INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

DEPARTMENT OF CIVIL ENGINEERING

Program: Master of Technology

Structural Engineering

VISION OF THE DEPARTMENT

To produce eminent, competitive and dedicated civil engineers by imparting latest technical skills and ethical values to empower the students to play a key role in the planning and execution of infrastructural & developmental activities of the nation.

MISSION OF THE DEPARTMENT

To provide exceptional education in civil engineering through quality teaching, state-of-the-art facilities and dynamic guidance to produce civil engineering graduates, who are professionally excellent to face complex technical challenges with creativity, leadership, ethics and social consciousness.

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(Autonomous)

Dundigal, Hyderabad - 500 043

DEPARTMENT OF CIVIL ENGINEERING

Program: Master of Technology (Structural Engineering)

PROGRAM OUTCOMES (PO's)	
PO1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineeringfundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2	**Problem analysis**: Identify, formulate, review research literature, and analyze complexengineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/development of solutions**: Design solutions for complex engineering problems anddesign system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct investigations of complex problems**: Use research-based knowledge and researchmethods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions..
PO5	**Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modernengineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6	**The engineer and society**: Apply reasoning informed by the contextual knowledge to assesssocietal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	**Environment and sustainability**: Understand the impact of the professional engineering solutionsin societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms ofthe engineering practice.
PO9	**Individual and team work**: Function effectively as an individual, and as a member or leader indiverse teams, and in multidisciplinary settings.
PO10	**Communication**: Communicate effectively on complex engineering activities with the engineeringcommunity and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11	**Project management and finance**: Demonstrate knowledge and understanding of theengineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12	**Life-long learning**: Recognize the need for, and have the preparation and ability to engage inindependent and life-long learning in the broadest context of technological change.

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DEPARTMENT OF CIVIL ENGINEERING

Program: Master of Technology (Structural Engineering)

The Program Specific outcomes (PSO's) listed below were developed specifically to meet the Program Educational Objectives (PEO's). The focus of these PSO's is consistent with the set of required PO's identified in the NBA accreditation guidelines.

The Civil Engineering PSO's require that graduates receiving a Bachelor of Technology in Civil Engineering degree from IARE demonstrate the following.

PROGRAM SPECIFIC OUTCOMES (PSO's)	
PSO1	**ENGINEERING KNOWLED:** Graduates shall demonstrate sound knowledge in analysis, design, laboratory investigations and construction aspects of civil engineering infrastructure, along with good foundation in mathematics, basic sciences and technical communication .
PSO2	**BROADNESS AND DIVERSITY: Graduates** will have a broad understanding of economical, environmental, societal, health and safety factors involved in infrastructural development, and shall demonstrate ability to function within multidisciplinary teams with competence in modern tool usage.
PSO3	**SELF-LEARNING AND SERVICE:** Graduates will be motivated for continuous self-learning in engineering practice and/or pursue research in advanced areas of civil engineering in order to offer engineering services to the society, ethically and responsibly.

ADVANCED CONCRETE LAB SYLLABUS

EXP. NO.	LIST OF EXPERIMENTS
1.	Consistency of fineness of cement
2.	Initial setting time and final setting time of cement
3.	Soundness of cement
4.	Compressive Strength of Cement
5.	Bulking of sand
6.	Shape tests of Coarse Aggregates
7.	Aggregate Impact Test and Crushing Strength Test
8.	Marsh cone test
9.	Workability test on SCC-Slump flow + T500
10.	Workability test on SCC-L-box (Reference method for passing ability)
11.	Workability test on SCC-J-ring (Reference method for passing ability)
12.	Workability test on SCC- V-funnel (Alternative method to T50 for filling ability)
13.	Workability test on SCC-U-funnel (U-shaped or Box-shaped apparatus)
14.	Permeability of concrete
15.	Accelerated curing of concrete
16.	Non-destructive test using Rebound hammer and Ultrasonic pulse velocity
17.	Influence of water-cement ratio on workability and strength of concrete
18.	Strain and deflection of member under loads

MANDATORY INSTRUCTIONS

1. Students should report to the labs concerned as per the timetable.
2. Record should be updated from time to time and the previous experiment must be signed by the faculty in charge concerned before attending the lab.
3. Students who turn up late to the labs will in no case be permitted to perform the experiment scheduled for the day.
4. After completion of the experiment, certification of the staff in-charge concerned in the observation book is necessary.
5. Students should bring a notebook of about 100 pages and should enter the readings/observations/results into the notebook while performing the experiment.
6. The record of observations along with the detailed experimental procedure of the experiment performed in the immediate previous session should be submitted and certified by the staff member in-charge.
7. Not more than FIVE students in a group are permitted to perform the experiment on a set up.
8. The group-wise division made in the beginning should be adhered to, and no mix up of student among different groups will be permitted later.
9. The components required pertaining to the experiment should be collected from Lab-in-charge after duly filling in the requisition form.
10. When the experiment is completed, students should disconnect the setup made by them, and should return all the components/instruments taken for the purpose.
11. Any damage of the equipment or burnout of components will be viewed seriously either by putting penalty or by dismissing the total group of students from the lab for the semester/year.
12. Students should be present in the labs for the total scheduled duration.
13. Students are expected to prepare thoroughly to perform the experiment before coming to Laboratory.
14. Procedure sheets/data sheets provided to the students groups should be maintained neatly and are to be returned after the experiment.
15. DRESS CODE:
    a. Boys - Formal dress with tuck in and shoes.
    b. Girls - Formal dress (salwarkameez).
    c. **Apron in blue color for both boys and girls.**
    d. **Wearing of jeans is strictly prohibited**

References:

1. Indian Standard Methods of Physical Tests for cements IS: 4031, Indian StandardsInstitution.
2. Indian Standard Specifications for ordinary and low heat Portland cement IS: 269, Indian Standards Institution.
3. Neville. A. M, Properties of concrete, 3rd edition, Pitman publishing company, 1981.
4. Gambhir .M.L, Concrete Manual, 4thEdn.,DhanpatRai Sons, Delhi
5. Indian Standard Methods of Test for Aggregate for concrete IS: 2386 Part-IV, Indian Standards Institution.
6. Indian Standard Specifications for Course and Fine Aggregate from Natural Sources for Concrete, IS: 383 Indian Standards Institution.

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EXPERIMENT NO: 1

CONSISTENCY OF FINENESS OF CEMENT

THEORY AND SCOPE:

A certain minimum quantity of water is required to be mixed with cement so as to complete chemical reaction between water and cement ,less water than this quantity required wood not complete chemical reaction thus resulting in reaction strength and more water increases water cement ratio and it reduces the strength. So correst proportion of w/c is required.

AIM:

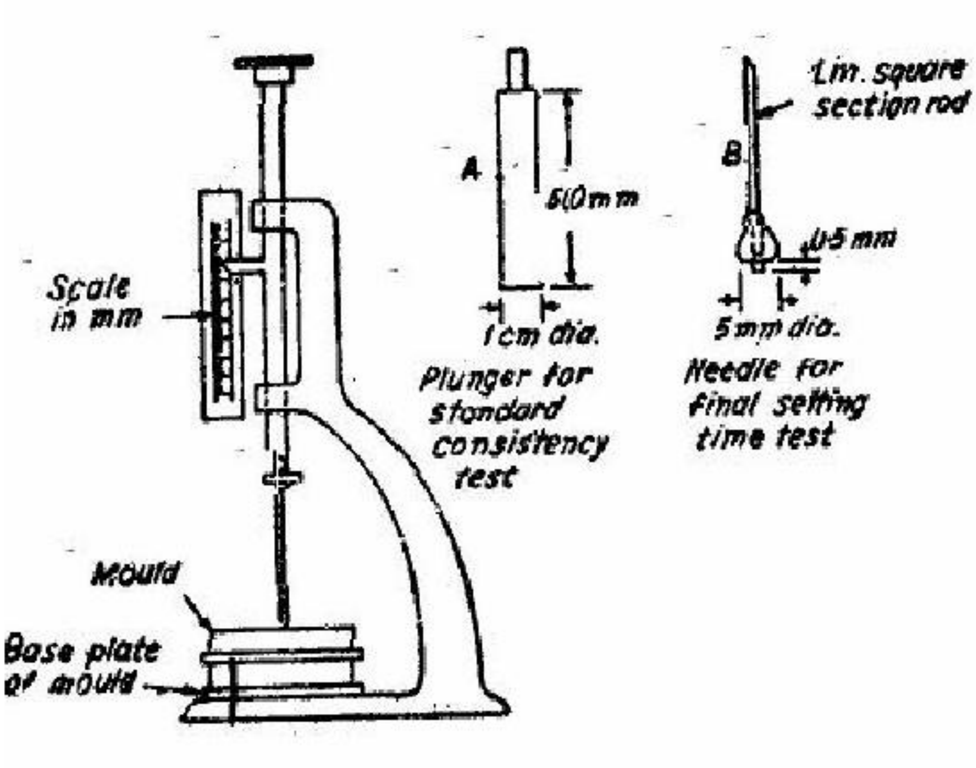
To determine the percentage of water required for preparing cement paste of standard consistency, used for other tests.

APPARATUS:

Vicat apparatus with plunger, I.S. Sieve No. 9, measuring jar, weighing balance

PROCEDURE:

1. The vicat apparatus consists of a D- frame with movable rod. An indicator is attached to the movable rod, which gives the penetration on a vertical scale.
2. A plunger of 10 mm diameter, 50 mm long is attached to the movable rod to find out normal consistency of cement.
3. Take 300 gm of cement sieved through I.S. Sieve No. 9 and add 30% by weight (90 ml) water to it. Mix water and cement on a non-porous surface thoroughly with in 3 to 4 minutes.
4. The cement paste is filled in the vicatmould and top surface is leveled with a trowel. The filled up mould shall be placed along with its bottom non-porous plate on the base plate of the vicat apparatus centrally below the movable rod. The plunger is quickly released into the paste. The settlement of plunger is noted. If the penetration is between 33 mm to 35 mm from top (or) 5 mm to 7 mm from the bottom, the water added is correct. If the penetration is less than required, the process is repeated with different percentages of water till the desired penetration is obtained.



Vicat Apparatus

OBSERVATION AND CALCULATION:

S.No.	Amuont of water mixed	Penetration of Plunger from top	Remark

RESULT: The normal consistency of cement =

EXPERIMENT NO: 2

INITIAL AND FINAL SETTING TIMES OF CEMENT

THEORY AND SCOPE:

Setting means becoming finer and harder, changing from seme liquid state to plastic state and form plastic state to solid state. Morter or concrete when mixed is in semi liquid state.
The chemical action between cement and water starts, and the mixture goes into plastic state.

AIM:
To find initial and final setting times of cement.

