.

Procedure:

1. Take 1Kg of sand in a clean dry plate. from a sample of 10Kg, by quartering & breaking clay lamps if any.
2. Arrange the sieves in order of IS Sieve No: 4.75mm, 2.36mm, 1.18mm, 600micron, 300mm, 150micron.Fix them in a Sieve Shaking machine with a pan at the bottom &Cover at the top.

3. Keep the sand in the top Sieve Carry out the Sieving in the set of Sieves as arranged before for not less than 10minutes.

4. Find mass retained on each Sieve & tabulate the reading in the observation sheet.

5. The grain size greater than 75 microns is determined by sieving set of sieves of decreasing order. Sieve opening place one below the other and separating out the different size ranges.

Two methods of sieve analysis are as follows

- Wet sieving applicable to soil and
- Dry sieving applicable only to soil which has negligible proportion of clay and silt.

Observation: Weight of fine aggregates for sieving = _____________gms.

Sl. No.	Sieve Size	Weight of sand retained	Cumulative weight retained	Cumulative % retained (C)	% Fineness (100-C)
1	10 mm				
2	4.75 mm				
3	2.36 mm				
4	1.18 mm				
5	600 µ				
6	300 µ				
7	150 µ				

Fineness Modulus $= \frac{\sum cumulative\ \%\ Retained}{W}$ **x 100**

Sl.No.	IS Sieve Size	Percentage Passing			
		Zone I	Zone II	Zone III	Zone IV
1	10 mm	100	100	100	100
2	4.75 mm	90 - 100	90 - 100	90 - 100	90 - 100
3	2.36 mm	60 - 95	75 - 100	85 - 100	95 - 100
4	1.18 mm	30 – 70	55 – 90	75 – 100	90 – 100
5	600 µ	15 – 34	35 – 59	60 – 79	80 -100
6	300 µ	5 – 20	8 – 30	12 – 40	15 – 50
7	150 µ	0 – 10	0 – 10	0 – 10	0 - 15

Source: IS 383: 2016

Experiment No.: 2 (e) **Date:**

DETERMINATION OF MATERIALS FINER THAN 75-MICRON (SILT CONTENT)

(IS: 2386 (Part I) – 1963)

Aim:

This method of test deals with the procedure for determining the total quantity of material finer than 75micron IS Sieve in aggregates by washing.

Procedure:

1. The test sample shall be dried to constant weight at a temperature of 110 ° ± 5 °C and weighed to the nearest 0.1 percent.
2. The test sample after being dried and weighed shall be placed in the container and sufficient water added to cover it. The contents of the container shall be agitated vigorously.
3. The agitation shall be sufficiently vigorous to result in the complete separation from the coarse particles of all particles finer than 75-micron and bring the fine material into suspension. Care shall be taken to avoid, as much as possible, the decantation of the coarse particles of the sample. The operation shall be repeated until the wash water is clear.
4. The wash water containing the suspended and dissolved solids shall be immediately poured over the nested sieves arranged with the coarser sieve on the top.
5. All material retained on the nested sieves shall be returned to the washed sample. The washed aggregate shall be dried to constant weight at a temperature not exceeding 110°C and weighed to the nearest 0.1 percent.

The amount of material passing the 75-micron IS Sieve shall be calculated as follows:

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

Where,

A = percentage of material finer than 75-micron

B = original dry weight, and

C = dry weight after washing.

TESTS ON COARSE AGGREGATES

(As per IS 2386: 1963 – Reaffirmed in 2012: Part I to IV

and specifications as per IS 383:2016)

Experiment No: 3(a) **Date:**

Specific Gravity and Water Absorption

Objective: to determine the specific gravity, apparent specific gravity and water absorption of aggregates.

Apparatus: Balance, Oven, Wire Basket, Stout Watertight Container, Dry Soft Absorbent Cloths, Shallow Tray

Theory: Specific gravity test of aggregates is done to measure the strength or quality of the material while water absorption test determines the water holding capacity of the coarse and fine aggregates. If water absorption of aggregates is more, they are porous and hence weak

Procedure:

1. The sample shall be thoroughly washed to remove finer particles and dust, drained and then placed in the wire basket and immersed in distilled water at a temperature between 22°C and 32°C with a cover of at least 5 cm of water above the top of the basket.
2. Immediately, after immersion the entrapped air shall be removed from the sample by lifting the basket containing it, 25 mm above the base of the tank and allowing it to drop 25 times at the rate of about one drop per second. The basket and aggregate shall remain completely immersed during the operation and for a period of 24 hours afterwards.
3. The basket and the sample shall then be jolted and weighed in water at a temperature of 22° to 32°, say of mass A_1 (If it is necessary for them to be transferred to a different tank for weighing, they shall be jolted 25 times as described above in the new tank before weighing)
4. The basket and the aggregate shall then be removed from the water and allowed to drain for a few minutes, after which the, aggregate shall be gently emptied from the basket on to one of the dry clothes, and the empty basket shall be returned to the water, jolted 25 times and weighed in water (Mass A_2).
5. The aggregate placed on the dry cloth shall be gently *surface* dried with the cloth, transferring it to the second dry cloth when the first will remove no further moisture. It shall then be spread out not more than one stone deep on the second cloth, and lest exposed to the atmosphere away from direct sunlight or any other source of heat for not less than 10 minutes, or until it appears to be completely surface dry. The aggregate shall be turned over at least once during this period and a gentle current of unheated air may be used after the first ten minutes to accelerate the drying of difficult aggregates. The aggregate shall then be weighed (Mass B).

