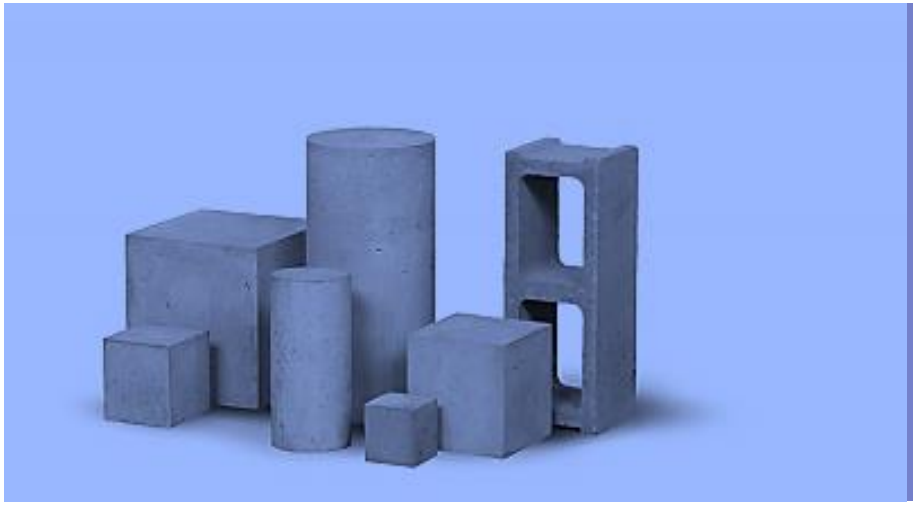

Department of

CIVIL AND ENVIRONMENTAL ENGINEERING

CEE214L Engineering Materials Lab

ENGINEERING MATERIALS LABORATORY

NORTH SOUTH UNIVERSITY
Center of Excellence in Higher Education
The First Private University in Bangladesh

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North South University

Department of Civil and Environmental Engineering

CEE 214L

ENGINEERING MATERIALS

LABORATORY MANUAL

CEE 214L: Engineering Materials Lab

COURSE DESCRIPTION:

Laboratory experiments on common materials used in the civil engineering purposes, such as steel, aggregates, cement, cement concrete, etc. 1 credit. 3 hours per week.

COURSE OBJECTIVE:

Provide the students a hands-on experience of conducting characterization and specification-conformation experiments at the laboratory for common materials used in the civil engineering purposes.

DETAIL COURSE CONTENTS (LAB EXPERIMENTS):

1. Introduction to Measuring Devices (ASTM C670).
2. Sieve Analysis of Fine and Coarse Aggregates (ASTM C136).
3. Specific Gravity and Absorption Capacity of Aggregate (ASTM C127).
4. Standard Test Method for Bulk Density (Unit Weight) and Voids in Aggregate (ASTM C29).
5. Determination of Normal Consistency of Cement with Vicat's Apparatus (ASTM C 127).
6. Determination of Initial Setting Time of Cement with Vicat's Apparatus (ASTM C 191).
7. Compressive Strength Test of Cement Mortar (ASTM C109).
8. Concrete Slump Test (ASTM C 143).
9. Standard Practice for Making and Curing Concrete Test Specimens in the Field (ASTM C31).
10. Compressive Strength Test of Cylindrical Concrete Specimen (ASTM 39).

EVALUATION:

Participation and attendance	= 35%
Lab Report	= 35%
Lab Exam	= 30%

LAB INSTRUCTIONS:

The course instructor or lab assistant/coordinator must be consulted before using any lab facility. Students are strongly advised to follow the general lab safety rules. Note that closed toe shoes are mandatory in all Civil Engineering laboratories. No sandals will be allowed in the lab. It is a student's responsibility to read the test procedures and text assignments before the scheduled labs. It is highly requested to maintain discipline in the lab like not to be late, refrain from making noise during lab time, not to leave the lab early.

MAPPING OF COURSE OUTCOME-PROGRAM OUTCOME (CO-PO):

Sl.	Course Outcomes (COs)	Program Outcome[1]	Bloom's taxonomy Domain /level[2]	Delivery methods and activities	Assessment tools
CO1	Conduct common laboratory experiments on materials used in the civil engineering purposes and use the experimental data to characterize those materials in order to conform to standard specifications.	**PO-5**	P1, P2, P3	Lecture, Demonstration	Participation, Lab report, Exam

Notes:

1. BSCEE Program Outcomes (POs):

- PO - 1: Engineering Knowledge
- PO - 2: Problem analysis
- PO - 3: Design/development of solutions
- PO - 4: Investigation
- PO - 5: Modern tool usage
- PO - 6: The engineer and society
- PO - 7: Environment and sustainability
- PO - 8: Ethics
- PO - 9: Individual work and teamwork
- PO - 10: Communication
- PO - 11: Project management and finance
- PO - 12: Life-long learning
- PO - 13: Contemporary Issues.

2. Domains and Levels of Bloom's Taxonomy

- "Cognitive" Domain (C): C1 - Recall data, C2 - Understand, C3 - Apply, C4 - Analysis, C5 - Synthesize, and C6 - Evaluate.
- "Affective" Domain (A): A1 - Receive, A2 - Respond, A3 - Value, A4 - Organize personal value system, and A5 - Internalize value system.
- "Psychomotor" Domain (P): P1 - Imitation, P2 - Manipulation, P3 - Develop precision, P4 -Articulation, and P5 - Naturalization.

EXAM AND GRADING POLICY:

Lab exam will be a written and/or viva based on the knowledge gained from experiments done in the lab. No makeup exam will be arranged unless an absolutely unavoidable valid reason for absence is found. For such unavoidable circumstances, written explanation must be submitted before the exam. Generally, NSU grading policy will be followed.

North South University
Department of Civil and Environmental Engineering

CEE 214L: ENGINEERING MATERIALS LAB

EXPERIMENT NO: 01
INTRODUCTION TO MEASURING DEVICES

Name:

ID:

Group:

Section:

Performance Date:

Submission Date:

EXPERIMENT NO: 01
INTRODUCTION TO MEASURING DEVICES

OBJECTIVE:

To introduce the students to common measuring devices. An introduction to precision and bias will be also included.

APPARATUS:

i. Slide calipers

ii. Balance

iii. Screw gauge

iv. Measuring tape

v. A few dial gauges with different ranges and sensitivities

vi. Load Cell

PROCEDURE:

Follow Class.