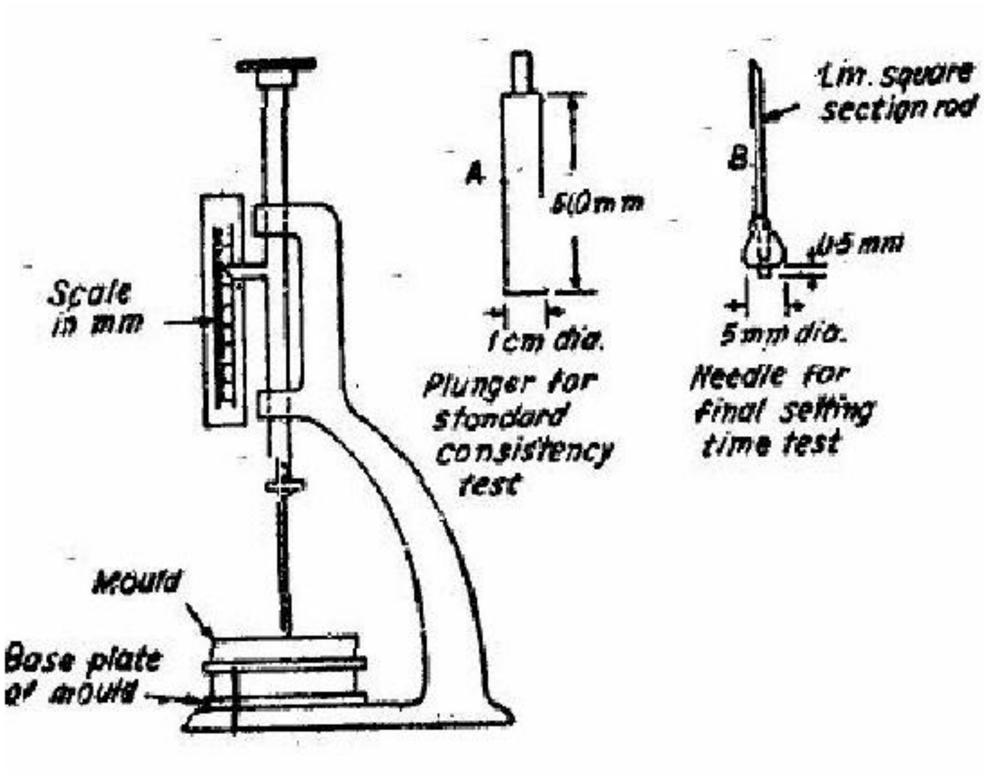
APPARATUS:
Vicat apparatus with mould, I.S. sieve No. 9, Initial and final setting time needles, measuring jar, weighing balance, etc.

PROCEDURE:

Initial setting time:
1.Initial setting time is defined as the time elapsed between the moment that the water is added to the cement, to the time that the paste starts losing its plasticity i.e. the initial setting time needle fails to penetrate the cement paste kept in the mould by about 33-35 mm from the top or 5-7 mm from bottom of the indicator is called initial setting time.
2. Take a cement sample weighing 300 gm, sieved through I.S. sieve No. 9 and mixed with percentage of water as determined in normal consistency test. Stopwatch should be started at the instant when water is added to the cement.
3. Prepared cement paste is filled in vicats mould and leveled with trowel. This mould filled with cement paste kept on the non porous plate is now placed under the movable rod with initial setting time needle of cross section 1mm x 1mm
4. The needle is quickly released and it is allowed to penetrate the cement paste. In the beginning the needle penetrates completely. It is then taken out and dropped at a fresh place.
5. This procedure is repeated at regular intervals till the needle does not penetrate the block for about 5 mm measured from the bottom of indicator. Note the time for initial setting of cement. The initial setting time of an ordinary Portland cement shall not be less than 30 minutes.

Final setting time:

1. After noting the time for initial setting of cement, the needle shall be replaced by the final setting time needle.
2. The movablerod is slowly released on to the cement paste.
3. In the initial stages he needle and collar may pierce through the paste. But after some time the same procedure is followed.
4. Such trials shall be carried out until the needle only makes as impression on the top surface of the cement paste and the collar of the needle fails to do so. Note the time for final setting time of cement.
5. The final setting time of an ordinary Portland cement shall not be more than 10 hours.



Vicat Apparatus

Result:

1. Initial setting time of cement=
2. Final setting time of cement=

EXPERIMENT NO: 3

SOUNDNESS OF CEMENT

THEORY AND SCOPE:

Unsoundness of cementmeans, that the cement having excess lime, magnesium sulphates, etc. due to excess of these items there will be volume changes and large expansions, there by reduces the durability of the structures.

AIM:

To find out the soundness of cement.

APPARATUS:
Le-chatelier Apparatus Cement, Water , Glass plate.

PROCEDURE:

1. The cement is gauged with 0.78 times the water required for standard consistency (0.78P) in a standard manner and filled in to the Le-Chateliermould kept on the glass plate.
The mould is covered on the top with another glass plate.
2. The whole assembly is immersed in water at temperature of 27^{o}C to 32^{o}C and kept there for 24 hrs.
3. Measure the distance between the indicator points.
4. Submerge the mould again in water, heat the water up to boiling point in 30 minutes and keep it boiling for 3 hrs.
5. Remove the mould from hot water and allow it to cool and measure the distance between the indicator points.
6. The distance between these two measurements gives the expansion of cement.
7. This must not exceed 10mm for OPC, RHC, LHC, etc.
8. If the expansion is more than 10mm, the cement is unsound.

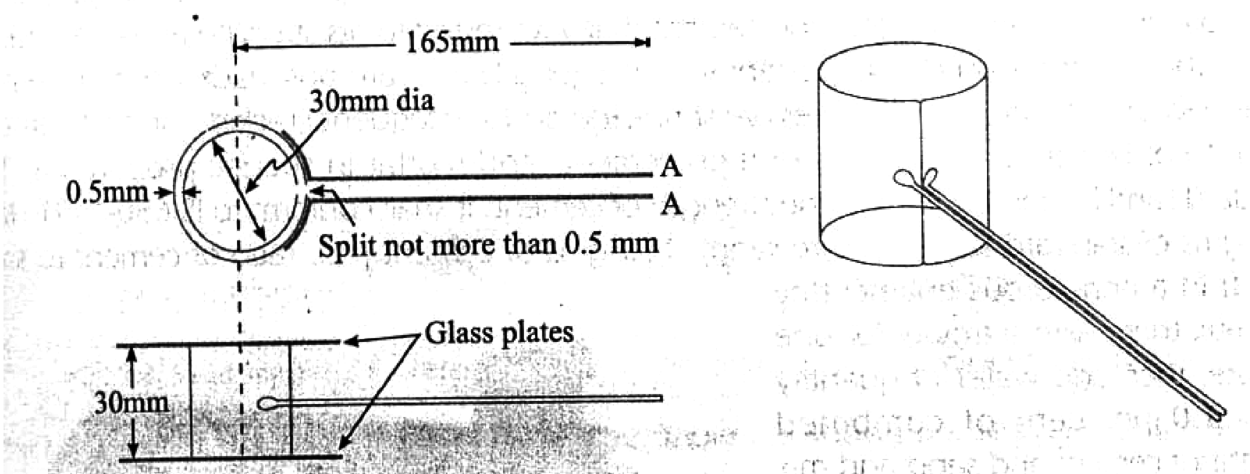


Fig. 2.9. Le-Chatelier apparatus for finding soundness of cement.

RESULT:

Soundness of given cement =

EXPERIMENT NO: 4

COMPRESSIVE STRENGTH OF CEMENT

THEORY AND SCOPE:

The compressive strength of cement mortar is determined strength of cement mortar is determined in order to verify whether the cement conforms to IS specification **(IS: 269-1976)** and whether it will be able to develop the required compressive strength of concrete. According **to IS: 269-1976**, the ultimate compressive strength of cubes of cement sand mortar of the ratio 1:3, containing (P/4+3.0) percent of water should be as.

AIM:

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

APPARATUS:

Universal Testing Machine or Compression Testing Machine, cube moulds, vibrating machine, crucible for mixing cement and sand measuring cylinder, trowels, non-porous plate and balance with weight box.

PROCEDURE:

1. Calculate the material required. The material for each cube shall be mixed separately and the quantities of cement and standard sand shall be as follows:

Cement = 200 gm.

Standard Sand = 600 gm.

Water = (P/4+3.0) percent = 84 gm.

2. The time of mixing (gauging) in any event shall not be less than 3 minutes and if the time taken to obtain a uniform colour exceeds 4 minutes the mixture shall be rejected and the operation is repeated with a fresh quantity of cement, sand and water.

3. Place the assembled mould on the table of the vibrating machine and firmly hold it in 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 the vibration period.

4. Immediately after mixing the mortar as explained above, fill the entire quantity of mortar

5. In the hopper of the cube mould and compact by vibration. The period of vibration shall be 2 minutes at the specified speed of 12000+400 cycles per minute.

6. Remove the mould from the machine and keep it at a temperature of 27+ 2^0C in an atmosphere of at least 90 percent relative humidity for 24 hours after completion of vibrations.

7. The cubes are removed from the mould and immediately submerge it in clean and fresh water and keep there until taken out just prior to breaking. The water is which the cubes are submerged shall be renewed after every 7 days and be maintained at a temperature of 27+ 2^0C, keep the cubes wet till they are placed in machine for testing.

8. Test the specimens at the required periods, test three cubes at the periods mentioned below, the periods being reckoned from the completion of vibration. The compressive strength shall be the average of the strengths of the three cubes for each period.

a) Ordinary Portland Cement: 3 and 7days.

b) Rapid Hardening Portland Cement: 1 and 3 days.

c) Low Heat Portland Cement: 3, 7 and 28 days.

The cubes shall be tested on their sides, the load being applied at the rate of 35 N/mm^2/ minute.

OBSERVATION AND CALCULATIONS:

Ordinary Portland cement

S.No.	**3-day strength**		**7-day strength**	
	Load in KN	**Strength in N/mm^2**	**Load in KN**	**Strength in N/mm^2**
1				
2				
3				
Average				

RESULT:

Compressive strength of cement=

EXPERIMENT NO: 5

BULKING OF FINE AGGREGATE

THEORY AND SCOPE:

The volume of fine aggregate may increase by 1% to 5% due to presence of moisture. This property of increase in volume of fine aggregate due to moisture is called bulking.

AIM:

To find out the bulking factor of fine aggregate.

APPARATUS:

Container, Sand, Water, Mixing Pan.

PROCEDURE:

1. Take about 6 liters of dry compacted sand and weigh it and dump it into a mixing pan.
2. Add a certain known percentage of water by weight of dry sand.
3. Mix rapidly and thoroughly till a uniform colour is obtained and fill the container with the wet sand without any tamping.
4. Now strike off the top surface and weigh and thus find the weight of wet sand.
5. Repeat the experiment No. of times increasing in water content from 1% to 20%.

CALCULATIONS:

W_1=Wt. of $1m^3$ of compacted dry sand.

W_2=Wt. of dry sand contained in $1m^3$ of wet loose sand.