(**Note:** If the apparent specific gravity only is required the above operation may be omitted)

Specific Gravity and water absorption test for coarse aggregate

Observations and Calculations

Sl. No.	Details	Trial 1	Trial 2	Trial 3
1	Mass of basket and the sample in water, A_1, g			
2	Mass of empty Basket in water, A_2, g			
3	Mass of saturated aggregate, $(A_1 - A_2) = A$, g			
4	Mass of surface-dry aggregate, B, g			
5	Mass of oven dried aggregate, C, g			
6	Specific Gravity = $\frac{C}{B-A}$			
7	Apparent Specific Gravity = $\frac{C}{C-A}$			
8	Water Absorption = $\frac{B-C}{C}$ x 100			

Bulk Density test on Coarse aggregate

Diameter of cylinder = d =_____cm

Height of cylinder = h =_______cm

Sl. No	Details	Trial 1	Trial 2
1	Volume of cylinder, V, m^3		
2	Mass of empty cylinder , M_1, kg		
3	Mass of cylinder + sand in loosest state, M_2, kg		
4	Mass of cylinder + sand in densest state, M_3, kg		
5	Bulk Density in loosest state, $\rho_{loosest}$, kg/m^3		
6	Bulk Density in densest state, $\rho_{densest}$, kg/m^3		

$$\rho_{loosest} = \frac{(M2-M1)}{M1}$$

$$\rho_{\text{Densest}} = \frac{(M3-M1)}{M1}$$

The aggregate shall then be placed in the oven in the shallow tray, at a temperature of IO0 to 110°C and maintained at this temperature for 24 f l/2 hours. It shall then be removed from the oven, cooled in the airtight container and weighed (Mass C).

Calculations:

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

Water Absorption = $\frac{B-C}{C}$ x 100

Where,

A = Mass of saturated aggregate in water, g = $(A_1 - A_2)$

B = Mass of saturated surface-dry aggregate in air, g

C = Mass of oven dried aggregate in air, g

Experiment No: 3(b) **Date:**

SIEVE ANALYSIS OF COARSE AGGREGATES

Objective: This method covers the procedure for the determination of particle size distribution of fine, coarse and all-in-aggregates by sieving or screening.

Apparatus: Sieves - Sieves of the sizes given in Table I, conforming to IS: 460-1962 Specification for Test Sieves (Revised) shall be used.

Procedure:

1. The sample shall be brought to an air-dry condition before weighing and sieving. This may be achieved either by drying at room temperature or by heating at a temperature of 100° to 110°C. The air-dried sample shall be weighed and sieved successively on the appropriate sieves starting with the largest. Care shall be taken to ensure that the sieves are clean before use.
2. Each sieve shall be shaken separately over a clean tray until not more than a trace passes, but in any case, for a period of not less than two minutes. The shaking shall be done with a varied motion, backwards and forwards, left to right, circular clockwise and anti-clockwise, and with frequent jarring, so that the material is kept moving over the. sieve surface in frequently changing directions. Material shall not be forced through the sieve by hand pressure, but on sieves coarser than 20 mm, placing of particles is permitted. Lumps of fine material, if present, may be broken by gentle pressure with fingers against the side of the sieve. Light brushing with a soft brush on the underside of the sieve may be used to clear the sieve openings.
3. Light brushing with a fine camel hair brush may be used on the 150-micron and 75-micron IS Sieves to prevent aggregation of powder and blinding of apertures. Stiff or worn out brushes shall not be used for this purpose and pressure shall not be applied to the surface of the sieve to force particles through the mesh.
4. On completion of sieving, the material retained on each sieve, together with any material cleaned from the mesh, shall be weighed.
5. In order to prevent binding of the sieve apertures by overloading, the amount of aggregate placed on each sieve shall be such that the weight of the aggregate retained on the sieve at completion of the operation is not greater than the value given for that sieve in Table I. Sample weights given in Table II will thus normally require several operations on each sieve.

Sl No.	IS Sieve Designation	Percentage Passing for Single-Sized Aggregate of Nominal Size						Percentage Passing for Graded Aggregate of Nominal Size			
		63 mm	40 mm	20 mm	16 mm	12.5 mm	10 mm	40 mm	20 mm	16 mm	12.5 mm
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
i)	80 mm	100	-	-	-	-	-	100	-	-	-
ii)	63 mm	85 to 100	100	-	-	-	-	-	-	-	-
iii)	40 mm	0 to 30	85 to 100	100	-	-	-	90 to 100	100	-	-
iv)	20 mm	0 to 5	0 to 20	85 to 100	100	-	-	30 to 70	90 to 100	100	100
v)	16 mm	-	-	-	85 to 100	100	-	-	-	90 to 100	-
vi)	12.5 mm	-	-	-	-	85 to 100	100	-	-	-	90 to 100
vii)	10 mm	0 to 5	0 to 5	0 to 20	0 to 30	0 to 45	85 to 100	10 to 35	25 to 55	30 to 70	40 to 85
viii)	4.75 mm	-	-	0 to 5	0 to 5	0 to 10	0 to 20	0 to 5	0 to 10	0 to 10	0 to 10
ix)	2.36 mm	-	-	-	-	-	0 to 5	-	-	-	-

Table 1 Maximum Weight to Be Retained at The Completion of Sieving

Max Size present in substantial Proportions	Minimum Weight of Sample to be taken for sieving (kg)
63	50
50	35
40 – 31.5	15
25	5
20 – 16	2
12.5	1
10	0.5
6.3	0.2
4.75	0.2
2.36	0.1

Table 2 Minimum Weight of Sample for Sieve Analysis

Max Size present in substantial Proportions	Minimum Weight of Sample to be taken for sieving (kg)
63	50
50	35
40 – 31.5	15
25	5
20 – 16	2
12.5	1
10	0.5
6.3	0.2
4.75	0.2
2.36	0.1

Sl.No.	Sieve Size	Weight of sand retained	Cumulative weight retained	Cumulative % retained (C)	% Fineness (100-C)
1	63				
2	50				
3	40				
4	32.5				
5	25				
6	20				
7	16				
8	12.5				
9	10				

$$\text{Fineness Modulus} = \frac{\sum Cumulative\ \%\ Retained}{W} \times 100$$

Experiment No: 3 (c) **Date:**

DETERMINATION OF COMBINED FLAKINESS & ELONGATION INDEX

IS: 2386 (Part I) – 1963

Aim:

This method of test lays down the procedure for determining the combined flakiness and elongation index of coarse aggregate.