DISCUSSION:

North South University
Department of Civil and Environmental Engineering

CEE 214L: ENGINEERING MATERIALS LAB

EXPERIMENT NO: 02
SIEVE ANALYSIS OF FINE AGGREGATE

Name:

ID:

Group:

Section:

Performance Date:

Submission Date:

EXPERIMENT NO: 02
SIEVE ANALYSIS OF FINE AGGREGATE

RELATED THEORY:

The term sieve analysis is given to the sample operation of dividing a sample of aggregates in to fraction each consisting of particles between specific limit. The analysis is conducted to determine the grading of material proposed for use as aggregates.

The term fineness modulus (F.M) is a ready index of coarseness or fineness of material. It is an empirical factor obtained by adding the cumulative percentages of aggregates. Retained on each of the standard sieves and dividing this sum arbitrarily by 100.

No.100, No.50, No.30, No.16, No.8, No.4, 3/8 in., ¾ in., 3 in., 1.5 in. are the ASTM standards sieves. This test method conforms to the ASTM standard requirements of specification C 136.

OBJECTIVE:

To determine the particle size distribution of fine and coarse aggregate.

APPARATUS:

i. Sieve (#4, #8, #16, #30, #50, # 100)

ii. Balance

iii. Stop Watch.

MACHINE:

i. Motorized Sieve Shaker (90sec).

MATERIAL:

i. Fine Aggregates (500gm).

PROCEDURE FOR FA:

1. Dry the sample to constant weight at a temperature of 110 + 5^0C or 110 - 5^0C.

2. Nest the sieve in order of decreasing size of opening from top to bottom and place the sample on the top sieve.

3. Agitate the sieves by hand or by mechanical apparatus for a sufficient period, say 1.5 minutes (One Minutes Thirty Seconds).

4. Limit the Quantity of material on a given sieve so that all particles have the opportunity to reach sieve openings a number of times during the sieving operation. For sieves with openings smaller than 4.75 mm (No.4), the weight retained on any sieve at the completion of the sieving operation shall not exceed 6 kg/m^2 (4g/in^2) of sieving surface. For sieves with openings4.75mm (No4) and larger, the weight in kg/m of sieving surface shall not exceed the product of 2.5 *(sieve opening in mm). In no case shall the weight be so great as to cause permanent deformation of the sieve cloth.

5. Continue sieving for a sufficient period and in such manner that after completion, not more than 1 weight % of the residue on any individual sieve will pass that sieve during 1 minute of continuous hand sieving.
6. Determine the weight of each size increment by weighing on a scale or balance to the nearest 0.1% of the total original dry sample weight. The total weight of the material after sieving should check closely with original weight of sample placed on the sieves. If the amount differs by more than 0.3% based on the original dry sample weight, the results should not be used for acceptance purposes.

DATA TABLE:

Sieve Number	Sieve Opening (mm)	Materials Retained (gm)	% Materials Retained	Cumulative % Retained	% Passing
# 4	4.75				
#8	2.36				
#16	1.18				
#30	0.60				
#50	0.30				
#100	0.15				
Pan	--				
Total		Σ=		Σ=	

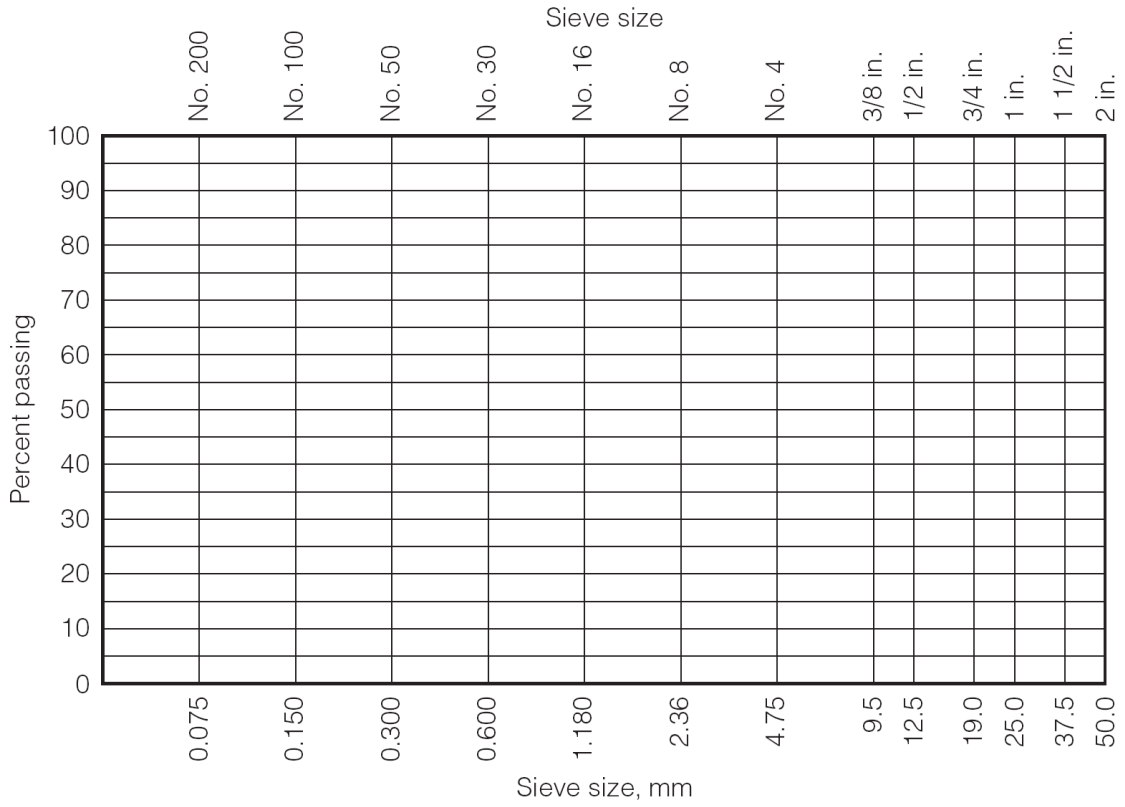
SAMPLE CALCULATION:

$$\text{Formula used in calculating \% retained} = \left(\frac{\text{Material Retained on each Sieve (in gm)}}{\Sigma \text{ Material Retained}} * 100\right)$$

Formula used in calculating Percent Passing = (100 – Cumulative percentage retained)

Therefore,

$$\text{Fineness Modulus} = \frac{\Sigma \text{ Cumulative percentage retained}}{100}$$



GRADATION CHART:

Draw a graph on Semi log paper (Percent Passing vs. Sieve Size in mm).