W_3=Wt. of $1m^3$ of wet sand

X = Percentage of water added

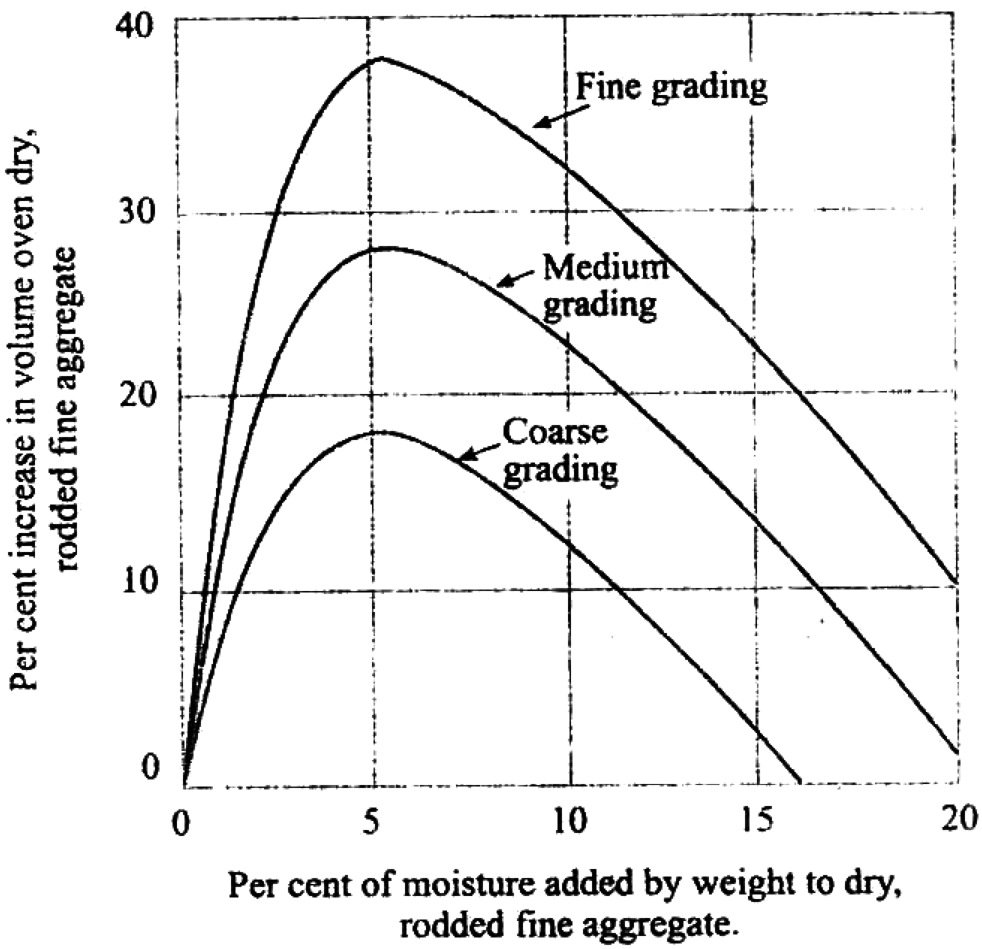
W_3=Wt. of dry sand + Wt. of water

$$W_3 = W_2 \left(1 + \frac{x}{100}\right)$$

$$W_2 = \frac{w_3}{1 + x/100}$$

$\therefore$ % of bulking $= \frac{W_1 - W_2}{W_1} x100$

Bulking factor $= \frac{W_1}{W_2}$



RESULT:

Bulking of given Sand = ---------------- % of water

EXPERIMENT NO: 06

SHAPE TESTS OF COARSE AGGREGATES

SHAPE TEST(FLAKINESS INDEX)

THEORY AND SCOPE:

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

AIM:

To determine the flakiness Index of a given aggregates sample.

APPARATUS:

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

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

PROCEDURE:

1.The sample is sieved with the sieves mentioned in the table.

2. A minimum of 200 pieces of each fraction to be tested are taken and weighed (w1gm).

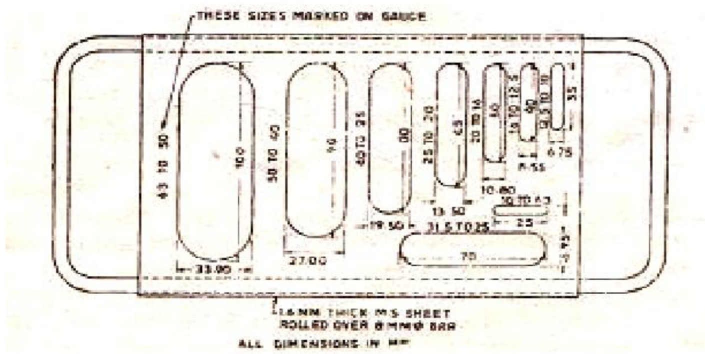
3. In order to separate flaky materials, each fraction is then gauged for thickness on

4. Thickness gauge, or in bulk on sieve having elongated slots as specified in the table.

5. Then the amount of flaky material passing the gauge is weighed to an accuracy of at least 0.1% of test sample.

6. Let the weight of the flaky materials passing the gauge be w1gm. Similarly the weights of the fractions passing and retained on the specified sieves be w1, w2, w3, etc. are weighed and the total weight w1+w2+w3+………. = wg is found. Also the weights of the materials passing each of the specified thickness gauge are found = W1, W2, W3… and the total weight of the material passing the different thickness gauges = W1+W2+W3+………. =Wg is found.

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



Thickness Gauge

Flakiness Index Test in Progress

SIZE OF AGGREATE		THICKNESS GAUGE (O.6 TIMES THE MEAN SIEVE)mm	Weight of the faction consisting of atleast 200 pieces in gm.	Weight of aggregates in each fraction passing thickness gauge,gm.
PASSING THROUGH I.S SIEVE mm	RETAINED ON I.S. SIEVE mm			
63	50	33.90		
50	40	27.00		
40	25	19.50		
31.5	25	16.95		
25	20	13.50		
20	16	10.80		
16	12.5	8.55		
12.5	10.0	6.75		
10	6.3	4.89		

Result: The flakiness index of the given sample of aggregates is _______________%.

SHAPE TEST *(Elongation Index)*

THEORY ANDSCOPE:

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

ANGULARITY NUMBER: The angularity number of an aggregate is the amount by which the percentage voids exceeds 33 after being compacted in a prescribed manner. The minimum allowable combined index of aggregates used in surface course of pavement is30%.

AIM:
To determine the Elongation Index of the given aggregate sample.

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

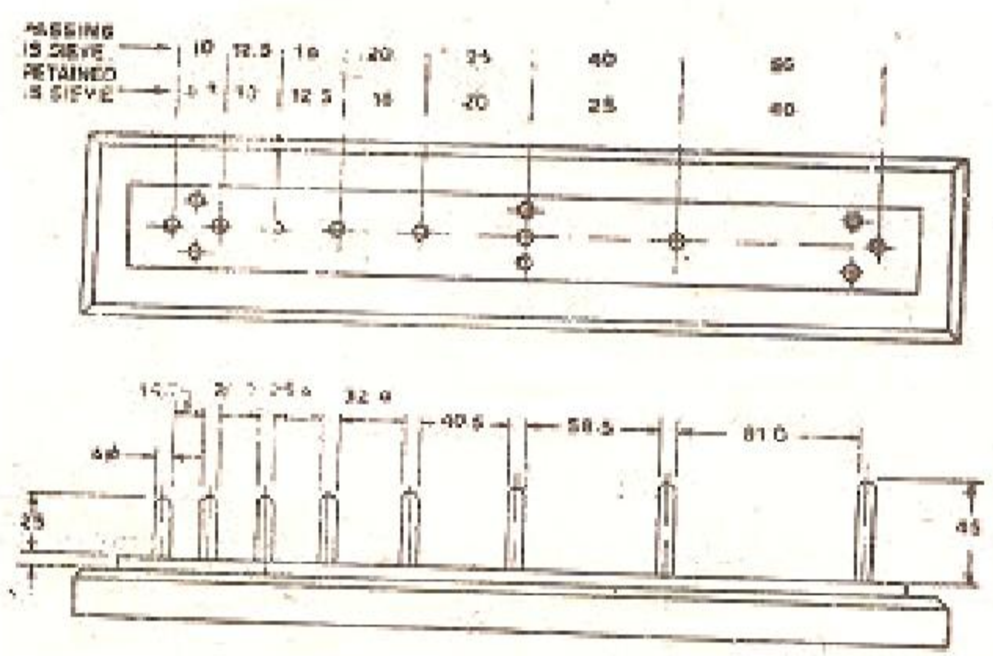
PROCEDURE:

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

$$= W_1+W_2+W_3+\ldots\ldots = Wg.$$

Also the weights of material from each fraction retained on the specified gauge length are found = x_1, x_2, x_3… and the total weight retained determined = $x_1+x_2+x_3+\ldots\ldots = x$ gm.

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



ALL DIMENSIONS IN MM

SIZE OF AGGREATE		LENGTH GAUGE (1.8 TIMES THE MEAN SIEVE)mm	Weight of the faction consisting of atleast 200 pieces in gm.	Weight of aggregates in each fraction passing thickness gauge,gm.
PASSING THROUGH I.S SIEVE mm	**RETAINED ON I.S SIEVE mm**			
63	50			
50	40	81.00		
40	25	58.50		
31.5	25	-		
25	20	40.50		
20	16	32.40		
16	12.5	25.60		
12.5	10.0	20.20		
10	6.3	14.70		

Result: The elongation index of a given sample of aggregate is ________________%.

EXPERIMENT NO: 07

AGGREGATE STRENGTH TEST

AGGREGATE IMPACT TEST

THEORY AND SCOPE:

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

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

AIM:

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

APPARATUS:

The apparatus consists of an

1. Impact testing machine: The machine consists of a metal base. A detachable cylindrical steel cup of internal diameter 10.2cm and depth 5cm. A metal hammer of weight between 13.5 to 14Kg, 10cm in diameter and 5cm long. An arrangement for raising the hammer and allow it to fall freely between vertical guides from a height of 38cm on the test sample in the cup.

2. A cylindrical metal measure having 7.5cm and depth of 5cm for measuring aggregates.

3. A tamping rod of circular cross section, 1cm in diameter and 23cm long, rounded at one end.

4. I.S. sieve of sizes 12.5mm, 10mm and 2.36mm.

5. Balance of capacity not less than 500gm to weigh accurate up to 0.01gm.

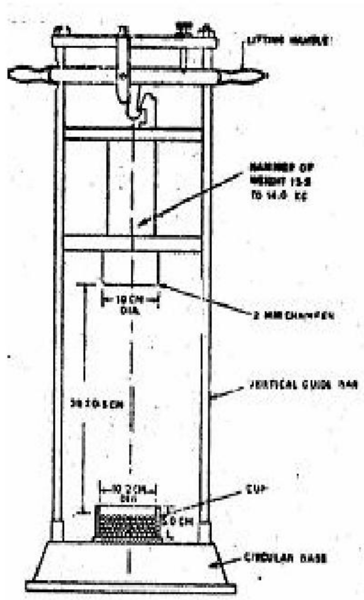
Various agencies have specified the maximum permissible aggregate Impact values for the different types of pavements. IRC has specified the following values.