Scope and Significance:

1. The degree of packing of the particles of one size depends upon their shape.
2. Due to high surface area to volume ratio, the flaky and elongated particles lower the workability of concrete mixes.
3. Flaky and elongated particles are considered undesirable for base coarse construction as they may cause weakness with possibilities of braking down under heavy loads.
4. BS-1241 specifies a Flakiness index not exceeding 30% irrespective of the aggregate size.
5. Maximum permitted Elongated index is 35, 40 or 45% for aggregate sizes 2 ½'' – 2'', 1 ½'' – ¾'' & ½'' –3/8''.
6. Both Flakiness and Elongation tests are not applicable to sizes smaller then 6.3mm i.e. ¼''sieve.

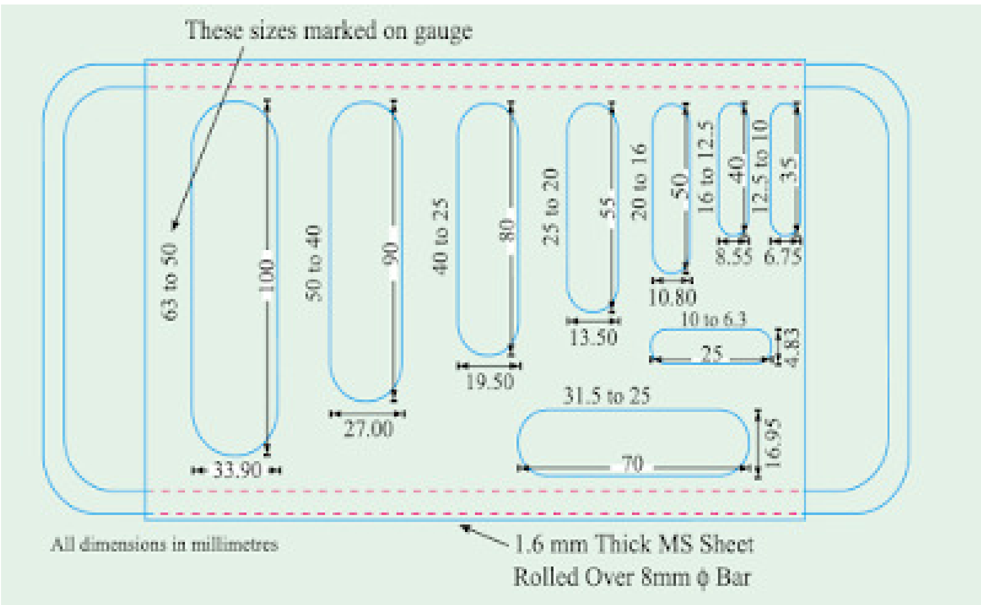


Fig: Flakiness Index

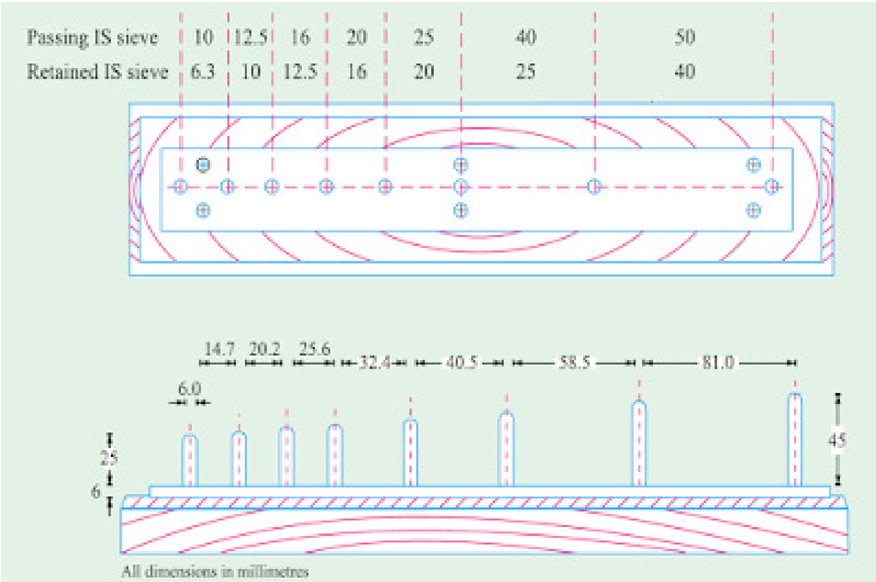


Fig: Elongation Index

TABLE V DIMENSIONS OF THICKNESS AND LENGTH GAUGES

(*Clauses* 4.2, 4.4.1, 4.4.2, 5.2 *and* 5.4.1)

Size of Aggregate		Thickness Gauge*	Length Gauge†
Passing Through IS Sieve	Retained On IS Sieve		
(1)	(2)	(3)	(4)
		mm	mm
63-mm	50-mm	33·90	—
50-mm	40-mm	27·00	81·0
40-mm	25-mm	19·50	58·5
31·5-mm	25-mm	16·95	—
25-mm	20-mm	13·50	40·5
20-mm	16-mm	10·80	32·4
16-mm	12·5-mm	8·55	25·6
12·5-mm	10-mm	6·75	20·2
10-mm	6·3-mm	4·89	14·7

*This dimension is equal to 0·6 times the mean sieve size.

†This dimension is equal to 1·8 times the mean sieve size.

Procedure:

1. To determine the combined flakiness and elongation index of coarse aggregate:
2. Take sufficient quantity (W1) of coarse aggregate sample by quartering so as to provide at least 200 pieces of any fraction.
3. Carry out sieving by hand: The sample shall be sieved with the sieves specified in the table 1. The sieving shall be done over a clean dry tray for a period not less than 2 minutes.

4. Pass the separated aggregate fractions as retained on the sieves in step 2 through the corresponding slots in the thickness guage.
5. Find the total mass W2 of the materials passing through the slots of the thickness guage.
6. Calculate the flakiness index as defined below. The flakiness index is an empirical factor expressing a total material passing through the slots of the thickness guage as the percentage of the mass of sample taken for testing.
7. The weight of particles not passes through the thickness gauge is recorded for each fraction. This is the weight W3 of aggregate considered to calculate the Elongation index.
8. Pass the separated aggregate fractions as retained on the sieves in step 2 through the corresponding slots in the thickness guage.
9. Find the total mass W4of the material retained on the length gauges.
10. Determine the elongation index as percentage material retained by the length gauges to the total weight of non-flaky aggregate sample.