DISCUSSION:

North South University
Department of Civil and Environmental Engineering

CEE 214L: ENGINEERING MATERIALS LAB

EXPERIMENT NO: 03

SPECIFIC GRAVITY AND ABSORPTION CAPACITY OF AGGREGATE

Name:

ID:

Group:

Section:

Performance Date:

Submission Date:

EXPERIMENT NO: 03

SPECIFIC GRAVITY AND ABSORPTION CAPACITY OF AGGREGATE

RELATED THEORY:

Aggregates generally contain pore, both permeable and impermeable, for which specific gravity has to be carefully defined. With this specific gravity of each constituent known, its weight can be converted into solid volume and hence a theoretical yield of concrete per unit volume can be calculated. Specific gravity of aggregate is also required in calculating the compacting factor in connection with the workability measurements. This test method covers the determination of bulk and apparent specific gravity, 23/23°C (73.4/72.4°F) and absorption of fine aggregate.

Bulk specific gravity is defined as the ratio of the weight of the aggregate (oven-dry or saturated surface dry) to the weight of water occupying a volume equal to that of the solid excluding the impermeable pores. This is used for calculation of the volume occupied by the aggregate in various mixtures containing aggregate on an absolute volume basis, ii) the computation of voids in aggregate, and iii) the determination of moisture in aggregate.

Apparent specific gravity is the ratio of the weight of the aggregate dried in an oven at 100 to 110°C (212 to 230°F) for 24 hrs. to the weight of water occupying a volume equal to that of the solid including the impermeable pores. This pertains to the relative density of the solid material making up the constituent particles not including the pore space within the particles that is accessible to water.

Absorption values are used to calculate the change in the weight of an aggregate due to water absorbed in the pore spaces within the constituent particles, compared to the dry condition. For an aggregate that has been in contact with water and that has free moisture on the particle surface, the percentage of free moisture can be determined by deducting the absorption from the total moisture content.

This test method conforms to the ASTM standard requirements of specification C127.

OBJECTIVE:

To determine the Specific Gravity and Absorption Capacity of coarse aggregate.

APPARATUS:

a) Balance- Sensitive to 0.05% of the sample weight at any point within the range used for the test, or 0.5g, whichever is greater.

b) Sample container- A wire basket of 3.35 mm (No.6) or finer mesh, or a bucket of approximately equal breath and height; with a capacity of 4 to 7 liters for 37.5mm (1.5in.) nominal maximum size aggregate. The container shall be constructed so as to prevent trapping air when the container is submerged.

c) Water tank- A watertight tank into which the sample container may be placed while suspended below the balance.

d) Sieves- A 4.75 mm (No.4) sieve or other sizes as needed.

SAMPLING:

1. Thoroughly mix the sample of aggregate and reduce it to the approximate quantity needed. Reject all material passing a 4.75 mm (No. 4) sieve by sieving and thoroughly washing to remove dust or other coatings from the surface. If the coarse aggregate contains a substantial quantity of material finer than the 4.75 mm sieve use the 2.36 mm (No.8) sieve in place of the 4.75 mm sieve.

2. The minimum weight of test sample to be used is given below :

Nominal Maximum Size mm (inch)	Minimum Weight of Test Sample, kg (1b)
12.5(1/2)or less	2(4.4)
19.0 (3/4)	3(6.6)
25.0(1)	4(8.8)
37.5(1½)	5(11)
50(2)	8(18)
63(2½)	12(26)
75(3)	18(40)
90 (3½)	25(55)
100(4)	40(88)
112(4½)	50(100)
125(5)	75(165)
150(6)	125(276)

PROCEDURE:

1. Dry the test sample to constant weight at a temperature of 110 ± 5°C (230 ± 9°F),cool in air at room temperature for 1 to 3 hr. for test samples of 37.5mm (1.5in.) nominal maximum size, or longer for larger sizes until the aggregate has cooled to a temperature that is comfortable to handle (approximately 50°C). Subsequently immerse the aggregate in water at room temperature for a period of 24+4hr.

2. Remove the test sample from the water and roll it in a large absorbent cloth until all visible films of water are removed. Wipe the larger particles individually. A moving stream of air

may be used to assist in the drying operation. Take care to avoid evaporation of water from aggregate pores during the operation surface drying. Weigh the test sample in the saturated surface–dry condition. Record this and all subsequent weights to the nearest 0.5 g. or 0.05% of the sample weight, whichever is greater.

3. After weighing, immediately place the saturated-surface-dry test sample container and determine its weight in water at 23±1.7°C (73.4±3°F), having a density of 997 ± 2 kg/m^3. Take care to remove all entrapped air before weighing by shaking the container while immersed.

4. Dry the test sample to constant weight at a temperature of 110 ±5°C (230 ±9°F), cool in air at room temperature 1 to 3 hr., or until the aggregate has cooled to a temperature that is comfortable to handle (approximately 50°C), and weigh.

CALCULATION:

a) Bulk Specific Gravity (oven-dry), S_d

Calculate the bulk specific gravity, 23/23°C (73.4/73.4°F), as follows:

$$\text{Bulk sp. gravity} = \frac{A}{B-C} =$$

where,

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

B = weight of saturated-surface-dry test sample in air, g, and

C = Weight of saturated test sample in water, g.

b) Bulk Specific Gravity (Saturated-surface dry) S_s

Calculate the bulk specific gravity at 23°C (73.4°F) based on weight of saturated-surface-dry aggregate as follows:

$$\text{Bulk sp. gravity (saturated-surface-dry)} = \frac{B}{B-C} =$$

c) Apparent Specific Gravity, S_a

Calculate the apparent specific gravity, 23/23°C (73.4/73.4°F), as follows:

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

d) Absorption, A

Calculate the percentage of absorption, as follows:

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

REPORT:

a) Report specific gravity results to the nearest 0.01, and indicate the type of specific gravity, whether bulk, bulk (saturated-surface-dry), or apparent.

b) Report the absorption result to the nearest 0.1%.

DATA SHEET:

Test No.	Wt of CA in air (SSD) **B** (g)	Wt of CA in water **C** (g)	Wt of CA in air (OD) **A** (g)	Bulk Sp. Gravity (SSD)	Bulk Sp. Gravity (OD)	Apparent Sp. Gravity	% of Absorption

DISCUSSION:

North South University
Department of Civil and Environmental Engineering

CEE 214L: ENGINEERING MATERIALS LAB

EXPERIMENT NO: 04
BULK UNIT WEIGHT AND VOIDS IN AGGREGATE

Name:

ID:

Group:

Section:

Performance Date:

Submission Date:

EXPERIMENT NO: 04

BULK UNIT WEIGHT AND VOIDS IN AGGREGATE (ASTM C29)

RELATED THEORY:

The bulk density of aggregate is needed for the proportioning of Portland cement concrete mixtures. The bulk density may also be used to determine the mass/volume relationships for conversions in purchase agreements. The percentage of voids between the aggregate particles can also be determined, on the basis of the obtained bulk density.