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

PROCEDURE:

1. The test sample consists of aggregates passing 12.5mm sieve and retained on 10mm sieve and dried in an oven for 4 hours at a temperature of 100 C to 110 C.
2. The aggregates are filled upto about 1/3 full in the cylindrical measure and tamped 25 times with rounded end of the tamping rod.
3. The rest of the cylindrical measure is filled by two layers and each layer being tamped 25 times.
4. The overflow of aggregates in cylindrically measure is cut off by tamping rod using it has a straight edge.
5. Then the entire aggregate sample in a measuring cylinder is weighted nearing to 0.01gm.
6. The aggregates from the cylindrical measure are carefully transferred into the cup which is firmly fixed in position on the base plate of machine. Then it is tamped 25 times.
7. The hammer is raised until its lower face is 38cm above the upper surface of aggregates in the cup and allowed to fall freely on the aggregates. The test sample is subjected to a total of 15 such blows each being delivered at an interval of not less than one second. The crushed aggregate is than removed from the cup and the whole of it is sieved on 2.366mm sieve until no significant amount passes. The fraction passing the sieve is weighed accurate to 0.1gm. Repeat the above steps with other fresh sample
8. Let the original weight of the oven dry sample be w1gm and the weight of fraction passing 2.36mm I.S sieve be w2gm. Then aggregate Impact value is expressed as the % of fines formed in terms of the total weight of the sample.

$$\text{Aggregate Impact Value} = 100 * \frac{w_2}{W_1} \% .$$



Aggregate Impact Testing Machine

OBSERVATION AND

CALCULATION:

Sl. No.	Details of Sample	Trail 1	Trail 2	Average
1	**Total Weight of aggregate sample filling the cylinder measure = W_1 g**			
2	**Weight of aggregate passing 2.36 mm sieve after the test = W_2 g**			
3	**Weight of aggregate retained 2.36 mm sieve after the test =W_2 g**			
4	**(W_1-W_2 + W_2)**			
5	**Aggregate Impact Value =(W_2/W_1)*100 Percent**			

Result:

The mean A.I.V is ____________________%.

AGGREGATE CRUSHING STRENGTH

THEORY AND SCOPE:

This is one of the major Mechanical properties required in a road stone. The test evaluates the ability of the Aggregates used in road construction to withstand the stresses induced by moving vehicles in the form of crushing. With this the aggregates should also provide sufficient resistance to crushing under the roller during construction and under rigid tyre rims of heavily loaded animal drawn vehicles.

The crushing strength or aggregate crushing value of a given road aggregate is found out as per ***IS-2386 Part- 4.***

The aggregate crushing value provides a relative measure of resistance to crushing under a gradually applied compressive load. To achieve a high quality of pavement aggregate possessing low aggregate crushing value should be preferred.

The aggregate crushing value of the coarse aggregates used for cement concrete pavement at surface should not exceed 30% and aggregates used for concrete other than for wearing surfaces, shall not exceed 45% as specified by Indian Standard (IS) and Indian Road Congress (IRC).

AIM:

To determine crushing strength of a given aggregate as per **IS: 2386 part - IV**

APPARATUS:

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

PROCEDURE:

1. The aggregate in surface-dry condition before testing and passing 12.5 mm sieve and retained on 10 mm sieve is selected.
2. The cylindrical measure is filled by the test sample of the aggregate in three layers of approximately equal depth, each layer being tamped 25 times by the rounded end of the tamping rod.
3. After the third layer is tamped, the aggregates at the top of the cylindrical measure are leveled off by using the tamping rod as a straight edge. Then the test sample is weighed. Let that be w_1 gm.
4. Then the cylinder of test apparatus is kept on the base plate and one third of the sample from cylindrical measure is transferred into cylinder and tamped 25 times by rounded end of the tamping rod.
5. Similarly aggregate in three layers of approximately equal depth, each layer being tamped 25 times by rounded end of the tamping rod.
6. Then the cylinder with test sample and plunger in position is placed on compression testing machine.
7. Load is then applied through the plunger at a uniform rate of 4 tonnes per minute until the total load is 40 tonnes and the load is released.
8. Aggregates including the crushed position are removed from the cylinder and sieved on a 2.36mm IS

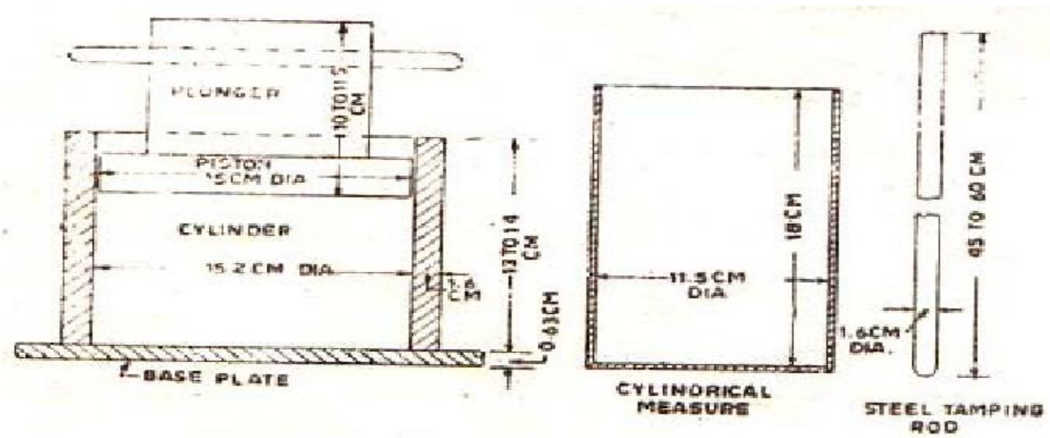
Sieve and material which passes this sieve is collected and weighed. Let this be w_2 gm.

9. The above step is repeated with second sample of the same aggregate. The two tests are made for the same specimen for taking an average value.

10. Total weight of dry sample taken is $w_1$gm. weight of the portion of crushed material passing 2.36mm IS sieve be w_2 gm.

Then the aggregate crushing value is defined as the ratio of weight of fines passing the specified IS sieve to the total weight of the sample (w_1).

Aggregate crushing value = $100*w_2/w_1$%



Aggregate Crushing Test Apparatus

OBSERVATION AND CALCULATION:

Trials	Total Weight of dry aggregate sample 10 gm	Weight of fines passing 2.36mm IS sieve, w2gm	Aggregate crushing value %	Average aggregate crushing strength value
1				
2				

Aggregate crushing value = $100*w_2/w_1$.

RESULT:

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

EXPERIMENT NO: 08

MARSH CONE TEST

THEORY AND SCOPE:

The term compatibility refers to the desired effect on performance when a specific combination of cement and chemical admixtures is used. In concrete mix design the superplasticizer dosage are fixed based on the composition of the paste (cement,water and chemical admixtures) with the maximum fluidity for a given water/cement ratio and a given chemical admixture/cement ratio. The characteristics of the fresh paste mostly govern the properties of the fresh concrete and this procedure will yield a concrete, With the desired workability for a given aggregate content. The only variable in this process is the superplasticizer/cement ratio. The optimum dosage of chemical admixture is decided for each batch of cement and each admixture. To formulate this objective, a test known as "Marsh Cone Test" is performed.

AIM:

To determine the optimum dosage of super plasticizer each batch of cement Self compacting concrete.

APPARATUS:

Marsh cone test ,stop watch

MARSH CONE TEST

PROCEDURE:

1. Mix the measured quantity of Cement, water and admixture thoroughly in a mechanical mixer for two minutes. While mixing, first put the water in mixing bowl and then add 2 Kg of cement to this water. Stirre for 1 minute and then add admixture dose and stirring operation is continued for next one minutes. Thus slurry is formed.
2. Pour one liter slurry into marsh cone duly closing the aperture with a finger.
3. Start the stop watch and simultaneously remove the finger. Note the time taken for emptying the Marsh Cone. This time is called the "Marsh Cone Time".
4. Repeat the test for 15 minutes and 60 minutes retention period for same mix and duly noting Marsh Cone time. The mixture of cement and admixture should be kept stirred throughout the test.
5. Repeat the test for different plasticizer dosage i.e. 0.2% to 2.0% (AS per IS 456: 2000).
6. A typical graph of Marsh Cone Time in Seconds vs Admixture/Cement dosage in percentage is drawn and optimum dose is ascertained. This point is known as "Saturation Point"
7. For Ambuja Cement and admixture, different w/c ratio i.e. 0.25, 0.30, 0.35, 0.40, 0.45, 0.50, 0.55 the whole procedure is repeated and for each combination of cement, water and plasticizer, saturation point is obtained.
8. Repeat step 2 to 9 for the Ambuja Cement and Conplast Sp 440 admixture.

OBSERVATION AND CALCULATIONS:

Sr. No.	Cement (Kg)	w/c ratio	Water (Kg)	Admix/ cement Dosage (%)	Admixture (mg)	Marsh Cone Time (0 min Retention) (Sec)	Marsh Cone Time (15min Retention) (Sec)	Marsh Cone Time (60 mill Retention) (Sec)
1	2.00	0.55	1.10	0.00	0.00			
2	2.00			0.20	4.20			
3	2.00			0.40	8.40			
4	2.00			0.60	12.60			
5	2.00			0.80	16.80			
6	2.00			1.00	21.00			
7	2.00			1.20	25.20			
8	2.00			1.40	29.40			
9	2.00			1.60	33.60			
10	2.00			1.80	37.80			
11	2.00			2.00	42.00			

RESULT:

Dosage of super plasticizer =

EXPERIMENT NO: 09

WORKABITY TEST ON SCC-SLUMP FLOW+ T500

THEORY AND SCOPE:

The slump flow test aims at investigating the filling ability of SCC. It measures two parameters: flow spread and flow time T500 (optional). The former indicates the free, unrestricted deformability and the latter indicates the rate of deformation within a defined flow distance.

AIM:

To measure the filling ability of Self compacting concrete.

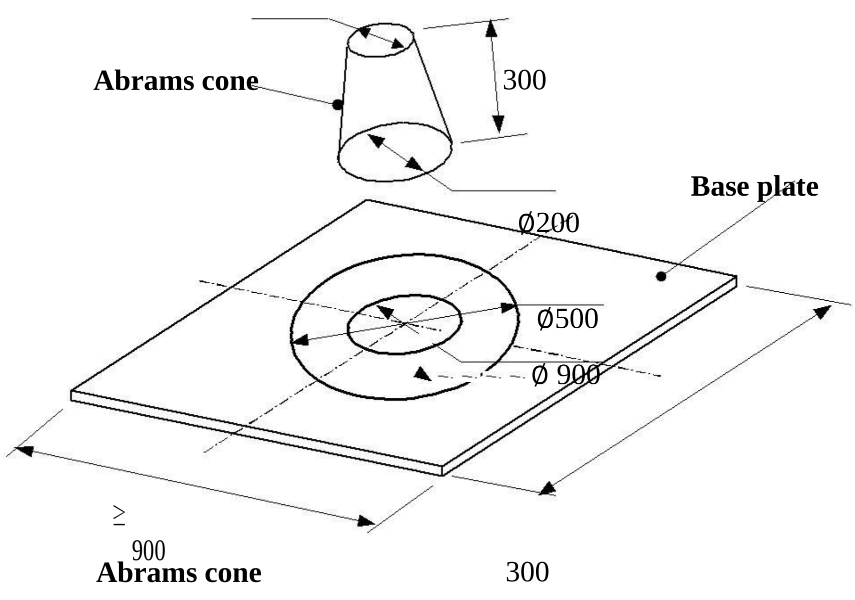
APPARATUS:

1. Base plate of size at least 900 × 900 mm, made of impermeable and rigid material(steel or plywood) with smooth and plane test surface (deviation of the flatness not exceed 3 mm), and clearly marked with circles of Ø200mm and Ø500mm at the centre, as shown in Fig- 2.
2. Abrams cone with the internal upper/lower diameter equal to 100/200 mm and theheight of 300 mm, as shown in Figure 1.
3. Weight ring (>9 kg) for keeping Abrams cone in place during sample filling. Anexample of its dimensions is given in Figure 2. Alternatively, a cast iron cone may be used as long as the weight of the cone exceeds 10 kg. As a second alternative the cone may be kept in position by human force.
4. Stopwatch with the accuracy of 0.1 second for recording the flow time T50.
5. Ruler (graduated in mm) for measuring the diameters of the flow spread.
6. Bucket with a capacity of larger than 6 litres for sampling fresh concrete.
7. Moist sponge or towel for wetting the inner surface of the cone and the test surface ofthe base plate.
8. Rag for cleaning spilled concrete if any.