Observation and calculations:

Flakiness index of coarse aggregates

Sl. No.	Size of aggregate			Weight of aggregate retained on each sieve	Weight of aggregate passing through slot
	Passing through IS: sieve, mm	Retained on IS: sieve, mm	Thickness gauge Size, mm		
1	63	50	33.90		
2	50	40	27.00		
3	40	31.5	19.50		
4	31.5	25	16.95		
5	25	20	13.50		
6	20	16	10.80		
7	16	12.5	8.55		
8	12.5	10	6.75		
9	10	6.3	4.89		
				$\sum W = W_1$	$\sum W = W_2$

$$\text{Flakiness Index of aggregates} = \frac{W2}{W1} * 100$$

Elongation index of aggregate

Sl. No.	Size of aggregate			Weight of aggregate retained on each sieve	Weight of aggregate passing through slot
	Passing through IS: sieve, mm	Retained on IS: sieve, mm	Length gauge Size, mm		
1	63	50	-------		
2	50	40	81.0		
3	40	31.5	58.5		
4	31.5	25	-------		
5	25	20	40.5		
6	20	16	32.4		
7	16	12.5	25.6		
8	12.5	10	20.2		
9	10	6.3	14.7		
				$\sum W = W_3$	$\sum W = W_4$

$$\text{Flakiness Index of aggregates} = \frac{W4}{W3} * 100$$

I S Sieve		Flakiness Index		Elongation Index	
Passing (mm)	Retained (mm)	Weight of aggregate taken, W_1 (gm)	Weight of aggregate passing on Thickness Gauge, W_2 (gm)	Weight of non-flaky aggregate retained on thickness gauge, W_3 (gm)	Weight of aggregate in each fraction retained on length gauge, W_4 (gm)
63	**50**				
50	**40**				
40	**31.5**				
31.5	**25**				
25	**20**				
20	**16**				
16	**12.5**				
12.5	**10**				
10	**6.3**				
Total					
Flakiness Index (W_2/W_1) X 100				Elongation Index (W_4/W_3) X 100	
Combined Flakiness and Elongation Index:				Specific Limit:	Max 40%

Results:

Combined Flakiness and Elongation Index = ___________%

Standard values:

Indian Road Congress has recommended the maximum allowable limits of flakiness index values for various types of construction, as given in table.

Sl. No.	Types of Pavement construction	Maximum limits of Flakiness index, %
1	Bituminous carpet	30
2	Bituminous / Asphaltic concrete Bituminous penetration macadam Bituminous surface dressing (single coat, two coats and precoated), Built-up Spray grout	25
3	Bituminous macadam Water bound macadam. Base and surfacing courses	15

Questions:

1. What are the flaky and elongated aggregates?
2. Define flakiness and elongation indices. What is their significance? What are the results expressed?
3. What is meant by size of slot of the thickness gauge, and that of a length gauge?
4. Describe the process of quartering an aggregate. Why is it done?
5. What precautions do you take while performing the experiment?
6. How do the flaky and elongated aggregate affect the resulting concrete?
7. How are the sizes of the thickness gauge and length gauge related to the sizes of the sieves through which the fraction has passed and retained, respectively?
8. How does the percentage wear change if the aggregate used in the abrasion test is flaky or elongated?

TESTS ON CONCRETE

Experiment No.: 4 (a) **Date:**

SLUMP TEST

(IS 1199:1959)

Objective:

To determine the consistency of concrete mix of given proportions.

Scope and significance:

Unsupported fresh concrete flows to the sides and a sinking in height takes place. This vertical settlement is known as Slump. In this test fresh concrete is filled into a mould of specified shape and dimensions, and the settlement or slump is measured when supporting mould is removed. Slump increases as water content is increased. For different works different slump values have been recommended.

The slump is a measure indicating the consistency or workability of cement concrete. It gives an idea of water content needed for concrete to be used for different works. A concrete is said to be workable if it can be easily mixed, placed compacted and finished. A workable concrete should not show any segregation or bleeding. Segregation is said to occur when coarse aggregate tries to separate out from the finer material and a concentration of coarse aggregate tries to separate out from the finer material and a concentration of coarse aggregate at one place occurs. This results in large voids, less durability and strength. Bleeding of concrete is said to occur when excess water comes up at the surface of concrete. This causes small pores through the mass of concrete and is undesirable.

By this test we can determine the water content to give specified slump value. In this test water content is varied and in each case slump value is measured till we arrive at water content giving the required slump value.

This test is not a true guide to workability. For example, a harsh mix cannot be said to have same workability as one with a large proportion of sand even though they may have the same slump.

Apparatus: Iron pan to mix concrete, slump cone, spatula, trowels, tamping rod and graduated cylinder.

Figure 1: Slump cone, tamping rod

Procedure:

For the given mix ratio materials are calculated to the required volume of concrete.

- Mix the dry constituents thoroughly to get a uniform colour and then add water.
- Place the mixed concrete in the cleaned slump cone mould in 4 layers, each approximately ¼ of the height of the mould. Tamp each layer 25 times with tamping rod distributing the strokes in a uniform manner over the cross-section of the mould. For the second and subsequent layers the tamping rod should penetrate in to the underlying layer.
- Strike off the top with trowel or tamping rod so that the mould is exactly filled.
- Remove the cone immediately, raising it slowly and carefully in the vertical direction.
- As soon as the concrete settlement comes to a stop, measure the subsidence of concrete in mm which will give the slump.

Note: Slump test is adopted in the laboratory or during the progress of work in the field for determining consistency of concrete where nominal maximum size of aggregate does not exceed 40mm.

Any slump specimen which collapses or shears off laterally gives incorrect results and if this occurs the test is repeated, only the true slump should be measured. Fig shows types of slump.