OBJECTIVE:

To determine the bulk unit weight and voids in aggregate in either a compacted or loose condition.

APPARATS:

- Measure. Use a rigid metal watertight container with a known volume. A minimum volume of the measure is required for different nominal maximum sizes of coarse aggregate. For a 25-mm (1 in.) nominal maximum aggregate size, a minimum volume measure of (9.3 liters) is required. 0.0093 m3 (9.3 liters) is required.

- Balance, tamping rod, shovel or scoop, and a plate glass.

PROCEDURE:

1. Calibrate the measure as follows:

   a) Fill the measure with water at room temperature and cover with a plate glass in such a way as to eliminate bubbles and excess water.
   b) Determine the mass of the water in the measure.
   c) Measure the temperature of the water, and determine its density as shown in the table. Interpolate as necessary.

Temperature		Density	
^0C	^0F	Kg/m^3	lb/ft^3
15.6	60	999.01	62.366
21.1	70	997.97	62.301
26.7	80	996.59	62.216
29.4	85	995.83	62.166

   d) Calculate the volume of the measure by dividing the mass of the water by its density.

2. Fill the measure with aggregate and compact it, either by rodding [for aggregates having nominal maximum size of 37.5 mm or less], jigging [for aggregates having a nominal

maximum size of 37.5 to 125 mm], or shoveling (if specifically stipulated).

a) Rodding Procedure: Fill the measure with aggregate in three layers of approximately equal volumes. Rod each layer of aggregate with 25 strokes of the tamping rod, evenly distributed over the surface.

b) Jigging Procedure: Fill the measure with aggregate in three layers of approximately equal volumes. Compact each layer by placing the measure on a firm base, raising the opposite sides alternately about 50 mm (2 in.), and allowing the measure to drop 25 times on each side.

c) Shoveling Procedure: Fill the measure to overflowing by means of a shovel or scoop, discharging the aggregate from a height not to exceed 50 mm (2 in.) above the top of the measure. Exercise care to avoid segregation.

3. Level the surface of the aggregate with the fingers or a straightedge. Determine the net weight of the aggregate to the nearest 0.05 kg (0.1 lb)

CALCULATION:

- $M = \frac{G-T}{V}$
- $\%\, Voids = \frac{(SW)-M}{SW} \times 100$

Where

M = bulk unit weight of aggregate, kg/m^3 (lb/ft^3)

G = weight of the aggregate plus the measure, kg (lb)

T = weight of the measure, kg (lb)

V = volume of the measure, m^3 (ft^3)

S = bulk specific gravity (dry basis) (ASTM C127 or C128)

W= Unit weight of water, 998kg/m^3 (62.3lb/ft^3)

REPORT:

Report the bulk unit weight (or loose bulk unit weight in case of shoveling), void content, and method of compaction.

DISCUSSION:

North South University
Department of Civil and Environmental Engineering

CEE 214L: ENGINEERING MATERIALS LAB

EXPERIMENT NO: 05
DETERMINATION OF NORMAL CONSISTENCY OF CEMENT WITH VICAT'S APPARATUS

Name:

ID:

Group:

Section:

Performance Date:

Submission Date:

EXPERIMENT NO 05
DETERMINATION OF NORMAL CONSISTENCY OF CEMENT WITH VICAT'S APPARATUS

RELATED THEORY:

The amount of water content that brings the cement paste to a standard condition of wetness is called "normal consistency". It has a marked effect upon the time of set as well as upon other properties. The paste at normal consistency is fairly stiff and is used only for the determination of time of set and soundness.

This test method conforms to the ASTM standard requirements of specification C187. The usual range of values being between 22 to 30 percent by weight of dry cement.

OBJECTIVE:

The objective of the experiment is to determine the normal consistency of cement with Vicat's Apparatus

APPARATUS:

a) Balance (sensitive to 0.1mg) set of metric weights. The permissible variations on weights in use in weighing the cement shall be as prescribed in Table-1. The permissible variations on new weights shall be one half of the values in Table-1.

Table-1: Permissible Variations on Weights

Weight, g	Permissible Variation on Weights in Use, plus or minus, g
500	0.18
300	0.15
250	0.13
200	0.10
100	0.07
50	0.04
20	0.02
10	0.02
5	0.01
2	0.01
1	0.01

b) 3 Glass Graduates, 200 or 250 ml capacity,

c) Mixing plate, small trowel, three 4-in. square glass plates.

d) Vicat Apparatus- The Vicat apparatus shall consist of a frame bearing a movable rod, weighing 300g, one end is the plunger end, being 10mm in diameter for a distance of at least 50mm, and the other end having a removable needle, 1mm in diameter and 50mm in length. The rod is reversible, and can be held in any desired position by a set screw, and has an adjustable indicator which moves over a scale (graduated in millimeter) attached to the frame. The paste is held in a rigid conical ring, resting on a glass plate about 100mm square. The rod shall be made of stainless steel having a hardness of not less than 35 HRC (Rockwell Hardness number), and shall be straight with the plunger end, which is perpendicular to the rod axis. The ring shall be made of a non-corroding, non-absorbent material, and shall have an inside diameter of 70mm at the base and 60mm at the top, and a height of 40mm. In addition to the above, the Vicat apparatus shall conform to the following requirements:

Weight of movable rod	300 ± 0.5g (0.661 lb ± 8 grains)
Diameter of plunger end of rod	10 ± 0.05mm (0.394 ± 0.002in.)
Diameter of needle	1±0.05mm (0.039±0.002 in)
Height of ring	40±1mm (1.57±0.04in)
Inside diameter of ring at bottom	70±3mm (2.75±0.12in)
Inside diameter of ring at top	60±3mm (2.36±0.12in)
Graduated scale	The graduated scale, when compared with a standard scale accurate to within 0.1mm at all points, shall not show a deviation at any point greater than 0.25mm.

MATERIAL:

i. Cement (Max 650 gm)

ii. Water (the water required for normal consistency for ordinary cement ranges from 22 to 30% by weight).

PROCEDURE:

Temperature and Humidity:

1. The temperature of the air in the vicinity of the mixing slab, the dry cement, molds, and base plates shall be maintained between 20 and 27.5°C (68 and 81.5°F).

2. The temperature of the mixing water shall not vary from 23°C (73.4°F) by more than ±1.7°C (±3°F).

3. The relative humidity of the laboratory shall be not less than 50%.

Preparation of Cement Paste:

1. Weigh out 650gm of cement and place on the mixing plate. Form crater in the center and add a measured quantity of water. (The water required for normal consistency for ordinary cement ranges from 22 to 30% by weight).