PROCEDURE:

1. Place the cleaned base plate in a stable and level position.
2. Fill the bucket with 6~7 litres of representative fresh SCC and let the sample stand stillfor about 1 minute (± 10 seconds).

3. During the 1 minute waiting period pre-wet the inner surface of the cone and the testsurface of the base plate using the moist sponge or towel, and place the cone in the centre on the 200 mm circle of the base plate and put the weight ring on the top of the cone to keep it in place. (If a heavy cone is used, or the cone is kept in position by hand no weight ring is needed).
4. Fill the cone with the sample from the bucket without any external compacting actionsuch as rodding or vibrating. The surplus concrete above the top of the cone should be struck off, and any concrete remaining on the base plate should be removed.
5. Check and make sure that the test surface is neither too wet nor too dry. No dry areaon the base plate is allowed and any surplus of the water should be removed – the moisture state of the plate has to be 'just wet'.
6. After a short rest (no more than 30 seconds for cleaning and checking the moist stateof the test surface), lift the cone perpendicular to the base plate in a single movement, in such a manner that the concrete is allowed to flow out freely without obstruction from the cone, and start the stopwatch the moment the cone looses contact with the base plate.
7. Stop the stopwatch when the front of the concrete first touches the circle of diameter500 mm. The stopwatch reading is recorded as the T50 value. The test is completed when the concrete flow has ceased.
8. Measure the largest diameter of the flow spread,d_{max}, and the one perpendicular to it,d_{perp}, using the ruler (reading to nearest 5 mm). Care should be taken to prevent the ruler frombending.
9. Clean the base plate and the cone after testing.



Abrams cone 300

Figure 1 — Base plate and Abrams cone

Table 1 — Precisions of the slump flow spread and flow time T50

Slump flow spread *S* [mm]	< 600	600 ~ 750	> 750
Repeatability *r* [mm]	N.A.	42	22
Reproducibility *R* [mm]	N.A.	43	28
Slump flow time T50 [sec]	**≤ 3.5**	**3.5 ~ 6**	**> 6**
Repeatability *r* [sec]	0.66	1.18	N.A.
Reproducibility *R* [sec]	0.88	1.18	N.A.

RESULT:

1. The slump flow spread *S* is the average of diameters d_{max} and d_{perp}, as shown in Equation (1). *S* is expressed in mm to the nearest 5 mm.

$$S = \frac{(d_{max} + d_{perp})}{2}$$

2. The slump flow time T50 is the period between the moment the cone leaves the baseplate and SCC first touches the circle of diameter 500 mm. T50 is expressed in seconds to the nearest 1/10 seconds.

EXPERIMENT NO: 10

WORKABITY TEST ON SCC, L-Box

THEORY AND SCOPE:

The method aims at investigating the passing ability of SCC. It measures the reached height of fresh SCC after passing through the specified gaps of steel bars and flowing within a defined flow distance. With this reached height, the passing or blocking behaviour of SCC can be estimated.

AIM:

To measure the passing ability of Self compacting concrete.

APPARATUS:

1. L- box, as shown in Figures 3 and 4. Two types of gates can be used, one with 3smooth bars and one with 2 smooth bars. The gaps are 41 and 59 mm, respectively.

2. Suitable tool for ensuring that the box is level i.e. a spirit level.

3. Suitable buckets for taking concrete sample.

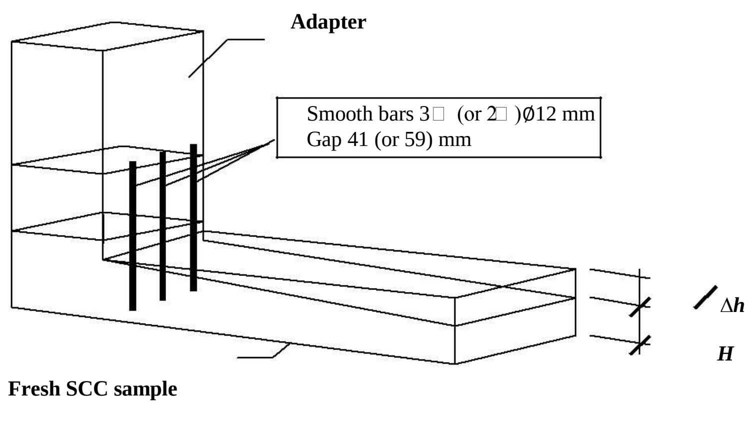


Figure 3 — Principle of the L-box test

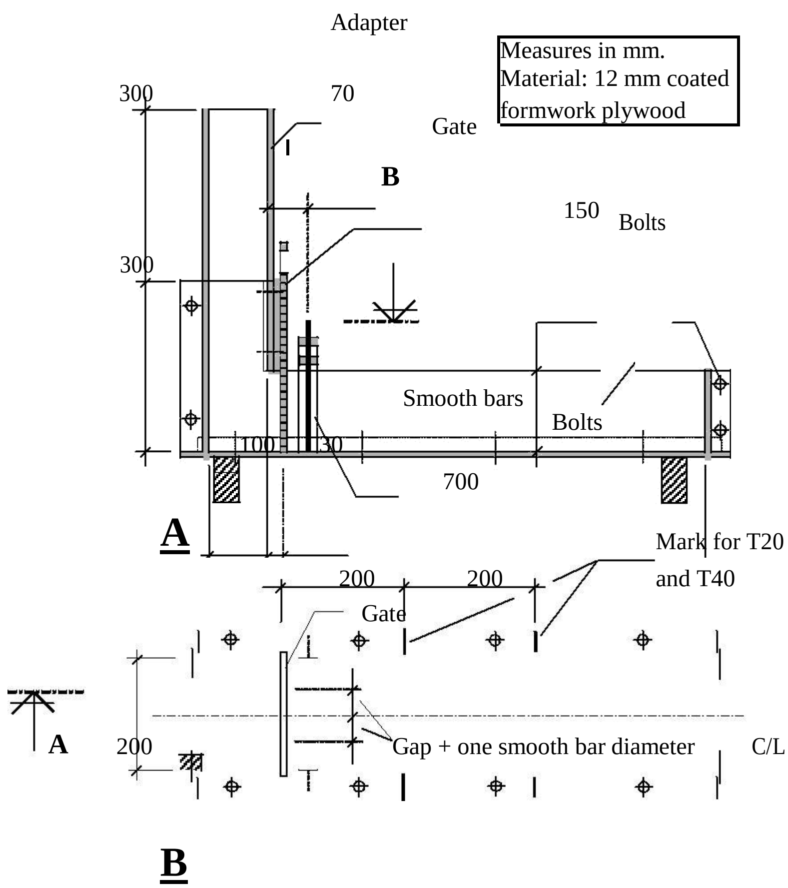


Figure 4 — Detailed dimensions of the L-box test

PROCEDURE

1. Place the L-box in a stable and level position.

2. Fill the vertical part of the L-box, with the extra adapter mounted, with 12.7 litres ofrepresentative fresh SCC.

3. Let the concrete rest in the vertical part for one minute (± 10 seconds). During thistime the concrete will display whether it is stable or not (segregation).

4. Lift the sliding gate and let the concrete flow out of the vertical part into the horizontalpart of the L-box.

5. When the concrete has stopped moving, measure the average distance, noted asΔh(see Figure 4), between the top edge of the box and the concrete that reached the end of the box, at three positions, one at the centre and two at each side

Table Precisions of the L-box passing or blocking ratio

Passing ratio P_L	**1**	**0.9**	**0.8**	**0.7**	**< 0.65**
Blocking ratio B_L	**0**	**0.1**	**0.2**	**0.3**	**> 0.35**
Repeatability *r*	0.01	0.06	0.10	0.15	0.18
Reproducibility *R*	0.03	0.07	0.11	0.16	0.18

RESULTS:

The passing ratio P_L or blocking ratio B_L is calculated using equations below, and expressed in dimensionless to the nearest 0.01.

$$P_L = \frac{H}{H_{max}}$$

Or

$$B_{L} = 1 - H/H_{max}$$

where H_{max} = 91 mm and $H = 150 - \Delta h$

EXPERIMENT NO: 11

WORKABITY TEST ON SCC, J-RING

THEORY AND SCOPE:

The J-ring test aims at investigating both the filling ability and the passing ability of SCC. It can also be used to investigate the resistance of SCC to segregation by comparing test results from two different portions of sample. The J-ring test measures three parameters: flow spread, flow time $T50_J$ (optional) and blocking step. The J-ring flow spread indicates the restricted deformability of SCC due to blocking effect of reinforcement bars and the flow time $T50_J$ indicates the rate of deformation within a defined flow distance. The blocking step quantifies the effect of blocking.

AIM:

To determine the filling ability and passing ability of self compacting concrete using J-ring test.

APPARATUS:

Open steel j-ring device, slump mould or cone, base plate, trowel, ruler.

PROCEDURE

1. Place the cleaned base plate in a stable and level position.

2. Fill the bucket with 6~7 litres of representative fresh SCC and let the sample stand stillfor about 1 minute (± 10 seconds).

3. Under the 1 minute waiting period pre-wet the inner surface of the cone and the test!urface of the base plate using the moist sponge or towel, and place the cone in the centre on the 200 mm circle of the base plate and put the weight ring on the top of the cone to keep it in place. (If a heavy cone is used, or the cone is kept in position by hand no weight ring is needed).

4. Place the J-ring on the base plate around the cone.

5. Fill the cone with the sample from the bucket without any external compacting actionsuch as rodding or vibrating. The surplus concrete above the top of the cone should be struck off, and any concrete remaining on the base plate should be removed.

6.Check and make sure that the test surface is neither too wet nor too dry. No dry areaon the base plate is allowed and any surplus of the water should be removed – the moisture state of the plate shall be ‘just wet’.