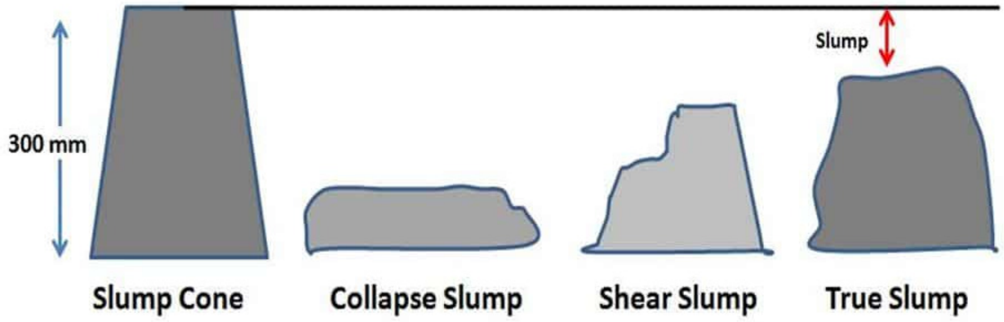


Fig: Types of Slumps

Observations &Results:

Water cement ratio	Slump (mm)

Standard values:

Sl. No.	Name of works	Slump, mm	Water-cement ratio
1	Concrete for roads and mass concrete	25 to 50	0.70
2	Concrete for R.C.C beams and slabs	50 to 100	0.55
3	Columns and retaining walls	75 to 125	0.45
4	Mass concrete in foundation	25 to 50	0.70

Questions:

1. What do you mean by workability and consistency of freshly mixed concrete?
2. What is slump of concrete?
3. What is the significance of slump test with the compaction factor test?
4. What are segregation and bleeding?
5. What are the undesirable effects of segregation and bleeding?
6. How can the bleeding be prevented?

Experiment No.: 4 (b) **Date:**

COMPACTION FACTOR TEST

(IS 1199:1959)

Objective:

To determine the workability of concrete mix of given proportions by the compaction factor test.

Scope and significance:

Compaction factor test is adopted to determine the workability of concrete, where nominal size of aggregates does not exceed 40mm, and is primarily used in laboratory. It is based upon the definition, that the workability is that property of the concrete which determines the amount of work required to produce full compaction. The test consists essentially of applying a standard amount of work to standard quantity of concrete and measuring the resulting compaction. To find the workability of freshly prepared concrete, the test is carried out as per specifications of IS: 1199- 1959. Workability gives an idea of capability of being worked, i.e. ideas to control the quantity of water in cement concrete mix to get uniform strength.

It is more sensitive and precise than slump test and is particularly useful for concrete mixes of low workability. The compaction factor (C.F) test is able to indicate small variations in workability over a wide range.

Apparatus:

Compaction factor apparatus, trowels, graduated cylinder, balance, tamping rod and iron buckets.

Procedure:

1. Keep the compaction factor apparatus on a level ground and apply grease on the inner surface of the hoppers and cylinder.
2. Fasten the flap doors.
3. Weigh the empty cylinder accurately and note down the mass as $\mathbf{W_1}$ kg.
4. Fix the cylinder on the base with fly nuts and bolts in such a way that the central points of hoppers and cylinder lie on one vertical line. Cover the cylinder with a plate.

5. **For the given mix ratio materials are calculated to the required volume of concrete.**
   a. Mix the sand and cement dry, until a mixture of uniform colour is obtained. Now mix the coarse aggregate and cement-sand mixture until coarse aggregate is uniformly distributed throughout the batch.
   b. Add the required amount of water to the above mixture and mix it thoroughly until concrete appears to be homogenous.
6. Fill the freshly mixed concrete in upper hopper gently and carefully with hand scoop without compacting. Fig shows apparatus used for determining compaction factor.

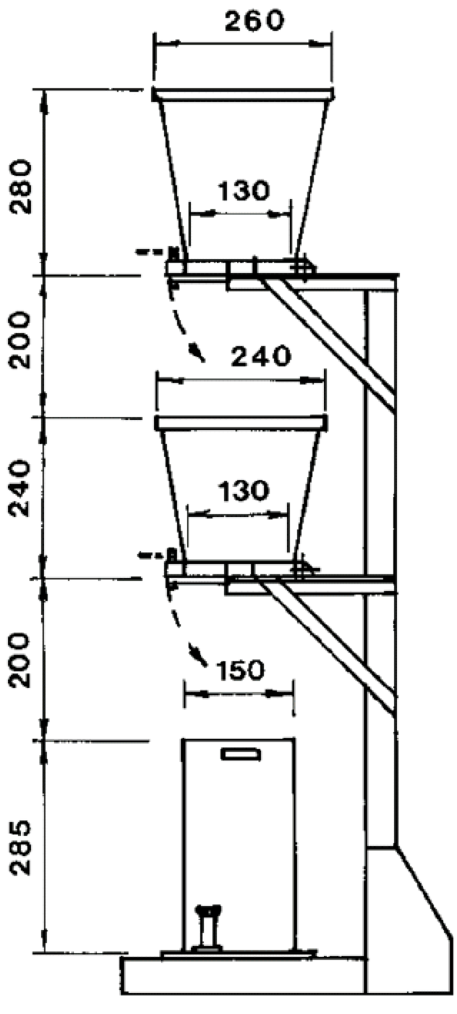


Fig: Compaction Factor Apparatus

Observations and Results:

Mass of the cylinder (**W1**) =_________kg.

Sl. No.	Water – Cement Ratio	Mass with Partially Compacted Concrete W2	Mass of Fully Compacted Concrete	Mass with Partially Compacted Concrete (W2 – W1)	Mass of Fully Compacted Concrete (W3 – W1)	C.F = $\frac{W2 - W1}{W3 - W1}$
1						
2						
3						
4						

Standard values Compacting Factor of concretes with 20mm or 40mm maximum size of aggregate:

Degree of workability	Compacting factor		Uses for which concrete is suitable
	Small apparatus	Large apparatus	
Very low	0.78	0.80	Roads vibrated by power-operated machines. At the more workable end of this group, concrete may be compacted in certain cases with hand operated machines.
Low	0.87	0.87	Roads vibrated by hand-operated machines. At the more workable end of this group, concrete may be manually compacted in roads using aggregates of rounded or irregular shape. Mass concrete foundations without vibration or lightly reinforced sections with vibration.
Medium	0.92	0.935	At the less workable end of this group, manually compacted flat slabs using crushed aggregates. Normal reinforced concrete manually compacted and heavily reinforced sections with vibration.
High	0.95	0.96	For section with congested reinforcement. Not normally suitable for vibrations

Questions:

1. What are Indian Standard Tests for determining the workability of concrete?
2. How do you compare a slump test with a compaction factor test?
3. What is the shape of curve between water cement ratio and compaction factor?
4. In what respects, compaction factor test is a better measure for workability than slump test?
5. What are the limitations of this method?