2. Turn the material at the outer edge into the crater within 30sec with a trowel.

3. After an additional interval of 30sec for the absorption of the water, complete the operation by continuous, vigorous mixing, squeezing and kneading with the hands for 1.5min.

Molding Test Specimen:

4. Quickly form the cement past into the approximate shape of a ball with gloved hands. Then toss six times through a free path of about 6in. (150mm) from one hand to another so as to produce a nearly spherical mass that may be easily inserted into the Vicat ring with a minimum amount of additional manipulation.

5. Press the ball, resting in the palm of one hand, into the larger end of the conical ring, held in the other hand, completely filling the ring with paste. Remove the excess at the larger end by a single movement of the palm of the hand.

6. Place the ring on its larger end on a plane, non-absorptive plate, and slice off the excess paste at the smaller end at the top of the ring by a single oblique stroke of a sharp-edged trowel held at a slight angle with the top of the ring and smooth the top, if necessary, with a few light touches of the pointed end of the trowel. During these operations of curing and smoothing take care not to compress the paste.

Consistency Determination:

7. Center the paste confined in the ring, resting on the plate, under the rod, the plunger end, of which shall be brought in contact with the surface of the paste, and tighten the set-screw. Then set the movable indicator (10mm dia) to the upper zero mark of the scale, or take an initial reading, and release the rod immediately. This must not exceed 30sec after completion of mixing. The apparatus shall be free of all vibrations during the test. The paste shall be of normal consistency when the rod settles to a point 10 ± 1 mm below the original surface in 30sec after being released.

DATA TABLE:

Group No	Amount of Cement (gm)	% of water	Amount of Water (gm)	Penetration (mm)	Remarks

GRAPHS:

Draw a normal graph paper (Penetration, mm vs. Percentages of Water).

RESULT:

- For 10mm penetration (From Graph), **Percentage of Water** required for **Normal Consistency** =
- **Amount of Water =**

DISCUSSION:

North South University
Department of Civil and Environmental Engineering

CEE 214L: ENGINEERING MATERIALS LAB

EXPERIMENT NO: 06
DETERMINATION OF INITIAL SETTING TIME OF CEMENT WITH VICAT'S APPARATUS

Name:

ID:

Group:

Section:

Performance Date:

Submission Date:

EXPERIMENT NO: 06
DETERMINATION OF INITIAL SETTING TIME OF CEMENT WITH VICAT'S APPARATUS

RELATED THEORY:

Cement, when mixed with water, forms slurry, which gradually becomes less plastic with the passage of time and finally a hard mass is obtained. In this process, a stage is reached when the cement paste is sufficiently rigid to withstand a definite amount of pressure. Cement, at this stage to have set and the time required to reach this stage is termed "setting time".

The term "initial setting time" indicates the beginning of the setting process of cement paste when cement paste starts losing its plasticity. The "final setting time" is the time elapsed between the moment the water is added to cement and the time when the paste completely lost its plasticity and attained sufficient stability to resist certain definite pressure.

This test method conforms to the ASTM standard requirements of specification C191. As per ASTM C150, Ordinary Portland Cement should have the initial setting time not less than 45 minutes & final setting time not more 375 minutes.

OBJECTIVE:

The objective of this experiment is to determine the initial setting time of cement.

APPARATUS:

i. Vicat's Apparatus

ii. 01 mm Needle

iii. Balance

iv. Stop Watch

v. Tray

vi. Trowel

vii. Water measuring jar

MATERIAL:

i. Cement (Max 650 gm)

ii. Water (percent amount of water from previous normal consistency test)

PROCEDURE:

Temperature and Humidity:

1. The temperature of the air in the vicinity of the mixing slab, the dry cement, molds, and base plates shall be maintained between 20 and 27.5°C (68 and 81.5°F).

2. The temperature of the mixing water and of the moist closet or moist room shall be 23°C ± 1.7°C (73.4°F ± 3°F).

3. The relative humidity of laboratory shall be not less than 50%. The moist closet or moist room shall be so constructed as to provide storage facilities for the specimens at relative humidity of not less than 90%.

Preparation of Cement Paste:

Mix 650 gms of cement with the percentage of mixing water required for normal consistency following the procedure described in Normal Consistency.

Molding Test Specimen:

Same procedure as in the preceding test Normal Consistency. Immediately after molding, place the test specimen in the moist closet or moist room and allow it to remain there except when determinations of time of setting are being made.

Time of setting determination:

1. Allow the time of setting specimen to remain in the moist cabinet for 30 min after molding without being disturbed. Determine the penetration of the 1-mm needle at this time and every 15-min thereafter for Ordinary Portland Cement (Type I & every 10 min for Rapid Hardening Cement, Type III) until a penetration of 25 mm or less is obtained.

2. For the penetration test, lower the needle of the rod until it rests on the surface of the cement paste. Tighten the set screw and set the indicator at the upper end of the scale, or take an initial reading. Release the rod quickly by releasing the set screw, and allow the needle to settle for 30 sec; then take the reading to determine the penetration.

No penetration test shall be made closer than1/ 4 in. (6.4 mm) for any previous penetration and no penetration test shall be made closer than 3/ 8 in. (9.5 mm) from the inside of the mold. Record the results of all the penetration tests and, by plotting penetration tests and, by interpolation or by plotting penetration vs. setting time curve, determine the time when a penetration of 25 mm is obtained. This is initial setting time. The final setting time is when the needle does not sink visibly into the paste.

SAMPLE CALCULATION:

Water required for cement paste of Initial Setting Time = amount of Cement (gm) × percent amount of water from previous normal consistency test

DATA TABLE:

Time (min)								
Penetration (mm)								
Time (min)								
Penetration (mm)								

GRAPHS:

Draw a normal graph paper (Penetration Depth, mm vs. Time in Minutes).

RESULT:

From the graph, 25mm penetration is obtained after _____ mins.

So Initial Setting time =

DISCUSSION:

North South University
Department of Civil and Environmental Engineering

CEE 214L: ENGINEERING MATERIALS LAB

EXPERIMENT NO: 07
COMPRESSIVE STRENGTH TEST OF CEMENT MORTAR

Name:

ID:

Group:

Section:

Performance Date:

Submission Date:

EXPERIMENT NO: 07

COMPRESSIVE STRENGTH TEST OF CEMENT MORTAR

RELATED THEORY:

The mechanical strength of hardened cement is the property of this material, which is, perhaps, the most important one for its structural use. Test for structural strength is not made on a neat cement paste because of difficulties in molding and testing with consequent large variations in results. The strength of cement is usually determined from tests on mortars. Several tests are performed to determine the tensile, compressive and shear strength of cement of mortar of certain portion. Cement mortar of concrete gives a compressive strength of about ten times its tensile strength.