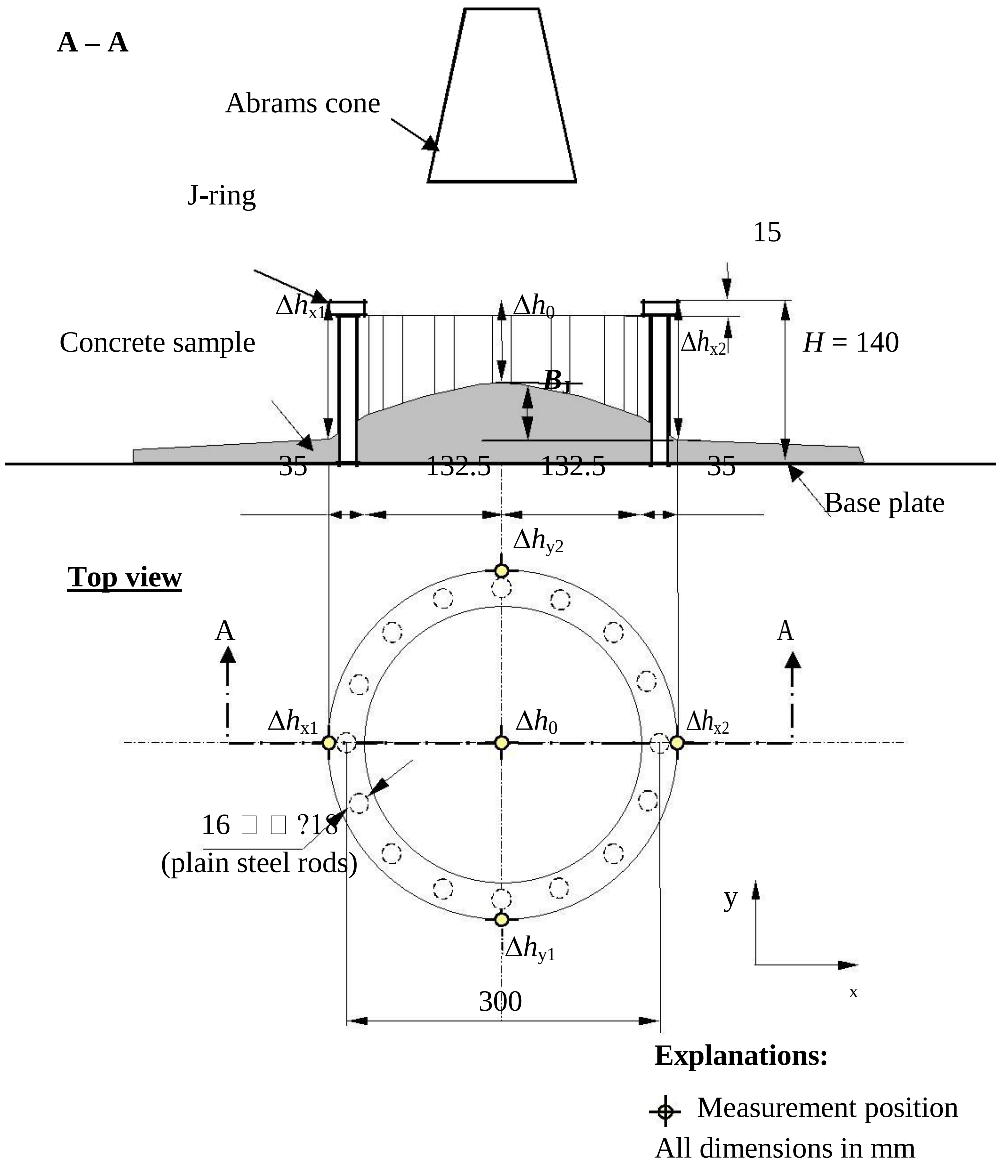


Figure 5 — Dimensions of the J-ring and positions for measurement of height differences

7. After a short rest (no more than 30 seconds for cleaning and checking the moist stateof the test surface), lift the cone perpendicular to the base plate in a single movement, in such a manner that the concrete is allowed to flow out freely without obstruction from the cone, and start the stopwatch the moment the cone loose the contact with the base plate.

8. Stop the stopwatch when the front of the concrete first touches the circle of diameter500 mm. The stopwatch reading is recorded as the $T50_J$ value. The test is completed when the concrete flow has ceased.

9. Lay the straight rod with the flat side on the top side of the J-ring and measure therelative height differences between the lower edge of the straight rod and the concrete surface at the central position (Δh_0) and at the four positions outside the J-ring, two (Δh_{x1}, Δh_{x2}) in the *x*-direction and the other two (Δh_{y1},Δh_{y2}) in the *y*-direction (perpendicular to *x*), as shown inFigure 6.

10. Measure the largest diameter of the flow spread,d_{max}, and the one perpendicular to it,d_{perp}, using the ruler (reading to nearest 5 mm). Care should be taken to prevent the ruler frombending.

11. Clean the base plate and the cone after testing.

Table — Precisions of the J-ring flow spread and flow time T500

J-ring flow spread S_J [mm]	**< 600**	**600 ~ 750**	**> 750**
Repeatability *r* [mm]	59	46	25
Reproducibility *R* [mm]	67	46	31
J-ring flow time T500 [sec]	**≤ 3.5**	**3.5 ~ 6**	**> 6**
Repeatability *r* [sec]	0.70	1.23	4.34
Reproducibility *R* [sec]	0.90	1.32	4.34
J-ring blocking step B_J [mm]	**≤ 20**		**> 20**
Repeatability *r* [mm]	4.6		7.8
Reproducibility *R* [mm]	4.9		7.8

Results

1. The J-ring flow spread$S_J$is the average of diametersd_{max}andd_{perp}, as shown inEquation (6). S_J is expressed in mm to the nearest 5 mm.

$$S = \frac{(d_{max} + d_{perp})}{2} = \_\_\_\_\_\_\_\_\_$$

2. The J-ring flow time T500is the period between the moment the cone leaves the baseplate and SCC first touches the circle of diameter 500 mm. T500 is expressed in seconds to the nearest 1/10 seconds.

3. The J-ring blocking step$B_J$is calculated using equation (7) and expressed in mm tothe nearest 1 mm.

$$B_J = \frac{\Delta h_{x1} + \Delta h_{x2} + \Delta h_{y1} + \Delta h_{y2}}{4} - \Delta h_0$$

EXPERIMENT NO: 12

WORKABITY TEST ON SCC-V FUNNEL TEST

THEORY AND SCOPE:

The V-funnel flow time is the period a defined volume of SCC needs to pass a narrow opening and gives an indication of the filling ability of SCC provided that blocking and/or segregation do not take place; the flow time of the V-funnel test is to some degree related to the plastic viscosity.

AIM:

To determine the viscosity and filling ability or passing ability of the self-compacting concrete.

APPARATUS:

1. V-funnel, as shown in Figure 7, made of steel, with a flat, horizontal top and placed onvertical supports, and with a momentary releasable, watertight opening gate.

2. Stopwatch with the accuracy of 0.1 second for recording the flow time.

3. Straightedge for levelling the concrete.

4. Buckets with a capacity of 12∼14 litres for taking concrete sample.

5. Moist sponge or towel for wetting the inner surface of the V-funnel.

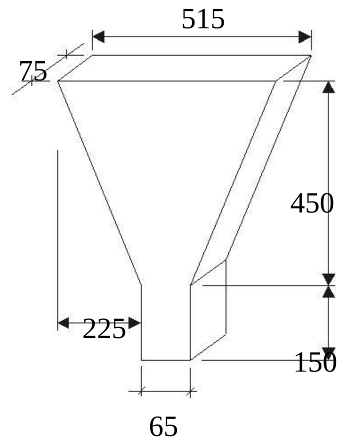


Figure 6 — Dimensions of the V-funne

PROCEDURE

1. Place the cleaned V-funnel vertically on a stable and flat ground, with the top openinghorizontally positioned.

2. Wet the interior of the funnel with the moist sponge or towel and remove the surplusof water, e.g. through the opening. The inner side of the funnel should be 'just wet'.

3. Close the gate and place a bucket under it in order to retain the concrete to be passed.

4. Fill the funnel completely with a representative sample of SCC without applying compaction or rodding.

5. Remove any surplus of concrete from the top of the funnel using the straightedge.

6. Open the gate after a waiting period of (10 2) seconds. Start the stopwatch at thesame moment the gate opens.

7. Look inside the funnel and stop the time at the moment when clear space is visiblethrough the opening of the funnel. The stopwatch reading is recorded as the V-funnel flow time, noted as t_V.

8. Clean the V-funnel after testing.

Table -Precisions of the V-funnel flow time

V-funnel flow time t_V [sec]	**3**	**5**	**8**	**12**	**≥ 15**
Repeatability *r* [sec]	0.4	1.1	2.1	3.4	4.4
Reproducibility *R* [sec]	0. 6	1.6	3.1	5.1	6.6

RESULTS:

The V-funnel flow time t_V is the period from releasing the gate until first light enters the opening,expressed to the nearest 0.1 second

EXPERIMENT NO: 13

WORKABITY TEST ON SCC-U BOX

THEORY AND SCOPE:

This standard covers the test method for passability through spaces of self-compacting concrete with a maximum coarse aggregate. Size 20 mm or less using a U-shaped or Box-shapedcontainer.This is a simple test to conduct, but the equipment may be difficult to construct. It provides a good direct assessment of filling ability-this is literally what the concrete has to do- modified by an unmeasured requirement for passing ability. The 35 mm gap between the sections of reinforcement may be considered too close. The question remains open of what filling height less than 30cm is still acceptable.

AIM:

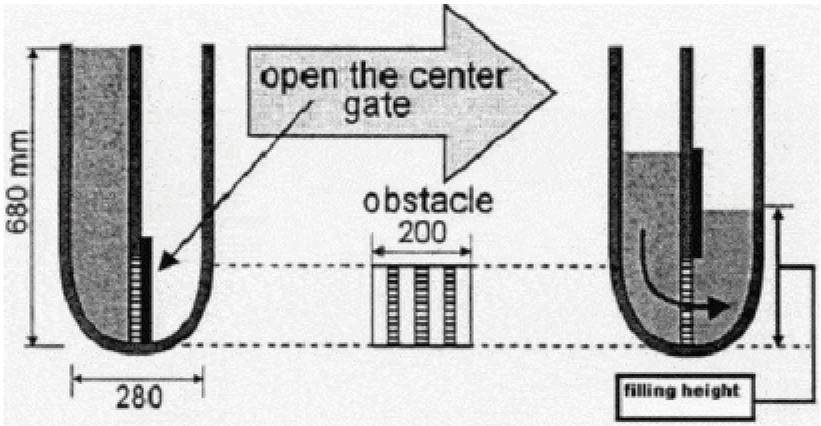
To determine passing ability of self-compacting concrete through spacing between reinforcement.

APPARATUS:

U box of a stiff non absorbing material,Scoop,Trowel,Stopwatch.

PROCEDURE:

1. About 20 liter of concrete is needed to perform the test, sampled normally.
2. Set the apparatus level on firm ground, ensure that the sliding gate can open freely and then close it.
3. Moisten the inside surface of the apparatus, remove any surplus water, fill the vertical section of the apparatus with the concrete sample. Leave it stand for 1 minute.
4. Lift the sliding gate and allow the concrete to flow out into the other compartment.
5. After the concrete has come to rest, measure the height of the concrete in the compartment that has been filled, in two places and calculate the mean (H1).
6. Measure also the height in the other equipment (H2).
7. Calculate H1-H2, the filling height. The whole test has to be performed within 5 minutes.



CALCULATION

1. Filling time--Express the measured filling time, Btime (sec), to the nearest 0.1 sec.
2. Fill height--Calculate the average fill height, Bh (mm), Of three measurements to an integer by rounding off at the first decimal place.
3. When measuring the coarse aggregate content after passing through the obstacle, calculate the coarse aggregate content, mG (kg/m3), in accordance with JIS A 1112 (Method of test for washing analysis of fresh concrete). Also calculate the mass ratio to the coarse aggregate content in the specified mixture proportions by the following equation:

Coarse aggregate mass ratio = mG/mGO

where mG = coarse aggregate content after passing through an obstacle calculated in accordance with JIS A 1112 (kg/m3)

mG. = coarse aggregate content in the specified mixture proportions (kg/m3).

Measurement of Fill Height, Bh

RESULT:

Fill height, Filling time, Btime Maximum fill height of the tester by calculation $Bh_{max=}$____

EXPERIMENT NO. 14

PERMEABILITY OF CONCRETE

THEORY AND SCOPE:

1. Permeability is the property that governs the rate of flow of a fluid into a porous solid.
2. Permeability occurs in hardened concrete
   (a) Trapped air pocket from in complete compaction.
   (b) Empty space due to the loss of mixing water in evaporation.

AIM:

To determine the permeability of the concrete specimen either cast in laboratory or obtained by cutting out cores from existing structure.

APPARATUS:

Permeability cell, water reservoir, pressure lines (leak proof).

PROCEDURE:

1. The specimen shall be surface dried and the dimension measured to the nearest 0.5mm.
2. Specimen should be kept in the centroid of the cell
3. Keep test mould in testing apparator.
4. Supply the water from water tank which attacked to the equipment.
5. Release the water from water tank of collect the water from outlet of the equipment.
6. Initially calculate the quantity of water in tank and quantity of water collected from the outlet.

CALCULATIONS:

COEFFICIENT OF PERMEABILITY

1. Determine the cross sectional area (A) in square metres of the test sample using the following formula:

$$A= \pi/4\ D2$$

where D = Diameter of test sample, to the nearest 0.001m.

2. Determine the applied pressure head (h) in metres of water.

3. The D'Arcy Coefficient of Permeability is calculated using the following formula:

$$k = Q / tAh$$

where k = D'Arcy Coefficient of Permeability (m/s)
Q = Volume of water in m^3
L = Length of the test sample in metres, to the nearest 0.001m
t = Elapsed time in seconds
h = Applied pressure head in metres of water
A = Area of the test sample in m^2

REPORTING

1. The D'Arcy Coefficient of Permeability, to the nearest significant figure for the inflow and outflow and the mean.
2. The source of the sample.
3. Any obvious features evident in the test sample such as surface defects, cracks etc.
4. The age of the sample if known.
5. A graphical presentation of the test data (Q versus t).
6. Mass of the test sample before and after test to the nearest 0.1g.

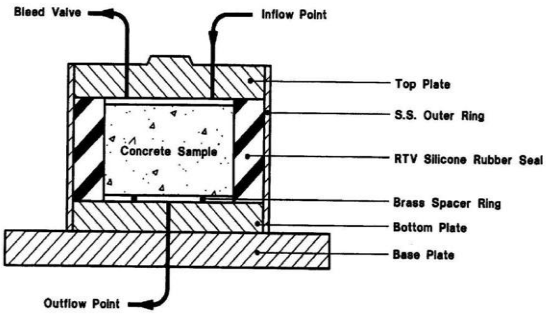


FIGURE 1
DETAILS OF PERMEABILITY CELL

RESULTS:

The D'Arcy Coefficient of Permeability is calculated using the following formula k=___________.

EXPERIMENT NO: 15

ACCELERATED CURING TANK

THEORY AND SCOPE:

To find the compression strength of cube after 24 hours, with these values we can final compressive strength of concrete IS: 9013-1978-Method of making, curing and determining compressive strength of accelerated cured concrete test specimen. Normally, the strength of concrete is found out after 7 days and 28 days. For some construction activities, it may be too late and need to know the strength earlier.

AIM

To find the strength of concrete after 24 hours using accelerated curing tank.

APPARATUS

Accelerated curing tank, Compression Testing Machine

Accelerated Curing Tank

PROCEDURE

1. Prepare the specimen and store it in moist air of at least 90% relative humidity and at a temperature of 27+2^{o}C for 23 hrs + 15 minutes.
2. Lower the specimen, into a curing tank with water at 100 ^{0}C and keep it totally immersed for 3 ½ hours + 5 minutes.
3. The temperature of water shall not drop more than 3oC after the specimens are placed and should return to boiling within 15 minutes.
4. After curing for 3 ½ hours + 5 minutes in the curing tank, the specimen shall be removed from the moulds and cooled by immersing in cooling water 27+2^{o}C for a period of at least one hour.
5. Read compressive strength test of concrete for further steps.

CALCULATION:

The corresponding strength at 28 days can be found out from the following correlation. (It is however suggested that a new specific correlation should be developed for the specific concrete used at site.)

R_{28} (Strength at 28 days) = 8.09 + 1.64 Ra

Where,

Ra = Accelerated Curing Strength in MPa.

RESULT:

Accelerated curing strength=

EXPERIMENT NO: 16

NON-DESTRUCTIVE TESTS

REBOUND HAMMER TEST:
THEORY AND SCOPE:

1. The rebound number determined by this method may be used to access the uniformity of concrete in situ, to delineate zones or regions (areas) of poor quality or deteriorated concrete in structures, and to indicate changes with time in characteristics of concrete such as those caused by the hydration of cement so that it provides useful information in determining when forms and shoring may be removed.
2. This test method is not intended as an alternative for strength determination of concrete.
3. Optimally, rebound number should be correlated with core testing information. Due to the difficulty of acquiring the appropriate correlation data in a given instance, the rebound number is most useful for rapidly surveying large areas of similar concretes in the construction under consideration.

AIM:

To determine the rebound number of hardened concrete which has close relation with compressive strength of concrete by using spring -driven steel hammer.

APPARATUS:

Rebound hammer, abrasive stone.

PROCEDURE:

1. Calibration of Hammer: Carefully calibrate hammer every time before use. Follow the instruction manual of each hammer.
2. Selection of the Test Surface: Concrete member to be tested shall be at least 100 mm (4 in) thick and fixed within a structure. Smaller specimens must be rigidly supported. Area exhibiting honeycombing, scaling, rough texture or high porosity should be avoided.
For convenience, you may use concrete cylinders casted in Test C-7 as test specimens.
3. Preparation of Test Surface: A test area shall be at least 150 mm (6 in) in diameter. Heavily textured, soft or surfaces with loose mortar shall be ground smooth with the abrasive stone. Smooth-formed or troweled surfaces shall be tested without grinding.
4. Testing:
a) Firmly hold the instrument in a position that allows the plunger to strike perpendicularly to the tested surface. Gradually increase the pressure on the plunger until the hammer impacts.
b) After impact, record the rebound number. Take ten reading from each test area. No two impact test shall be closer together than 25 mm (1 in). Examine the impression made on the surface after

impacted, and disregard the reading if the impact impact crushes or breaks through a near surface air void.

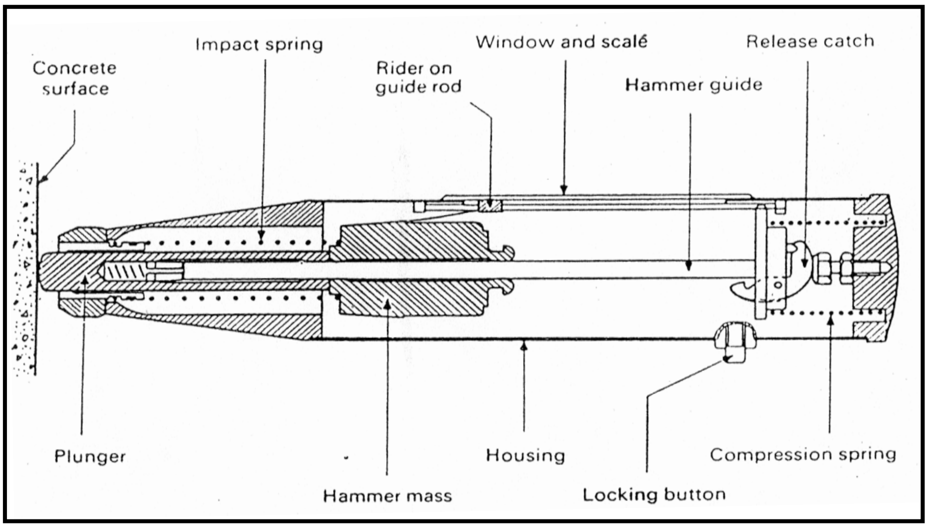
c) Discard readings differing from the average of 10 readings by more than 7 units and determine the average of the remaining readings. If more than 2 readings differ from the average by 7 units, discard the entire set of readings.

d) The rebound number used for estimation of concrete strength should be calculated from

$$R = (C * Rdg) + Q$$

where R is rebound number (to the nearest 0.5), C is coefficient of the hammer (Nominal value/Calibration value), Rdg is nominal impact reading and Q is correction for the inclination of impact as shown in table:

Rdg	Upward		Downward	
	+90 degree	+45 degree	-45 degree	-90 degree
10	NA.	NA.	+2.4	+3.2
20	-5.4	-3.5	+2.5	+3.4
30	-4.7	-3.1	+2.3	+3.1
40	-3.9	-2.6	+2.0	+2.7
50	-3.1	-2.1	+1.6	+2.2
60	-2.3	-1.6	+1.3	+1.7



Basic Features of Rebound hammer

CALCULATIONS:

No.	Calibration Test (Standard steel)	Concrete cylinders test		
		No.1	No.2	No.3
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
Average				

RESULT: Reynolds number =_---------

ULTRASONIC PULSE VELOCITY METHOD

THEORY AND SCOPE:

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

1. The Homogeneity of the Concrete

2. The Presence of Cracks, Voids and other Imperfections

3. Changes in the Structure of the Concrete Caused by the Exposure Condition, Corrosion, Wear etc. which may occur with time,

4. The Quality of the Concrete in Relation to the Specified Standard Requirements.

5. The Quality of One Element of Concrete in Relation to the Another.

6. The Values of the Dynamic Elastic Modulus of the Concrete.

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

AIM:

To access the quality of the concrete by the UPV test.

APPARATUS:

1. Electrical pulse generator

2. Transducer - one pair

3. Amplifier

4. Electronic timing device.

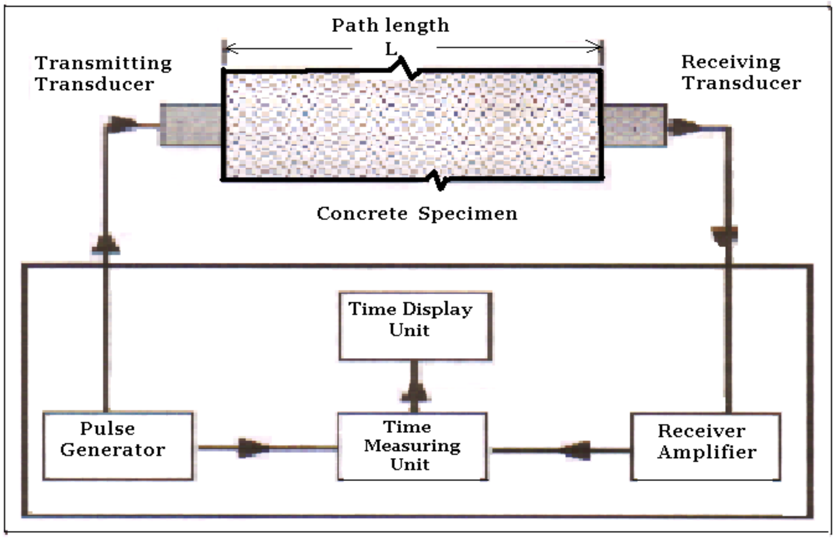


Fig. 3: Schematic Diagram of Ultrasonic Pulse Velocity Method

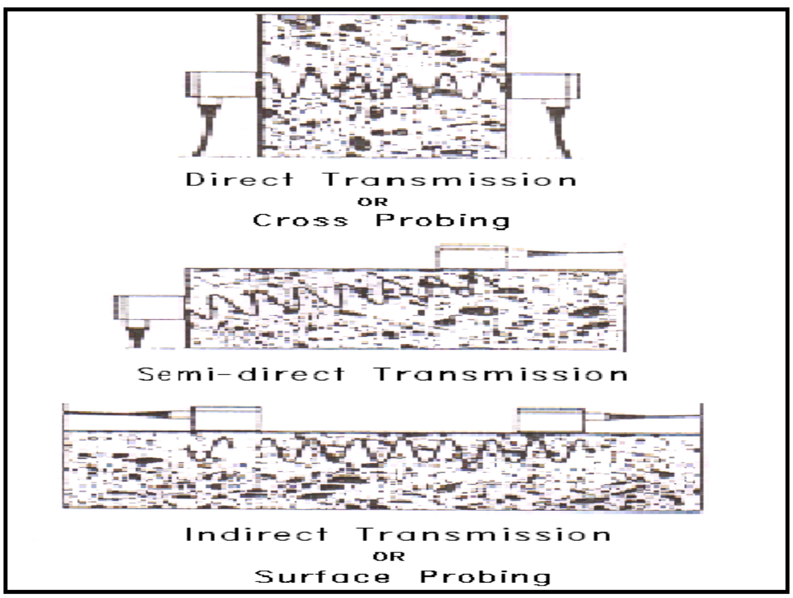


Fig. 4 : Different Methods of Propagating Ultrasonic Pulses through Concrete

PROCEDURE:

1. Select the most suitable test point on the materials to be tested, measure the path length(L),to be transferred in the concrete before the pulses of vibrations is converted into an electrical signal by the second transur.

2. Erect platform of suitable height to provide an access to the test points (predesigned) and marked location.for selection of receiving locations following should be considered.

3. Smoother the uneven, concrete surfaces to make the pulse velocity measurement possible.

4. For maximum accuracy, select micro-second range for the measured path length upto 400mm microsecond range may be selected range.

5. Apply complaint to the face of the transducers (petroleum jelly or grease may severe the purpose) mount the pulse transmitting transducer an one surface of the concrete member by pushing it hard onto the surface of the concrete member by pressing it hard onto the surface of the material under test.

6. mount the second transducer,called electrical signal receiving transducer, on the other surface of the concrete member at the predetermined location with acoustical transducer and an electronic timing circuit to measure the transit time't' of the pulse.

7. generate a longitudinal vibration pulse by transmitting or electro acoustical transducer,which held in contact with one surface member.

8. continue holding the transducers onto the surface of the material until consistent reading appears on the display, which is the time in microsecond for the ultrasonic pulse to travel the distance'L".

9.record the transmit time't' of the pulse as the mean value of the display reading when the unit digits hunts between two values.

10. compute the pulse velocity 'V' given by
V=L/T

Table 2 : Velocity Criteria For Concrete Quality Grading

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

RESULT:

Type of transmission	Travel length “L”mm	Transit true “T”sec	Pulse velocity L/T mm/sec
Receiving point No.			
a)			
b)			
c)			

EXPERIMENT NO: 18

STRAIN AND DEFLECTION OF MEMBER UNDER LOADS

AIM:

To determining the flexural strength of moulded concrete flexure test specimens

APPARATUS:

Testing Machine

Beam Moulds **-** The beam moulds shall conform to IS: 10086-1982. The standard size shall be 15 × 15 ×70 cm. Alternatively, if the largest nominal size of the aggregate does not exceed 19 mm, specimens 10 × 10 × 50 cm may be used.

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

THEORY AND SCOPE:

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

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

PROCEDURE:

1. **Sampling of Materials -** Samples of aggregates for each batch of concrete shall be of the desiredgrading and shall be in an air-dried condition. The cement samples, on arrival at the laboratory, shall be thoroughly mixed dry either by hand or in a suitable mixer in such a manner as to ensure the greatest possible blending and uniformity in the material.
2. **Proportioning -** The proportions of the materials, including water, in concrete mixes used fordetermining the suitability of the materials available, shall be similar in all respects to those to be employed in the work.
3. **Weighing -** The quantities of cement, each size of aggregate, and water for each batch shall bedetermined by weight, to an accuracy of 0.1 percent of the total weight of the batch.
4. **Mixing Concrete -** The concrete shall be mixed by hand, or preferably, in a laboratory batch mixer,in such a manner as to avoid loss of water or other materials. Each batch of

concrete shall be of such a size as to leave about 10 percent excess after moulding the desired number of test specimens.

5. Mould - The standard size shall be 15 × 15 × 70 cm. Alternatively, if the largest nominal size of theaggregate does not exceed 19 mm, specimens 10 × 10 × 50 cm may be used.

6. Compacting - The test specimens shall be made as soon as practicable after mixing, and in such away as to produce full compaction of the concrete with neither segregation nor excessive laitance.

7. Curing - The test specimens shall be stored in a place, free from vibration, in moist air of at least 90percent relative humidity and at a temperature of 27° ± 2°C for 24 hours ± ½ hour from the time of addition of water to the dry ingredients.

8. Placing the Specimen in the Testing Machine - The bearing surfaces of the supporting and loadingrollers shall be wiped clean, and any loose sand or other material removed from the surfaces of the specimen where they are to make contact with the rollers.

9. The specimen shall then be placed in the machine in such a manner that the load shall be applied to the uppermost surface as cast in the mould, along two lines spaced 20.0 or 13.3 cm apart.

10. The axis of the specimen shall be carefully aligned with the axis of the loading device. No packing shall be used between the bearing surfaces of the specimen and the rollers.

11. The load shall be applied without shock and increasing continuously at a rate such that the extreme fibre stress increases at approximately 7 kg/sq cm/min, that is, at a rate of loading of 400 kg/min for the 15.0 cm specimens and at a rate of 180 kg/min for the 10.0 cm specimens.

12. The load shall be increased until the specimen fails, and the maximum load applied to the specimen during the test shall be recorded. The appearance of the fractured faces of concrete and any unusual features in the type of failure shall be noted

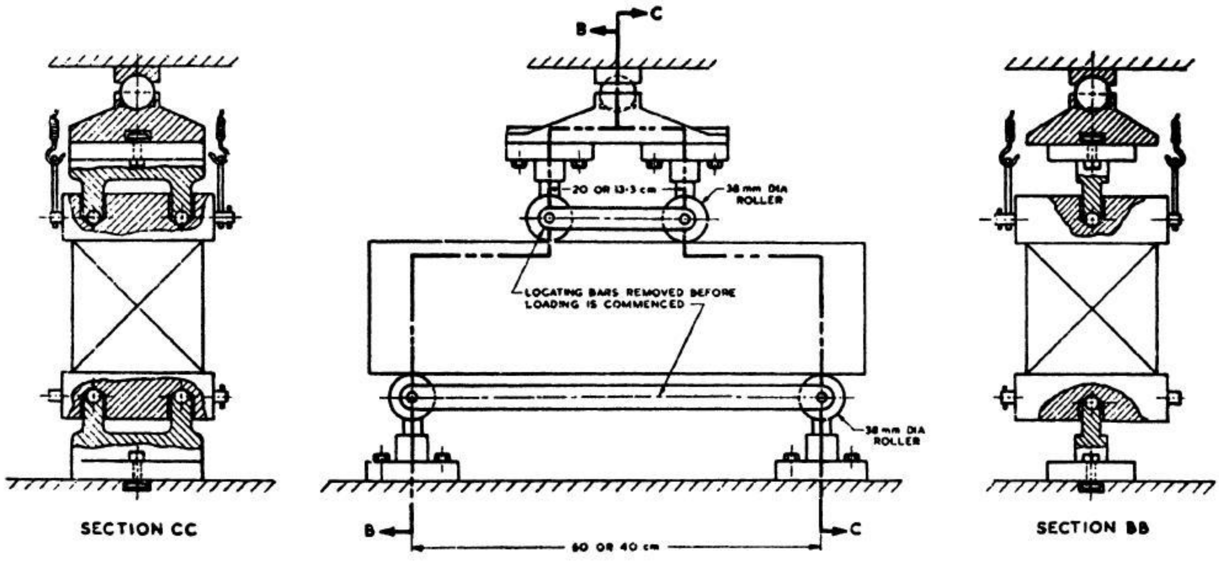


FIG. 3 ARRANGEMENT FOR LOADING OF FLEXURE TEST SPECIMEN

TABLE

Mix proportion of concrete	**For 1 cubic meter of concrete**	**For one batch of mixing**
Coarse aggregate (kg)		
Fine aggregate (kg)		
Cement (kg)		
Water (kg)		
S/A		
w/c		
Admixture		

Sr. No.	Age of Specimen	Identification Mark	Size of Specimen (mm)	Span Length (mm)	Maximum Load (N)	Position of Fracture _a‘ (mm)	Modulus of Rupture (MPa)
1	7 Days						
2							
3							
4	28 Days						
5			`				
6							

CALCULATION:

The flexural strength of the specimen shall be expressed as the modulus of rupture f_b, which, if _a‘ equals the distance between the line of fracture and the nearer support, measured on the centre line of the tensile side of the specimen, in cm, shall be calculated to the nearest 0.5 kg/sq cm as follows.

when _a‘ is greater than 20.0 cm for 15.0 cm specimen, or greater than 13.3 cm for a 10.0 cm specimen, or

$$f_b = \frac{P*l}{A*d^2}$$

$$f_b = \frac{3P*a}{b*d^2}$$

when _a‘ is less than 20.0 cm but greater than 17.0 cm for 15.0 cm specimen, or less than 13.3 cm but greater than 11.0 cm for a 10.0 cm specimen.

Where

b = measured width in cm of the specimen,

d = measured depth in cm of the specimen at the point of failure,

l = length in cm of the span on which the specimen was supported,and

p = maximum load in kg applied to the sp ecimen.

RESULT:

i) The average 7 Days Modulus of Rupture of concrete sample is found to be …..…..

ii) The average 28 Days Modulus of Rupture of concrete sample is found to be …..…..