Experiment No.: 4 (c) **Date:**

VEE BEE CONSISTOMETER TEST

(IS 1199:1959)

Objective:

To determine the workability of freshly mixed concrete by the use of Vee - Bee consistometer.

Scope and Significance:

The workability of fresh concrete is a composite property, which includes the diverse requirements of stability, mobility, compactability, placeability and finishability. There are different methods for measuring the workability. Each of them measures only a particular aspect of it and there is really no unique test, which measures workability of concrete in its totality. This test gives an indication of the mobility and to some extent of the compatibility of freshly mixed concrete.

The test measures the relative effort to change a mass of concrete from one definite shape to another (i.e. from conical to cylindrical) by means of vibration. The amount of effort called remoulding effort is taken as the time in seconds required completing the change. The results of this test are of value in studying the mobility of the masses of concrete made with varying amount of water, cement and with various types of grading of aggregate.

The time required for complete remoulding in seconds is considered as a measure of workability and is expressed as the number of Vee-Bee seconds. The method is suitable for dry concrete. For concrete of slump in excess of 50mm, the remoulding is so quick that the time cannot measure.

Apparatus:

Cylindrical container, Vee-Bee apparatus (consisting of vibrating table, slump cone) standard iron rod, weighing balance and trowels.

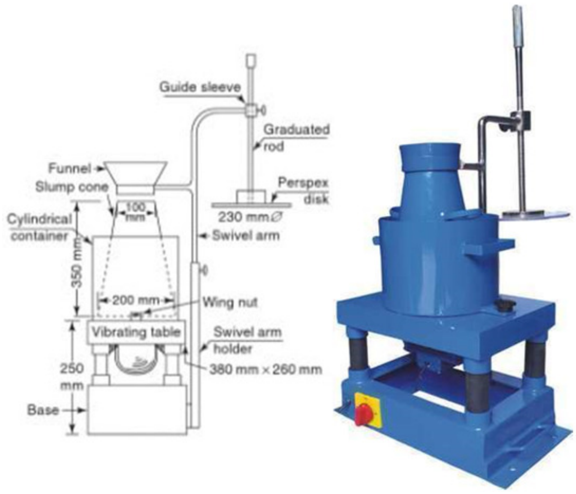


Fig: Vee – Bee Consistometer Apparatus

Procedure:

1. Place the slump cone in the cylindrical container of the consistometer. Fill the cone in four layers, each approximately one quarter of the height of the cone. Tamp each layer with 25 strokes of the rounded end of the tamping rod. The strokes are distributed in a uniform manner over the cross-section of the cone and for the second and subsequent layers the tamping bar should penetrate into the underlying layer. After the top layer has been ridded, struck off level the concrete with a trowel so that the cone is exactly filled.
2. Move the glass disc attached to the swivel arm and place it just on the top of the slump cone in the cylindrical container. Adjust the glass disc so as to touch the top of the concrete cone, and note the initial reading on the initial reading on the graduated rod.
3. Remove the cone from the concrete immediately by raising it slowly and carefully in the vertical direction. Lower the transparent disc on the top of concrete. Note down the reading on the graduated rod.
4. Determine the slump by taking the difference between the readings on the graduated rod record in the steps (2) and (3) above.
5. Switch on the electrical vibrations and start the stop watch. Allow the concrete to remould by spreading out in the cylindrical container.
6. The vibrations are continued until the concrete is completely remoulded, i.e. the surface becomes horizontal and the whole concrete surface adheres uniformly to the transparent disc.
7. Record the time required for complete remoulding seconds which measures the

workability expressed as number of Vee-Bee seconds.

Observations and Calculation:

Initial reading on the graduated rod, **a**		
Final reading on the graduated rod, **b**		
Slump (**b**) – (**a**), cm		
Time for completing remoulding, seconds		

Results:

The consistency of the concrete is: __________

Standard values:

Workability description	**Vee-Bee Time, Seconds**
Extremely dry	32 – 18
Very stiff	18 – 10
Stiff	10 – 5
Stiff plastic	5 – 3
Plastic	3 – 0
Flowing	------

Questions:

1. What property does it measure of the freshly mixed concrete?
2. What are the advantages and disadvantages of this method of test over the other methods?
3. Describe the factors affecting the choice of the method test?

Experiment No.: 4 (d) **Date:**

COMPRESSIVE STRENGTH OF CONCRETE

(IS 519:1959)

Objective:

To determine the compressive strength of concrete cubes.

Scope and significance:

Concrete is primarily is strong in compression and in actual construction, the concrete is used in compression. Concrete besides strong in compression is also good in other qualities. Higher the compressive strength better is the durability. Bond strength also improves with the increase in compressive strength and is important in RCC works. Compressive strength also indicates extent of control exercised during construction. Resistance to abrasion and volume stability improves with the compressive strength. Test for compressive strength is, therefore very important in quality of concrete. Preparation and conduct of compressive strength is comparatively easy and give more consistent results than tensile or flexural strength. This test for determining the compressive strength of concrete has, therefore attained maximum importance. For acceptance criteria, refer to IS: 456. Generally, 15cm cubes are used for testing at 28days.

Apparatus required:

Cube moulds 150mm size as per IS: 516, Trowels, GI sheet for mixing, 16mm dia, 400mm long tamping rod with bullet pointed at the lower end, glass plate thicker than 6.5mm or 13mm thick machined plate and of dimensions greater than 17.5mm, 100-ton compressive testing machine.