This test method converse determination of the compressive strength of hydraulic cement mortars, using 2-in or 50-mm cube specimens.

This test method conforms to the ASTM standard requirements of specification C109. The standard requirement of minimum compressive strength as per ASTM C150 for Ordinary Portland cement (type I) are as follows.

Age (Days)	Minimum compressive Strength,- psi (MPa)
3	1800 (12.4)
7	2800 (19.3)
28	4000 (27.6)

OBJECTIVE:

The objective of this experiment is to determine the direct compressive strength of cement mortar.

APPARATUS:

1. Balance (sensitive to 0.1 gm),
2. 250-ml graduated measuring jar,
3. 2sets of 2-in cube molds with base plates,
4. Mixing pans,
5. Temper,
6. Trowels, and
7. Testing machine.

The sand use for making test specimens shall be natural silica sand conforming to the requirements for graded standard sand (natural silica sand conforming C 778) in the following specification.

Sieve	**Accumulative % Retained**
No. 16	None
No. 30	2±2
No. 40	30±5
No. 50	75±5
No. 100	98±2

Ingredients		Number of specimens	
		6	9
Cement, g		500	740
Sand, g		1375	2035
Water, ml	Portland (0.485)	242	359
	Air-containing (0.46)	230	340

PROCEDURE:

Composition of mortars: The proportion of materials for the slandered mortars shall be 1 part of cement to 2.75 parts of graded standard sand by weight. Use a water-cement ratio of 0.485 for all Portland cement.

The quantities of materials to be mixed at one time in the batch of mortar for making six and nine specimens.

Preparation of mortar:

1. Place required amount of water in dry mixing bowl.
2. Add the cement to the water and mix for 30 second.
3. Add nearly one-half of the sand and mix for 30 sec.
4. Add the remainder of the sand and mix vigorously for 2 minutes.

Molding Test Specimens:

Fig.1: Order of Tempering in molding of Test Specimens.

a) Place a layer of mortar about 1 in. (25mm) (approximately one half of the depth of the mold) in all of the cube compartments. Tamp the mortar in each cube compartment 32 times in about 10 sec in 4 rounds, each round to be at right angles to the other and consisting of eight adjoining strokes over the surface of the specimens as illustrated in fig. 1. The temping pressure shall be just sufficient to ensure uniform filling of the molds. The 4 rounds of temping (32 strokes) of the mortar shall be completed in one cube before going to the next.

b) When the temping of the first layer in all of the cube compartments is completed, fill the compartments with remaining mortar and then temp as specified for the first layer. During tamping of the second layer bring in the mortar forced out onto the tops of the molds after each round of tamping by means of the gloves figures and the temper upon completion of each round and before starting the next round of tamping.

c) On completion of tamping, the tops of all cubes should extend slightly above the tops of the molds. Bring in the mortar that has been forced out on to the topes of the molds with a trowel and smooth off the cubes by drawing the flat side of the trowel (with the leading edge slightly raised) one across the top of the each cube at right angles to the length of the mold. Then for the purpose of leveling the mortar that protrudes above top of the molds of more uniform thickness, draw the fiat side of the trowel (with leading edge slightly raised) lightly once along the length of the mold. Cut off the mortar to plane surface flush with the top of the mold by drawing the straight edge of the trowel (held nearly perpendicular to the mold) with sawing motion over the length of the mold.

Storage of Test Specimens:

Immediately upon completion of molding, place the test specimens in the moist closet or moist room. Keep all the specimens, immediately after molding, in the mold on the base places in the moist closet or moist room from 20 to 24 h with their upper surfaces exposed to the moist air but protected from creeping water. If the specimens are removed from the mold before 24 h old, and then immerse the specimens, except those for the 24-h test, in saturated limewater in storage tanks constructed of no corroding materials. Keep the storage water clean by changing as required.

Determining of compressive strength:

Test the specimens immediately after their removal from the moist closet in the case of 24-h specimen, and from storage water in the case of all other specimens. All the test specimens for a given test age should be broken under compressive force within the permissible time tolerance prescribed as follows:

Test Age	Permissible Tolerance
24 h	±½ h
3 days	±1 h
7 days	±3 h
28 days	±12 h

a) If more than one specimen at a time is removed from the moist closet for the 24-h tests, keep the specimens covered with a damp cloth until the time of testing. If more than one specimen at a time is removed from the storage water of testing, keep these specimens in water at a temperature of 73.4±3°F (23±1.7°C) and have sufficient depth to completely immerse each specimen until the time of testing.
b) Wipe each specimen to a surface-dry condition, and remove any loose sand grains or incrustations from the face that will be contact with the bearing blocks of the testing machine. Check these faces by applying a straightedge. If there is applicable curvature, grind the face or faces or discard the specimen. A periodic check of the cross-sectional area of the specimens should be made.
c) Apply the load to specimen faces that were in contact with the true plane surface of the mold. Carefully place the specimen in the testing machine bellow the center of the upper bearing block. Prior to the testing of each cube, it shall be ascertained that the spherically seated block is free to tilt. Use no cushioning or bedding materials. An initial loading up to one half of the expected maximum loads for specimens having excepted maximum loads of more than 3000 lbf (13.3 KN) may be applied at any convenient rate. Apply no initial loading to specimens having expected maximum loads of less than 3000 lbf (13.3KN). adjust the rate of load application so that the load remainder of the load or the entire load in the case of expected maximum loads of less than 3000 lbf (13.3KN) is applied, without interruption, to failure such a rate that the maximum load will be reached in neither in 20 sec nor in more than 80 sec from the start of loading. Make no adjustment in the controls of the testing machine while a specimen is yielding prior to failure.

CALCULATION:

Record the total maximum loads indicated by the testing machine, and calculate the compressive strength in pounds per square inch (or passels). If the cross sectional area of a specimen varies more than 15 % from the normal, Use the actual area for the calculation of the compressive strength.

- Draw the strength vs. age curve on a plain graph paper
- Report the result to the nearest 10-psi (70 kPa).

DATA TABLE:

Cement: gm.		Sand: gm.		Water-cement ratio:	
Age (days)	Specimen No.	Crushing Load	Specimen Area	Compressive strength	Average compressive strength

DISCUSSION:

North South University
Department of Civil and Environmental Engineering

CEE 214L: ENGINEERING MATERIALS LAB

EXPERIMENT NO: 08
CONCRETE SLUMP TEST

Name:

ID:

Group:

Section:

Performance Date:

Submission Date:

EXPERIMENT NO: 08
CONCRETE SLUMP TEST (ASTM 143)

RELATED THEORY:

The concrete slump test measures the consistency of fresh concrete before it sets. It is performed to check the workability of freshly made concrete, and therefore the ease with which concrete flows. It can also be used as an indicator of an improperly mixed batch.