Fig: Compressive strength

Procedure:

1. Fill concrete into the mould in layers approximately 5cm deep by moving the scoop around the top edge of the mould. This is done in order to ensure a symmetrical distribution of the concrete within the mould.
2. **Compaction:** If compaction is done by hand, tamp the concrete with the standard rod, strokes being uniformly distributed over the cross-section of the mould. For 15cm cube, number of strokes should not be less than 35 per layer. Strokes should penetrate into the underlying layer. Tamp the sides of the mould to close the voids left by tamping bars.

   If compaction is done by vibration, then each layer is compacted by means of suitable vibrating hammer or vibrator or vibrator table. Mode a quantum of vibration of laboratory specimen shall be as nearly the same as those of adopted in actual operations.
3. **Curing:** Store the specimen in a water bath at temperature of 27° ± 20° C for 24 ± ½ hour from the time of addition of water to dry the 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.
4. **Test for compressive strength:**

   Age at test; usually testing is done after 7 days and 28 days, the days being measured from the time the water is added to the dry ingredients. Test at least three specimens at a time. Test specimens, after about half an hour removal from the water, till it is in surface saturated dry condition. If the specimens are received dry, keep them in water for 24 hours before testing.

   Note down the dimensions of specimens nearest to 0.2mm and also note down their weight.
5. **Placing specimen in the machine:**
   a) 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.
   b) Align carefully the centre of thrust of the spherically seated platen.
   c) Apply load slowly and at the rate of 140kg/cm^2/minute till the cube breaks.

d) Note the maximum load and appearance of the concrete failure i.e. whether aggregate has broken or cement paste has separated from the aggregate etc.

Observations, Calculations and Results:

Date of casting = ________

Date of testing = ________

Sl. No.	Weight (kg)	Length (mm)	Breadth (mm)	Height (mm)	Area (mm^2)	Failure Load (kN)	Compressive Strength (N/mm^2)	Remarks

Results:

Mean characteristic compressive strength = _______ N/mm^2

Questions:

1. Why is the compression test supposed to be the most important for concrete?
2. Discuss the acceptance criterion for concrete as given in IS456?
3. How is the strength related to the cube compressive strength?

Experiment No.: 4 (e) **Date:**

SPLIT TENSILE STRENGTH OF CONCRETE

(IS 519:1959)

Objective:

To determine the split tensile strength of concrete of given mix proportions.

Scope and Significance:

The tensile strength is one of the basic and important properties of the concrete. The concrete is not usually expected to resist the direct tension because of its low tensile strength and brittle nature. However, the determination of tensile strength of concrete is necessary to determine the load at which the concrete members may crack. The cracking is a form of tension failure.

Apart from the flexure test the other methods to determine the tensile strength of concrete can be broadly classified as (a) direct methods and (b) indirect methods. The direct method suffers from a number of difficulties related to holding the specimen properly in the testing machine without introducing stress concentration, and to the application of uniaxial tensile load which is free from eccentricity of load will introduce combined bending and axial force condition and the concrete fails at the apparent tensile stress other than the tensile strength.

As there are many difficulties associated with the direct tension test, a number of indirect methods have been developed in the specimen. The tensile stress at which the failure occurs is termed as the tensile strength of concrete.

The splitting tests are well known indirect tests used for determining the tensile strength of concrete sometimes referred to as split tensile strength of concrete. The test consists of applying a compressive line load along the opposite generators of concrete cylinder placed with its axis horizontal between the compressive platens. Due to the compression loading a fairly uniform tensile stress is developed over nearly 2/3rd of the loaded diameter as obtained from an elastic analysis. The magnitude of this tensile stress O_{sp} (acting in a direction perpendicular to the line of action of applied loading) is given by the formula (IS 5816-1970).

The splitting tensile strength, = 2P / π DL

The ratio of the split tensile strength to cylinder strength not only varies with the grade of the concrete but is also dependent on the age of concrete. This ratio is found to decrease with time after about a month. The air-cured concrete gives lower tensile strength than that given by moist- cured concrete. The flexural strength as obtained by rupture test is found to be greater than the split tensile strength. This test is becoming very popular because of the following advantages viz. The test is simple to perform and gives more uniform results than that given by other tests. The strength determined is closer to the actual tensile strength of concrete than the modulus of rupture value.

The same moulds and testing machine can be used for compression and tension tests similar to the splitting of the cylinder cubes can also be split either (a) along its middle parallel to the edges by applying opposite compressive forces through 15mm square bar of sufficient length or (b) along one of its diagonal planes by applying compressive forces along two opposite edges. In the side splitting of cubes, the tensile strength is obtained from O_{sp}= 0.642 P / S2 and in diagonal splitting. It is determined from O_{sp}= 0.5187 PS 2 where P is the failure load and S is the side of the cube.

Apparatus:

Compression testing machine, weighing balance, mixer, tamping rods.

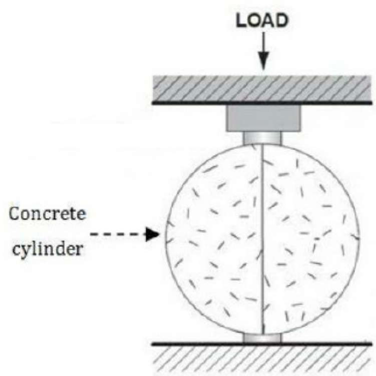


Fig: Split Tensile Test

Procedure:

1. **For the given mix ratio, materials are calculated to the required volume of concrete**. Mix them thoroughly until uniform colour is obtained. This material will be sufficient for casting three cylinders of the size for casting three cylinders of the size 150 mm diameter x 300mm length.

2. In mixing by hand cement and fine aggregate be first mixed dry to uniform colour and then coarse aggregate is added and mixed until coarse aggregate is uniformly distributed throughout the batch. Now, the water shall be added and the ingredients are mixed until resulting concrete is uniform in colour. Mix at least for two minutes.
3. Pour concrete in moulds oiled with medium viscosity oil. Fill the cylinder mould in four layers each of approximately 75mm and ram each layer more than 35 times with evenly distributed strokes.
4. Remove surplus concrete from the top of the moulds with the help of trowel.
5. Cover the moulds with wet mats and put the identification mark after about 3 to 4 hours. Removethespecimensfromthemouldafter24hoursandimmersetheminwaterforcuring. These tests are usually conducted at the range of 7–28 days. The time age shall be calculated from the time of addition of water to the dry ingredients.
6. Test at least three specimens for each age of test follows, draw diametrical lines on two ends of the specimen so that they are in the same axial plane.
7. Determine the diameter of specimen to the nearest 0.2mm by averaging the diameters of the specimen lying in the plane of pre-marked lines measured near the ends and the middle of the specimen also shall be taken be nearest 0.2mm by averaging the two lengths measured in the plane containing pre-marked lines.
8. Centre one of the plywood strips along the centre of the lower pattern. Place the specimen on the plywood strip and align it so that the lines marked on the end of the specimen are vertical and centered over the plywood strip. The second plywood strip is placed length wise on the cylinder centered on the lines marked on the ends of the cylinder.
9. The assembly is positioned to ensure that lines marked on the end of the specimen are vertical and the projection of the plane passing through these two lines interest the centre of the platen.
10. Apply the load without shock and increase it continuously at the rate to produce a split tensile stress of approximately 1.4 to 2.1 N/ mm^2 /minute, until no greater load can be sustained. Record the maximum load applied to the specimen.
11. Note the appearance of concrete and any unusual feature in the type of failure.
12. Compute the split tensile strength of the specimen to the nearest 0.25N/mm^2.

Observations and Calculations:

Specimen No.	Dia of the specimen (mm)	Length of the specimen (mm)	Failure Load (kN)	Splitting Tensile Strength (N/mm^2)

Results:

Split tensile strength of concrete = ________

Questions:

1. What is the basic difference between direct and indirect method used in tensile strength determination which one is superior and why?
2. Why do you perform the split cylinder test?
3. Derive expression used for competition of tensile strength from split cylinder test?
4. Why is plywood strips used in the test?

Experiment No.: 4 (f) **Date:**

FLEXURAL STRENGTH OF CONCRETE

(IS 519:1959)

Objective:

To determine, the strength of concrete using flexural test

Apparatus:

The following apparatus are required for the test.

Prism mould (15 cm x 15 cm x 70cm), (10 cm x 10 cm x 50 cm)

Flexural test machine

Scope and Significance of Test:

Concrete is relatively strong in compression and weak in tension. In RCC concrete members, little dependence is placed on tensile strength of concrete since steel reinforcing bars are provided to resist all tensile forces. However, tensile stresses are likely to develop in concrete due to drying shrinkage, rusting of steel reinforcement, temperature gradient and many other reasons. Therefore, the knowledge of tensile strength of concrete is of importance.

The theoretical maximum tensile stress at the bottom face at failure is termed the modulus of rupture. It is about 1.5 times the tensile stress determined by the splitting test.

The flexural strength of the specimen shall be expressed as the modulus of rupture. The theoretical maximum tensile stress reached in the bottom fibre of the test beam is known as the modulus of rupture f_{cr}, if 'a' equals to the distance between the line of fracture and nearest support, measured on the centre line of support, measured on the centre line of the tensile side of the specimen, in cm, shall be calculated as follows:

$fb = pl/bd^2$

(when **a** > 20.0cm for 15.0cm specimen or > 13.0cm for 10cm specimen)

or

$fb = 3pa/bd^2$

(when **a** < 20.0cm but > 17.0 for 15.0cm specimen or < 13.3 cm but > 11.0cm for 10.0cm specimen.)

Where,

a = the distance between the line of fracture and the nearer support, measured on the center line of the tensile side of the specimen

b = width of specimen (mm)

d = failure point depth (mm)

l = supported length (mm)

p = max. Load (kN)

Procedure:

1. Test specimens are stored in water at a temperature of 24° C to 30° C for 48 hours before testing. They are tested immediately on removal from the water whilst they are still wet condition.
2. The dimension of each specimen should be noted before testing.
3. The bearing surface of the supporting and loading rollers is wiped and clean, and any loose sand or other material removed from the surfaces of the specimen where they are to make contact with the rollers.
4. The specimen is then placed in the machine in such manner that the load is applied to the upper most surface as cast in the mould.
5. The axis of specimen is carefully aligned with the axis of the loading device. No packing is used between the bearing surfaces of the specimen and rollers.
6. The load is applied without shock and increasing continuously at a rate of the specimen. The rate of loading is 4kN/min for the 150m specimen and 18 kN /min for the 100m specimen.
7. The load is increased until the specimen fails and the maximum load applied to the specimen during the test is recorded.

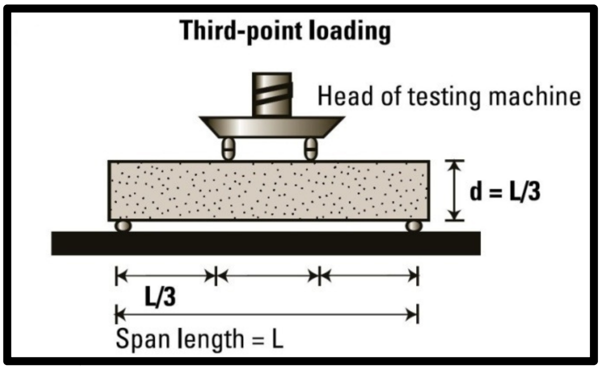


Fig: Flexural Strength Test

Result:

The flexural strength of the given concrete is _______N/mm^2

IS Specification:

An estimate of the tensile strength from the compressive strength from the compressive strength can be estimated using the formula:

Flexural strength, $f_{cr}= 0.7\sqrt{f_{ck}}$

Where f_{ck} is the characteristic cube compressive strength of concrete in N/mm^2

Technical Discussions:

The splitting tensile test is a simple test and the results are more uniform than other tension tests. The tensile strength obtained is closer to the actual tensile strength of concrete than the flexural tensile strength which is about 1.25 to 2 times the split tensile strength.