OBJECTIVE:

Concrete slump test is to determine the workability of concrete.

APPARATUS:

i. Mold for slump test, ii. Balance
iii. Non pours base plate iv. Measuring tape,
v. Temping Rod, vi. Measuring scale,

MACHINE:

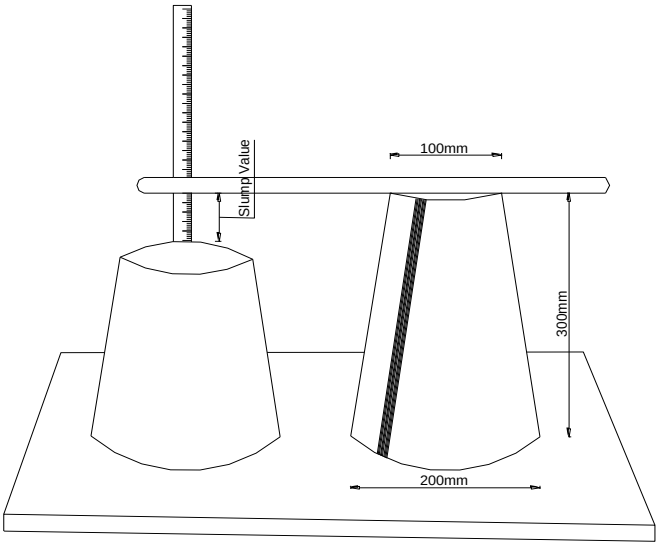
i. Tilting Drum Mixer

MATERIALS:

i. Cement ii. Fine Aggregate iii. Coarse Aggregate

PROCEDURE:

Mix concrete either manually or with a mechanical mixer. If a large quantity of mixed concrete exits, obtain a representative sample.
2. Dampen the mold and place it, with its larger base at the bottom, on a flat, moist, nonabsorbent rigid surface.
3. Hold the mold firmly in place by standing on the two foot-pieces.
4. Immediately fill the mold in three layers, each approximately one-third of the volume of the mold. Note that one-third of the volume is equivalent to a depth of 67 mm (2-5/8 in.), whereas two-thirds of the volume is equivalent to 155 mm (6-1/8 in.).
5. Rod each layer 25 strokes, using the tamping rod. Uniformly distribute the strokes over the cross section of each layer. Rod the second and top layers each throughout its depth so that the strokes penetrate the underlying layer. In filling and rodding the top layer, heap the concrete above the mold before rodding is started. If the rodding operation results in subsidence of concrete below the top edge of the mold, add additional concrete to keep an excess of concrete above the top of the mold at all times.
6. After the top layer has been rodded, strike off the surface of concrete by means of a screening and rolling motion of the tamping rod.
7. Remove the mold immediately from the concrete by raising it up carefully without lateral or torsional motion. The slump test must be completed within 2.5 minutes after taking the sample.



SAMPLE CALULATION:

DATA TABLE:

Casting ratio	Cement	Fine Aggregate	Coarse Aggregate	w/c ratio	Req. water

RESULT OF CONCRETE SLUMP TEST:

Slump for the given sample = mm

When slump test is carried out, following the shape of concrete slump test can be observed to find out and mark on it.

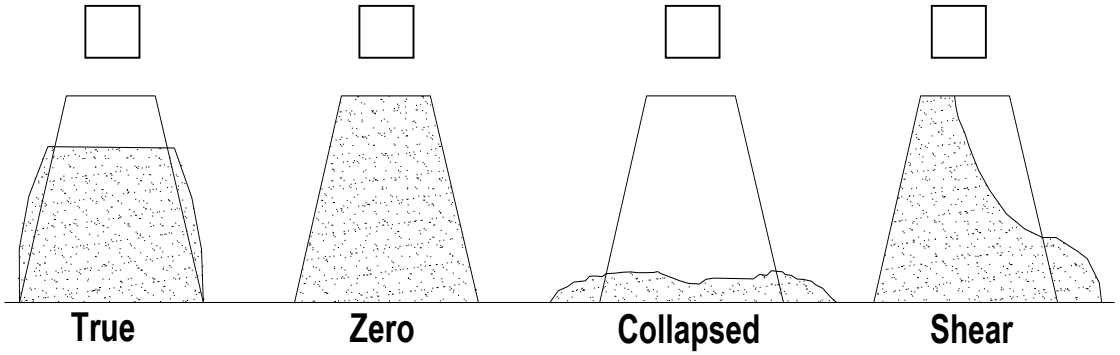


Fig: Types of Concrete Slump Test Results

DISCUSSION:

North South University
Department of Civil and Environmental Engineering

CEE 214L: ENGINEERING MATERIALS LAB

EXPERIMENT NO: 09
MAKING AND CURING CONCRETE CYLINDER

Name:

ID:

Group:

Section:

Performance Date:

Submission Date:

EXPERIMENT NO 09

MAKING AND CURING CONCRETE CYLINDERS (ASTM C31)

RELATED THEORY:

This practice provides standardized requirements for making and curing Portland cement concrete test specimens. Specimens can be used to determine strength for mix design, quality control and quality assurance.

OBJECTIVE:

To determine how to make and cure concrete cylindrical specimens.

APPARATUS:

- Cylindrical molds made of steel or another nonabsorbent and nonreactive material. The standard specimen size used to determine the compressive strength of concrete is 152 mm (6 in.) diameter by 304 mm (12 in.) high for a maximum aggregate size up to 50 mm (2 in.). Smaller specimens, such as 102 mm (4 in.) diameter by 203 mm (8 in.) high, are sometimes used, but they are not ASTM standards.

- Tamping rod with a length of 0.6 m (24 in.), diameter of 16 mm (5/8 in.), and rounded ends.

- Moist cabinet or room with not less than 95% relative humidity and 23 ± 1.7°C (73±3°F) temperature or a large container filled with lime-saturated water for curing.

- Miscellaneous items including vibrator (optional), scoop, and trowel.

PROCEDURE:

1. Weigh the required amount of coarse aggregate, fine aggregate, Portland cement, and water.

2. Mix the materials in the mixer for 3 to 5 min. If an admixture is used, it should be mixed with water before being added to the other materials.

3. Check slump, air content, and temperature of concrete.

4. For cylindrical specimens, place concrete into the mold using a scoop or trowel. Fill the cylinder in three equal layers, and rod each layer 25 times. Tap the outside of the cylinder 10 to 15 times after each layer is rodded. Strike off the top and smooth the surface. Vibrators can also be used to consolidate the concrete instead of rodding. Vibration is optional if the slump is between 25 mm to 75 mm (1 in. to 3 in.) and is required if the slump is less than 25 mm (1 in.)

5. Cover the mold with wet cloth to prevent evaporation.

6. Remove the molds after 16 hours to 32 hours.

7. Cure the specimen in a moist cabinet or room at a relative humidity of not less than 95% and a temperature of 23 ± 1.7°C (73±3°F) or by submersion in lime-saturate water at the same temperature.

PRECAUTIONS:

1. Segregation must be avoided. Over vibration may cause segregation.

2. In placing the final layer, the operator should attempt to add an amount of concrete that will exactly fill the mold after compaction. Do not add no representative concrete to an under-filled mold.

3. Avoid overfilling by more than 6 mm (1/4 in.).

REPORT:

1. Record mix design weights, slump, temperature of the mix, and air content.

2. Specimen type, number of specimens, dimensions, and any deviations from the standard preparation procedure.

3. Include this information with the report on the strength of the concrete.

DISCUSSION:

North South University
Department of Civil and Environmental Engineering

CEE 214L: ENGINEERING MATERIALS LAB

EXPERIMENT NO: 10
COMPRESSIVE STRENGTH TEST OF CYLINDRICAL CONCRETE SPECIMEN

Name:

ID:

Group:

Section:

Performance Date:

Submission Date:

EXPERIMENT NO: 10
COMPRESSIVE STRENGTH TEST OF CYLINDRICAL CONCRETE SPECIMEN

INTRODUCTION:

The compressive strength of concrete is one of the most important and useful properties of concrete. In most structural applications concrete is employed primarily to resist compressive stresses. Nevertheless, strength usually gives an overall picture of the quality of concrete because it is directly related to the structure of the hardened cement paste. Values obtained will depend on the size and shape of the specimen, batching, mixing procedures, the methods of sampling molding, and fabrication and the age, temperature, and moisture conditions during curing.

The test method covers determination of compressive strength of cylindrical specimens such as molded cylinders and drilled cores. It is limited to concrete having a unit weight in excess of 50 lb/ft^3 (800 kg/m^3). The test method consists of applying a compressive axial load to molded cylinders or cores at a rate which is within a prescribed range until failure occurs. The compressive strength if the specimen is calculated by dividing the maximum load attained during the test by the cross-sectional area of the specimen.

The results of the test method may be used as a basis for quality control of concrete proportioning, mixing, and placing operations; determination of compliance with specifications; control for evaluating effectiveness of admixtures and similar uses.

The test method conforms to the ASTM standard requirements of specification C39 for cylinder and BS1881 for cube.

OBJECTIVE:

To measure concrete quality by doing compressive strength test of cylindrical concrete specimen.

APPARATUS:

i. Cylindrical Mold.

ii. Tamping Rod.

iii. Balance.

iv. Water measuring jar.

vi. Trowel.

vii. Hand Gloves.

MACHINE:

i. Duel Frame Compression Machine.

ii. Tilting Drum Mixer.

PROCEDURE:

Cylindrical specimens:

- Fill each mold with concrete in four layers, tamping each layer 25 times with 5/8 in. steel tamping rod. If vibrator is used, its frequency should not be greater than 7000/ minutes if it is an internal electric vibrator. In case of an external vibrator, the frequency will be 3600/ mm.
- While filling the molds, occasionally stir and scrape together the concrete remaining in the mixing pan to keep the materials from separating. Fill the molds completely, smooth off the tops evenly.

Cover the cylinders immediately and place in the moist storage for 24 ± 8 hours at a temperature of 23 ± 1.7^0C, then remove the specimens from molds and immerse in saturated limewater until testing.

Method of Testing:

a) Compression tests of moist-cured specimens shall be made as soon as practicable after removal from moist storage.

b) Test specimens shall be kept moist by any convenient method during the period between removals from moist storage and testing. They shall be tested in the moist condition.

c) All test specimens for a given test age shall be broken within the permissible time tolerances prescribed as follows:

Test Age	Permissible Tolerance
24 h	$\pm$ 0.5 h or 2.1 %
3 days	2 h or 2.8 %
7 days	6 h or 3.6 %
28 days	20 h or 3.0 %
90 days	2 days or 2.2 %

d) Placing the Specimen- Place the plain (lower) bearing block, with its hardened face up, on the table or platen of the testing machine directly under the spherically seated (upper) bearing block. Wipe clean the bearing faces of the upper and lower bearing block and of the test specimen and place the test specimen on the lower bearing block. Carefully align the axis of the specimen with the center to thrust of the spherically seated block. As the spherically seated block is brought to bear on the specimen, rotate its movable portion gently by hand so that uniform seating is obtained.

e) Rate of Loading- Apply the load continuously and without shock. For hydraulically operated machines, the load shall be applied at a rate of movement (platen to crosshead measurement) corresponding to a loading rate on the specimen within the range of 20 to 50

psi / sec. (0.14 to 0.34 MPa / sec). The designated rate of movement shall be maintained at least during the latter half of the anticipated loading phase of the testing cycle.

f) During the application of the first half of the anticipated loading phase a higher rate of loading shall be permitted.

g) Make no adjustment in the rate of movement of the platen at any time while a specimen is yielding rapidly immediately before failure.

h) Apply the load until the specimen fails, and record the maximum load carried by the specimen during the test. Note the type of failure and the appearance of the concrete.

RECORD DATA: ☐ **Local Sand** ☐ **Sylhet Sand** ☐ **Brick** ☐ **Stone**

Data	Specimen 1	Specimen 2	Specimen 3
Casting ratio			
w/c ratio			
Diameter			
Height			
Weight			

CALCULATION:

Calculate the compressive strength of the specimen by dividing the maximum load carried by the specimen during the test by the average cross-sectional area and express the result to the nearest 10 psi (69 kPa).

If the specimen length to diameter ratio is less than 1.8, multiply the obtained result by the appropriate correction factor shown in the following table:

L/D	1.75	1.50	1.25	1.00
Factor	0.98	0.96	0.93	0.87(Note 5)

Note-5: These correction factors apply to lightweight concrete weighing between 100 and 120 lb / ft^3 (1600 and 1920 kg /m^3) and to normal weight concrete. They are applicable to concrete dry or soaked at the time of loading. Values not given in the table shall be

determined by interpolation. The correction factors are applicable for nominal concrete strengths from 2000 to 6000 psi (13.8 to 41.4 MPa).

DATA SHEET:

Serial No.	Age of Specimen (Day)	Area of Specimen (Sq. mm)	Maximum Load (KN)	Crushing Strength (MPa)

DISCUSSION: