FEDERAL UNIVERSITY OYE-EKITI

FACULTY OF ENGINEERING AND TECHNOLOGY

CONSTRUCTION TECHNOLOGY (CVE 307)

DEPARTMENT OF CIVIL ENGINEERING

300 LEVEL LABORATORY

MANUAL

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CONSTRUCTION MATERIALS PRACTICAL

1.0 INTRODUCTION TO CONSTRUCTION MATERIALS

What is material testing?

Material testing is the measurement of the characteristics and behaviour of materials such as metals, concrete, ceramics or plastics under various conditions. The data thus obtained can be used in specifying the suitability of materials for various applications. E.g. Building or aircraft construction, machinery and packaging etc.

Material testing breaks down into five major categories:

1. Mechanical testing
2. Testing for thermal properties
3. Testing for electrical properties
4. Testing for resistance to corrosion, radiation and biological deterioration
5. Non-destructive testing

National and International bodies such as International Organization for Standardization (ISO) with headquarters in Geneva and the American Society for Testing and Materials (ASTM) established these standard test methods.

What is a construction material?

An item, material or supply consumed or used in a construction project and incorporated in the constructed building or structure.

What are the different types of construction materials used in construction?

Basically, we have five types of construction materials, namely;

- Aggregates (fine and coarse aggregates)
- Steel reinforcement
- Cement

- Concrete
- Bitumen

TESTS CARRIED OUT ON DIFFERENT CONSTRUCTION MATERIALS

1. Aggregates
    a. Sieve analysis
    b. Water absorption
    c. Aggregate impact value
    d. Aggregate abrasion value
    e. Aggregate crushing value

2. Bitumen
    a. Determining bitumen content
    b. Determining flash and fire point of bitumen
    c. Determining penetration of bitumen
    d. Determining softening point of bitumen
    e. Determining specific gravity of bitumen
    f. Determining ductility of bitumen
    g. Determining marshal stability of bitumen

3. Cement
    a. Fineness test
    b. Soundness test
    c. Consistency test
    d. Setting time test

4. Concrete
    Tests of Fresh concrete
    a. Slump test
    b. Compacting factor test
    c. VeBe test
    d. K-slump test

Tests on Hardened concrete

a. Compression strength test
b. Flexural strength test
c. Rebound hammer test
d. Ultrasonic pulse velocity test

5. Steel reinforcement
    a. Tensile strength test
    b. Bend test
    c. Re-bend test
    d. Shear test
    e. Brinell hardness test
    f. Impact test
    g. Torsion test

2.0 GENERAL INSTRUCTIONS

1. **Methods:** There are two classes into which methods of testing may be divided; direct and indirect methods. The direct method includes all of those tests in which the character of the property under consideration is directly determined, either in the material or in the sample of it. The indirect method includes all of those methods by which the quality of the material is inferred from the results of tests upon related properties.

   Since variations in the manner of conducting a test may cause a variation in the results, it is apparent that for certain kinds of tests all observers should follow uniform methods.

2. The student should make use of standard methods of testing in order that he may gain knowledge of those methods, that his results may be compared with the results obtained by other experimenters and that his result may be of the greatest practical use in his own engineering practice.

3. **Care of small Apparatus:** Small pieces of apparatus which are kept in lockers should be cleaned and returned to their places as soon as possible after use.

4. Handle glassware with care. To remove cement which has set upon glassware, vinegar and muriatic acid can be used. However, if glassware is thoroughly cleaned with water before the cement hardens; there will be no necessity for the use of acid.

5. **Use of testing machines:** No machine should be started without the approval of the instructor. Before starting a machine, all tools, small pieces of apparatus and other loose articles should be removed from the vicinity or be so placed that they will not fall into the gears.

6. In preparing to use a large testing machine, attach the necessary grips or the compression heads which are required for the tests to be made. As soon as failure occurs, throw the machine out of gear and take your readings.

7. In using a testing machine, the proper speed to use will depend on the nature of the test. For compression tests of short specimens, the slowest speed will usually be required. For ordinary tensile tests, the next speed faster than the slowest will properly be satisfactory. The fastest speeds should be used only for shifting the position of the moving head to facilitate placing of removing the specimens.

8. In making tensile tests, the specimen is held by two sets of grips. If the thickness or diameter of the specimen is small, it is necessary to insert a filler between each grip and the machine head. The thickness of the filler plates or the number used should be sufficient to prevent the grips from projecting from the head.

9. **Assignment of Equipment:** When an assigned apparatus is found to be damaged, the facts should be reported to the instructor for necessary action.

10. Equipments should be properly cleaned and kept in the right places after use.

11. **Marking test specimens:** Instructions on how to mark test specimens should be followed carefully to avoid mistakes and damage of work piece.

3.0 PREPARING LABORATORY REPORTS

The guideline below is used to prepare laboratory reports.

i. **Title:** This section contains the title of the test, the nature of the test and the specification number used.

ii. **Scope of the test:** A brief statement of the purpose and significance of the test should be indicated.

iii. **Apparatus:** Equipments used should be briefly described.

iv. **Materials:** The materials used or tested should be described.

v. **Theory:** This section summarizes the test/experiment or it gives us an overview of what the test is all about.

vi. **Definitions and Process Terminology:** This section contains terminology and definition of specific words and test related terms.

vii. **Procedure:** Clearly and concisely list the procedure in the order the test is carried out.

viii. **Raw Data:** This section contains the raw data gotten from the test. All laboratory data shall be submitted in tabular form.

ix. **Calculations and Results:** Observations relating to the behavior of the materials should be included. All equations or formulas used should be clearly indicated. Calculations should be properly checked. The results of the test should be summarized in tabular or graphical form.

x. **Figures and Diagrams:** This section contains clear and concise diagrams and/or figures in accordance with the laboratory requirement. Figures including the equipment front and side views, parts and panels can be displayed in this section.

xi. **Discussion:** There should be included a brief discussion in which attention is drawn to the silent facts shown by the tables and diagrams. The test results should be compared with the standard values.

xii. **Conclusion:** Include modification procedures, calibration procedures and any additional information that will be helpful.

xiii. **References (if applicable):** Include references to any manuals, documents or textbooks used in compiling the reports.

4.0 MATERIAL TESTING EQUIPMENTS

i. Cement Sampler: This device is used for obtaining samples for inspection from cement packed in barrels.

ii. Set of Sieves: Coarse sieves are used for screening cement to remove lumps, and fines sieves are used for determining the fineness of cement. Both classes of sieves are designated by number, the number of meshed per lineal inch being the same as the number of the sieve.

iii. Apparatus for determining the weight of cement: The device below produces a uniform compactness by allowing the cement to fall from a coarse sieve **a**, suspended on hangers **b** to permit shaking, and fixed at a distance of three feet above the top of the measuring box **c**.

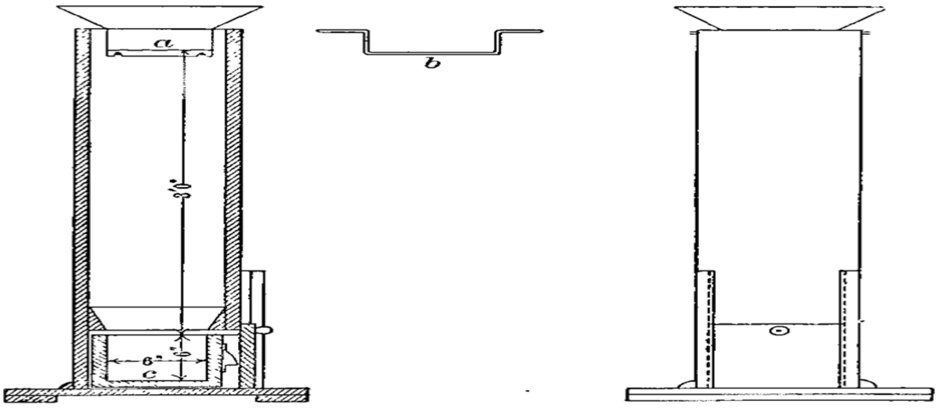


Fig. 6. — Apparatus for Determining Weight of Cement

iv. **Hand Trowels:** It is used for mixing cement or concrete. The most convenient sizes are five-inch, six-inch and ten-inch trowels.

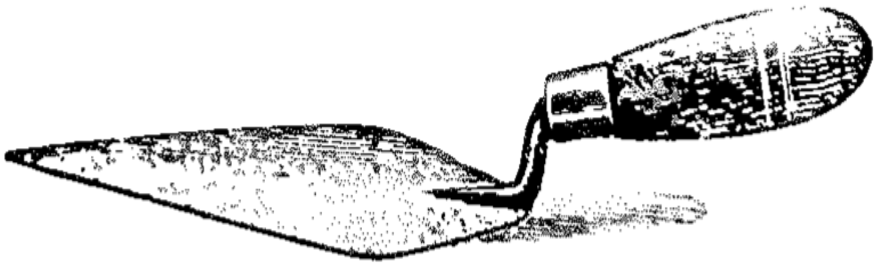


Fig. 8. — Mason's Trowel

v. **Balances and Scales:** It is used for taking or measuring the weight of cement samples. E.g. Triple beam Balance, Digital Balance (Mettler Balance, Ohaus Balance Sartorius Balance, A & D Balance. Scientech Balance, MyWeigh Balance etc).

vi. **Displacement Flasks:** For the purpose of determining the specific gravity of cement, a flask is used which is graduated to indicate the volume displaced by the introduction of a small quantity of cement into the liquid inside the flask. E.g. Le Chatelier's flask.

vii. **Measuring Glasses:** For the purpose of measuring the quantity of water to be used in making cement paste of mortar, a graduated cylinder is used.

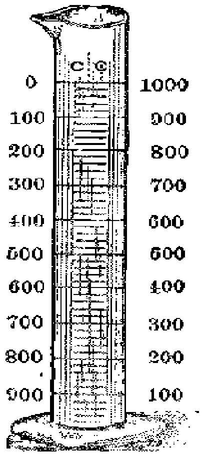


Fig. 13.—Graduated Cylinder

viii. **Vicat Apparatus:** The vicat apparatus is a device for measuring the distance which a weighted needle or weighted plunger will penetrate a ring (mould) filled with cement paste. The vicat apparatus is used for determining the proper percentage of water to be used in gauging the cement and also for determining the rate of setting.

The apparatus comes with 2 needles, a mould and a base plate. The lighter needle without cap is used for initial setting time of cement by the heavy needle with cap is used for the final setting time of cement.

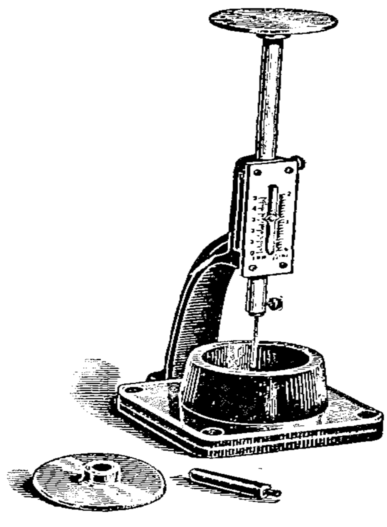
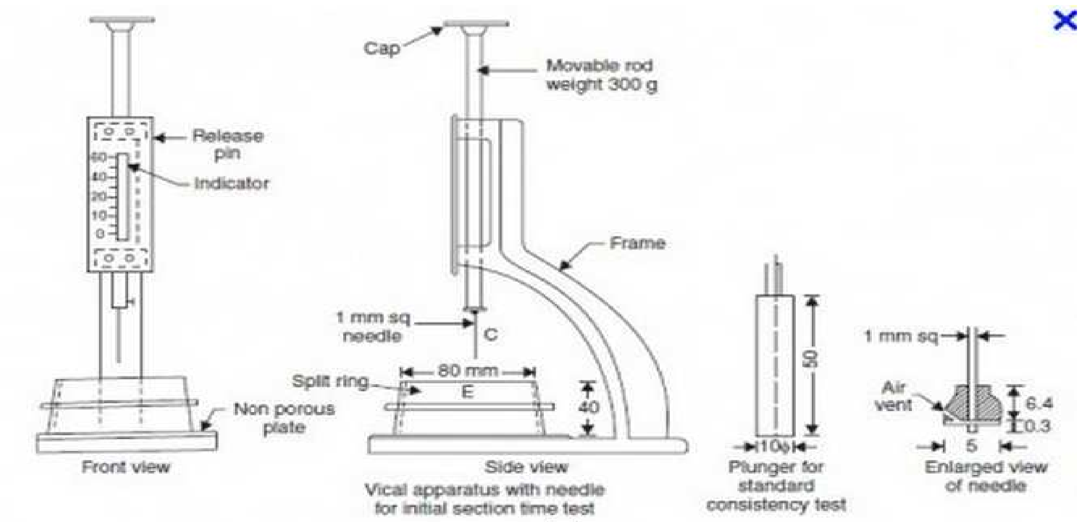


Fig. 15. — Vicat Apparatus



Vicat apparatus

ix. **Moulds:** Moulds ordinarily employed in making specimens for determining the tensile strength of cement are of two kinds: Individual moulds and Gang moulds.

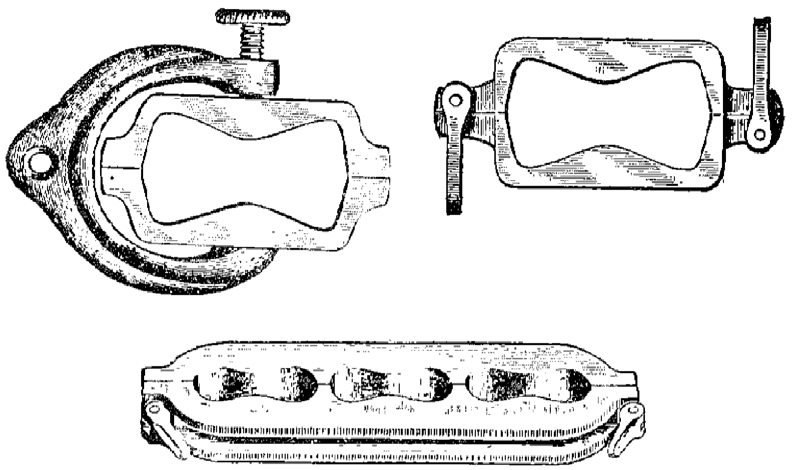


Fig. 17. — Briquette Molds

For the purpose of making specimens for compression tests of cement mortar, cube, beam or cylindrical moulds made of either cast iron or wood is used.

x. **Universal Testing Machine (UTM WAW 2000B):** The UTM is used to test materials for the tensile strength and compressive strength. In addition, the UTM perform other tests like bending and shear tests. The UTM works on hydraulics employing the hydraulic system of pulleys and levers to move its machine parts.

Component Parts:

The machine is divided into three basic parts;

- Upper cross beam: This part of the machine is stationary.
- Motion cross beam: This part of the machine moves and its movement can be controlled with its control buttons (UP and DOWN). Its movement is clearly visible.
- Work bench: This part of the machine also moves but not like the motion cross beam. Its movement can only be noticed or seen on the scale attached to the UTM. It moves only during tests. The workbench also house important parts of the machine like the motor, hydraulic hose and chains etc.

<u>DIAGRAM OF THE UNIVERSAL TESTING MACHINE (UTM WAW 2000B)</u>

CONCRETE MIX DESIGN

Title: Concrete mix design for different grades of concrete.

Aims:

- To select suitable construction materials for concrete design.
- To design concrete for a specific purpose or job.
- To produce concrete and check for properties like strength, durability, workability etc as per site requirement.
- To optimize the properties of concrete.
- To achieve good quality concrete at site economically.

Materials: Gravel, sand, cement, water.

Theory:

What is concrete mix design?

Concrete mix design is the method of correct proportioning of ingredients of concrete in order to optimize the properties of concrete such as workability, durability, strength, cohesiveness, initial set retardation and imperviousness as per site requirements.

In other words, we determine the relative proportions of ingredients of concrete to achieve desired strength and workability in the most economical way.

Properties desired from concrete in plastic state (fresh concrete)

1. Workability
2. Cohesiveness
3. Initial set retardation

Properties desired from concrete in plastic state (fresh concrete)

1. Strength
2. Imperviousness
3. Durability

Methods of concrete mix design

1. IS method

2. Doe method
3. ACI (American Concrete Institute) method
4. RRL method (Road Note4 method)

Requirements for concrete mix design

The requirements which form the basis of selection and proportioning of mix ingredients are:

a) The minimum compressive strength required from structural consideration

b) The adequate workability necessary for full compaction with the compacting equipment available.

c) Maximum water-cement ratio and/or maximum cement content to give adequate durability for the particular site conditions.

d) Maximum cement content to avoid shrinkage cracking due to temperature cycle in mass concrete.

Before the mix design

Before designing the mix, some bothering questions to ask are;

1. What slump do you need?
2. What target strength of concrete are you expecting?
3. Do you need entrained air?
4. What maximum size of aggregates is best for the job?
5. Are admixtures inclusive in your design?

Types of mixes

i. Nominal mixes: These are mixes of fixed cement-aggregate ratio which ensures adequate strength. Due to the variability of mix ingredients, the nominal concrete for a given workability varies. They are mixes for ordinary grades of concrete.

ii. Standard mixes: These are mixes with widely varying strength. They are mixes for standard grades of concrete.

iii. Designed mixes: In these mixes, the performance of the concrete is specified by the designer but the mix proportions are determined by the producer of concrete. The approach results in the production of concrete with the appropriate properties most economically. They are mixes for higher grades of concrete.

Decision variables in mix design

i. Water/Cement ratio
ii. Cement content
iii. Relative proportion of fine and coarse aggregates
iv. Use of admixtures

Factors affecting the choice of mix proportions

1. Compressive strength
2. Workability
3. Durability
4. Maximum nominal size of aggregates
5. Grading and type of aggregates

Mix proportion designations

The common method of expressing the proportions of ingredients of a concrete mix is in the terms of parts or ratios of cement, fine and coarse aggregates.

For e.g., a concrete mix of proportions 1:2:4 means that cement, fine and coarse aggregate are in the ratio 1:2:4 or the mix contains one part of cement, two parts of fine aggregate and four parts of coarse aggregate.

Examples of mix proportions for grades M10-M25 are: 1:3:6(M10), 1:2:4(M15), 1:1.5:3(M20), 1:1:2(M25)

Factors to be considered for mix design

- The grade designation giving the characteristic strength requirement of concrete.
- The type of cement influences the rate of development of compressive strength of concrete.
- Maximum nominal size of aggregates to be used in concrete may be as large as possible within the limits prescribed by IS 456:2000.
- The cement content is to be limited from shrinkage, cracking and creep.

- The workability of concrete for satisfactory placing and compaction is related to the size and shape of section, quantity and spacing of reinforcement and technique used for transportation, placing and compaction.

TABLE SHOWING THE WORKABILITY AND SLUMPS FOR CONCRETE AND THEIR DIFFERENT USES

Degree of Workability	Slump (mm)	Use for which concrete is suitable
Very Low	0-25	Roads vibrated by power-operated machines. At the more workable end of this group, concrete may be compacted in certain cases with hand-operated machines.
Low	25-50	Roads vibrated by hand-operated machines. At the more workable end of this group, concrete may be, manually compacted in roads using aggregate of rounded or irregular shape. Mass concrete foundations without vibration or lightly reinforced sections with vibration.
Medium	50-100	At the less workable end of this group, manually compacted flat slabs using crushed aggregates. Normal reinforced concrete manually compacted and heavily reinforced sections with vibrations.
High	100-175	For sections with congested reinforcement. Not normally suitable for vibration.

Table – Assumed standard deviation (s)

Grade of concrete	M10	M15	M20	M25	M30	M35	M40	M50
Standard deviation assumed (N/mm^2)	3	3.5	4.0	4.0	5.0	5.0	5.0	5.0

Design Procedure:

Designing concrete mixes are in stages or steps. Solving for the parameters below will be our guide in determining the appropriate mix design for any grade of concrete.

Questions:

1. Find the target mean strength.
2. Determine water/cement ratio.
3. Determine water content.
4. Determine cement content.
5. Determine fine and coarse aggregate proportions.

Result:

Target mean strength = ...

Water/Cement ratio = ...

Volume of fine aggregates = ...

Volume of coarse aggregates = ...

Volume of cement = ...

Volume of water = ...

Mix proportions:

Cement =

Water =

Fine aggregates =

Coarse aggregates =

Water cement ratio =

Yield =

SLUMP TEST

Title: Determining the workability of concrete by slump test

Aim: To determine medium and high workability of fresh concrete mixes

Theory:
What is slump test?
Slump test is a type of concrete test appropriate for concrete mixes of medium and high workability.

The test is carried out by filling the slump cone with freshly mixed concrete which is tamped with a steel rod in three layers. The concrete is levelled off with the top of the slump cone, the cone removed and the slump of the sample is immediately measured.

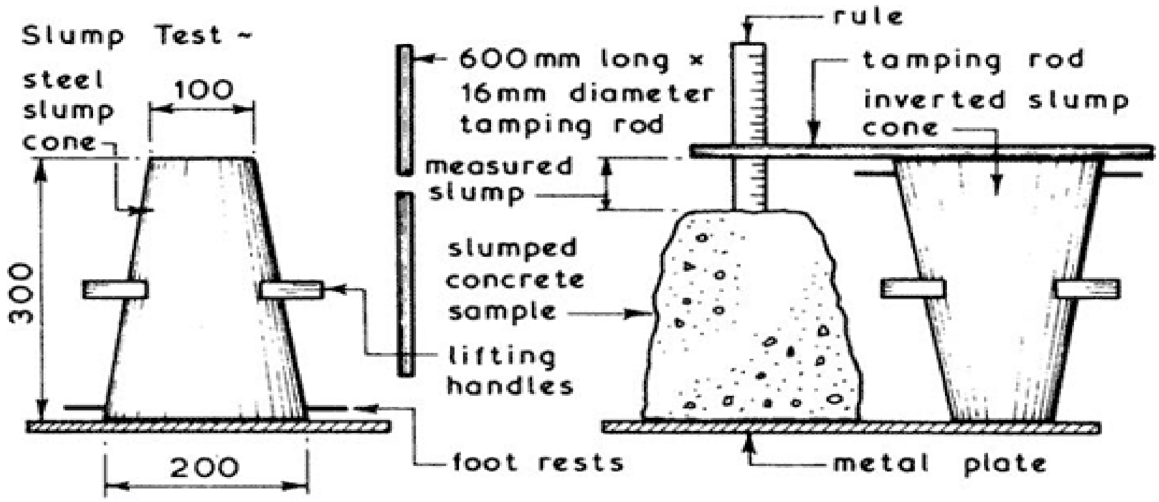
Types of slump
Slumps are categorized based on the difference in height of the slumped concrete and the cone. There are three types of slump, namely;

1. True slump (slump size 25-50mm)
2. Shear slump (slump size up to 150mm)
3. Collapse slump (slump size 150-250mm)

Apparatus:

1. Slump cone measuring 100mm(top dia.) x 200mm(bottom dia.) x 300mm(height)
2. Tamping rod measuring 600mm long x 16mm dia.
3. Steel rule
4. Slump cone funnel
5. Scoop
6. Base plate

Figure 1: Slump Test Apparatus



RECOMMENDED SLUMPS FOR VARIOUS TYPES OF CONSTRUCTIONS

S/N	TYPE OF CONSTRUCTION	Maximum slump (mm)	Minimum slump (mm)
1.	Reinforced foundation walls and footings	75	25
2.	Plain footings, caissons and substructure walls	75	25
3.	Beams and reinforced walls	100	25
4.	Building columns	100	25
5.	Pavement and slabs	75	25
6.	Mass concrete	75	25

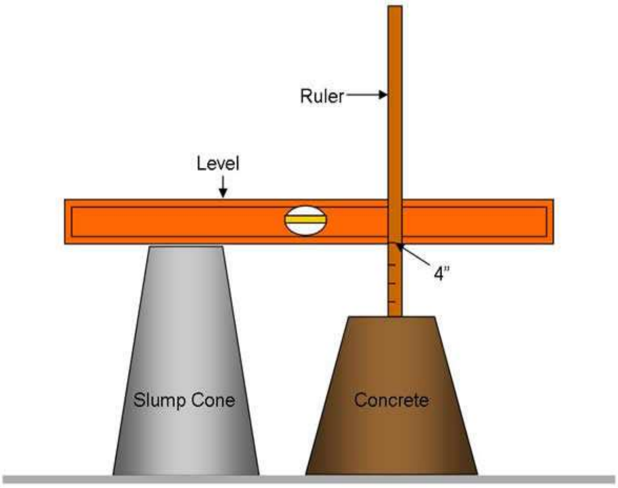
Simplified Procedure:

i. Setting up the slump test apparatus.
ii. Fill the slump cone with concrete.
iii. Level the concrete with the top of the cone.
iv. Remove the cone
v. Measure the slump.

Setting up the slump cone apparatus

Filling the slump cone

Levelling, removing cone and measuring



Measuring Slump

Slumped concrete

Standard Procedure:

1. Clean the internal surface of the cone thoroughly, and apply light coat of oil.
2. The cone is placed on a smooth, horizontal, rigid and non-absorbent surface.
3. The cone is filled in three layers with freshly mixed concrete, each approximately to one-third of the height of the cone.
4. Each layer is tamped 35 times by the rounded end of the tamping rod (strokes are distributed evenly over the cross section).

5. After the top layer is rodded, the concrete is struck off the level with the hand trowel.
6. The cone is removed from the concrete immediately by raising it slowly in the vertical direction.
7. The difference in level between the height of the cone and that of the highest point of the subsided concrete is measured.
8. This difference in height in mm is the slump of the concrete.

Questions:

What is the difference in height in mm?

State the type of slump

Why do you tamp the concrete?

What property of concrete is measured or determined?

State 5 safety measures you observed during test?

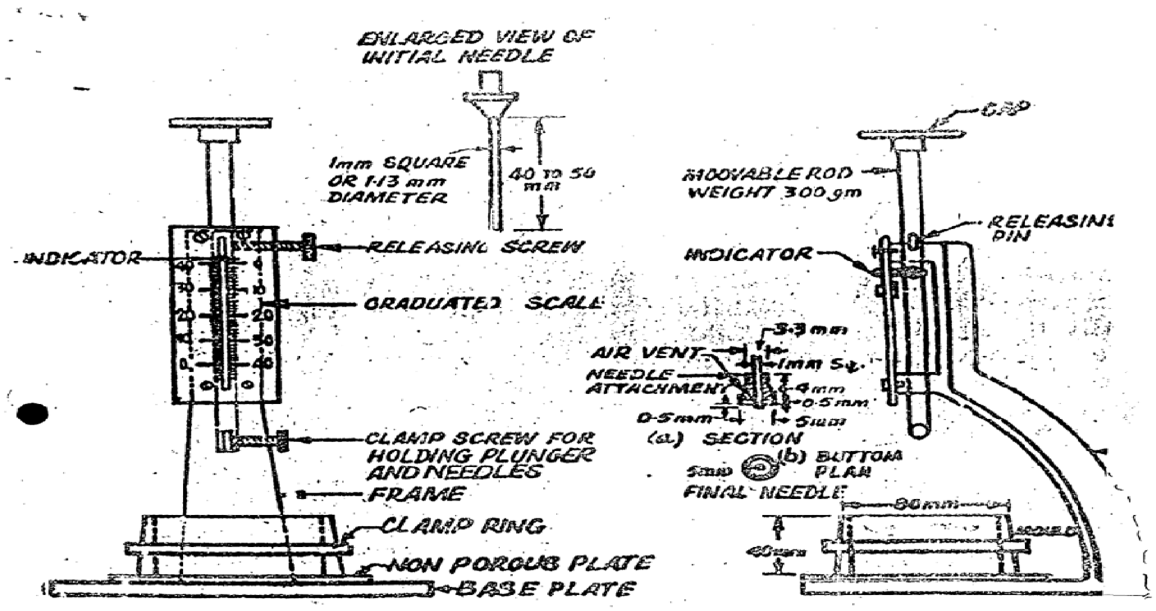
SETTING TIME OF CEMENT

Title: Initial and final setting times of cement

Aim: To determine the initial and final setting times of cement paste

Apparatus:

1. Vicat Apparatus
2. Stop Watch
3. Measuring Jar
4. Hand Trowel
5. Weighing Balance



Vicat's apparatus :—It consists of a metal frame, having a m

VICAT'S APPARATUS

Procedure:

- Weigh a given quantity of cement (say 400gm) using a weighing balance set to 0.1g sensitivity
- Calculate the amount of water required for gauging as 0.85 times the amount of water required to procedure a paste of standard consistency (i.e. 25% by weight of dry cement for consistency). Add this calculated quantity of water to heap and simultaneously start stop watch.

- Mix cement with water to form paste.
- Start the stop clock.
- Put the cement paste into the mould and level it with the top of the mould using a hand trowel.
- Place the test block i.e. cement paste in the mould, under the rod bearing the needle.

Initial setting time:

- Insert the initial setting time needle in the plunger.
- Lower the needle gently in order to make contact with the surface of the cement paste and release quickly, allowing it to penetrate the test block.
- Repeat the above procedure at intervals of 2minutes until the needle fails to pierce the test block to a point 5.0 ± 0.5mm measured from the top of the mould.
- The time period elapsing between the time water is added to the cement and the time the needle fails to pierce the test block by 5.0 ± 0.5mm measured from the top of the mould, is the initial setting time of the cement paste.
- Record the initial setting time of the cement paste in minutes.

Final setting time:

- Replace the initial setting time needle with the one with an annular attachment. This needle with annular attachment is also called the final setting time needle.
- Lower the needle gently in order to make contact with the surface of the cement paste and release quickly, allowing it to penetrate the test block.
- Repeat the above procedure every 10minutes, until the needle makes an impression on the surface of the test block, while the attachment fails to do so.
- The time period elapsing from the time water is added to the cement to form paste and the time the needle makes an impression of 5mm on the surface of the test block while the attachment fails to do so, is the final setting time.
- Record the final setting time of the cement paste in minutes.

Result:

- The initial setting time of cement is …………………………………………… minutes
- The pierced height of the initial setting time needle …………………. mm
- The final setting time of cement is .... minutes
- The pierced height of the final setting time needle …………………… mm

Question:

- State 5 safety measures you observed during the test.

FINENESS OF CEMENT BY DRY SIEVING

Title: To determine fineness of cement by dry sieving

Aim: The aim of this test is to find out the quantity of coarse material present in cement.

Theory:

What is fineness?
Cement is in the form of powder, which is obtained by grinding the various raw materials. The grinding produces finer particles of cement. The degree to which cement is grounded to smaller and smaller particles is called **fineness of cement**.

Effect of fineness on properties of cement:
During the formation of cement paste, water is mixed with cement. A chemical reaction occurs between water and cement, this is called **hydration**. The strength of cement concrete or mortar develops with hydration. More the rate of hydration, faster is the development of strength. Finer the cement, higher the rate of hydration and so, faster the development of strength. This is because finer cement offers greater surface area of particles for hydration. At the same time, the rate of development of heat due to hydration also increases.

Advantage of using finer cement:
The cement develops strength earlier and so formwork can be removed earlier thus reducing cost of production.

Disadvantage of using finer cement:
The finer ground cement is likely to deteriorate earlier due to setting because of moisture in air. Also, the drying shrinkage is higher in case of finer cements.

Methods of finding fineness of cement:
Fineness of cement is found by two methods, namely:

- By method of dry sieving.
- By specific surface method – finding fineness of cement using "Blanine's air permeability apparatus".

Though method B is more accurate, it is rarely used except for specific purpose. Method A is quite good for field work.

Method [A]

To find fineness of cement by dry sieving method. In this method, the cement sample is sieved dry on a IS sieve no. 9. The residue left is expressed as percentage of weight of sample.

Apparatus:

1. 90 micron IS Sieve.
2. Weighing balance [2kg] accurate to 0.1gm with weights.
3. Brittle brush 25mm size.

Material:

Cement sample weighing about 100gm.

Procedure:

1. Weigh cement sample accurately and record weight (W1). Place the sample on sieve no. 9. (it is preferable to take W1 = 100gm for simplifying calculations).
2. Break air set lumps in the sample with fingers.
3. Hold the sieve in both hands and sieve with a gentle wrist motion without spilling the cement and keeping cement well spread on the screen. Carry out continuous circular motion of the sieve for a period of 15 minutes.
4. Collect the residue left on the sieve, using brush if necessary, and weigh residue.

Let the weight of residue be W2.

Observations and Calculations:

1. Weight of the cement sample = ……………………………… W1 gm
2. Weight of residue = …………………………………… W2 gm

Percentage residue = P = W2/W1 x 100 = ………………………………… %

Result:

Percentage residue of cement sample by dry sieving = P = …………………………………. %

TENSILE STRENGTH TEST

Title: Tensile testing of metallic materials

Aim: The objective of this lab experiments is to incrementally load a steel bar till failure, while recording the value of the load and the change in length of the steel bar at each stage. Then based on the collected data,

- The material's stress-strain relationship is obtained.
- The following structural properties are determined: Modulus of elasticity, yield strength, ultimate tensile strength, failure strength and strain to failure.
- To determine the reduction of cross-sectional area.

Theory:

The most common material in construction besides concrete is steel. Concrete, though it has a high compressive strength, its tensile strength is usually much lower and mounts up to 8 – 12 % of its compressive strength. Steel, therefore, is used in concrete structural elements to bare tensile loads and bending moments.

The major components of steel are Iron and carbon which ranges between 0.01 and 1 percent. Sulfur, phosphorus, manganese, silicon and as much as 20 other alloys are present in steel and are added in various quantities to steel during its manufacturing process depending on the desired hardness, toughness and tensile strength of steel.

Reinforcing steel bars are usually manufactured in 3 different forms:

- Plain bars
- Deformed bars
- Plain & deformed wires

Plain Bars

Deformed Bars

Plain and deformed wires

The deformation in deformed steel bars is intended to increase the bonding between steel and concrete and to prevent slippage of the steel reinforcement bars.
Steel reinforcement bars are produced mainly with four different yield strengths, shown in the table below. The grade of steel indicates its yield strength in mpa.

Table showing Reinforcement Steel Strength

Type	σ_{yield} (psi)	σ_{yield} (MPa)	Grade
Type 1	40,000	300	40
Type 2	50,000	350	50
Type 3	60,000	400	60
Type 4	75,000	500	75

Apparatus:

- Universal Testing Machine (UTM WAW 2000B)
- Computer with MaxTest
- Extensometer
- Vernier Caliper
- Permanent marker
- Safety toolkit
- Ruler or measuring tape

Materials: Circular rod (Steel) with diameter ranging from 16mm to 70 mm

Procedure:

1. Label each specimen with your group's initials and an identification number (i.e., #1, #2, etc.) on each end.

2. Using the vernier caliper, take measurements of the length and the thickness and calculate the cross-sectional area.

3. Insert the work piece in between the jaws (upper and lower) of the UTM and tighten the jaws with the up and down clamp. Ensure that the work piece is held firmly between the jaws before you proceed.

4. Load the program “MaxTest” on the PC.

5. Set test type to “Tensile”.

6. Enter specimen information by first setting the MODE -> Analyse Mode. Next, under DATA, click on the “insert specimen information” to enter all the required details of your work piece like length, diameter and area.

7. Enter other parameters like Displacement, Speed, and Load to control the movement of the machine during operation and clear your values to zero to avoid negative readings before, during and after the test.

8. Set the MODE -> Test Mode to start test.

9. After failure, the machine will stop and return on its own if its set to “Stop while destroy” and “Auto return”, if not, stop the machine once failure occurs and the green arrow initially pointing upward, starts pointing downward. Click on the return button on “MaxTest” to return the machine to its original state.

Note: Remember to power off the machine after the test by clicking on the small red button on the control panel and open the “Oil Home Valve”. Use the big red button for emergency stopping of the machine in case of accident.

Analysis and Results:

• Plot the stress versus strain curve.
• Determine yield strength σ_{yd}, using the 0.2% offset method.
• Calculate (or use your stress-strain plot) the ultimate tensile strength.

$$\sigma_{t,ult} = P_{max} / A_0$$

Where:

$\sigma_{t,ult}$ = ultimate tensile strength, MPa (psi)

P_{max} = maximum load carried by the specimen during the test, KN

A_0 = original cross-sectional area of specimen, mm^2

• Calculate the strain to failure, or elongation

$$\% \text{ Elongation} = (L_f - L_0) / L_0 \times 100$$

Where:

L_f = gauge length after failure, mm

L_0 = original gauge length, mm

• Calculate the modulus of elasticity

$$E = \sigma/\varepsilon$$

Where:

E = Modulus of elasticity, Mpa (psi)

σ = stress, Mpa (psi)

ε = corresponding strain, mm/min

• Calculate (or use your stress-strain plot) the failure strength

$$\sigma_f = P_f / A_0$$

Where:

σ_f = failure strength, MPa (psi)

P_f = final load carried by the specimen during the test, KN

A_0 = original cross-sectional area of specimen, mm^2

• Calculate the reduction of cross-sectional area

$$\%Reduction = (A_0 - A_f) / A_0 \times 100$$

Where:

A_f = cross-sectional area after failure, mm^2

To calculate the cross-sectional area after failure, fit the ends of the fractured specimen together and measure the mean diameter or width and thickness at the smallest cross-section.

• Calculate the percentage error (%Error)

$E_{Experimental} = \Delta\sigma/\Delta\varepsilon$ i.e. the slope of the graph

$E_{Theoretical, steel} = 29 \times 100^6$ psi

$$\% \text{Error} = \frac{(E_{Experimental} - E_{Theoretical, steel})}{E_{Theoretical, steel}} \times 100$$

Table of values

		Before Test		After Test		From Data					
Spec. #	**Material**	A_0	L_0	A_f	L_f	σ_{yd}	$\sigma_{t,ult}$	σ_f	**E**	**%Elong**	**%Red. Area**
1.											
2.											
3.											
4.											
5.											

COMPRESSIVE STRENGTH TEST

Aim: To test for the compressive strength of concrete

Apparatus:

- Mixing equipments
- Concrete moulds
- Tamping rod
- Curing tank or pond
- Universal Testing Machine (UTM WAW 2000B).

Materials:

Cement, Fine aggregates, Coarse aggregates and water

Procedure:

- Mix a required quantity of concrete by the job's design mix proportion. E.g. mix 370 gm of standard sand, 185gm of cement and 555gm.
- Add water quantity (P/4 + 3.0) % of combined weight of cement and sand and mix the three ingredients thoroughly until the mixture is of uniform colour. The time of mixing should be less than three minutes and not more than four minutes.
- Cast the mixed concrete into moulds.
- Using the tamping rod, ensure an even distribution of concrete in the mould by apply the concrete in 3 layers and tamping 35 blows per layer.
- Level the concrete with the top of the mould and smoothen out the rough surface with a hand trowel.
- Remove the concrete after 24 hours from their moulds and cure for some days in the curing tank of pond before crushing.
- Take the cube out of water and dry with cloth at 7, 14 and 28 days.
- Measure the dimensions (L x B) of the cube.
- Crush the cured concrete at 7, 14 and 28 days of curing with the Universal Testing Machine (UTM) to give the various strengths of the concrete after 7, 14 and 28days of casting.

Crushing of concrete cubes using the Universal Testing Machine (UTM WAW 2000B):

Procedure:

1. Label each specimen with your group's initials and an identification number (i.e., #1, #2, etc.) on each concrete cube.

2. Using the meter rule, take measurements of the length and width of the concrete cube and calculate the cross-sectional area.

3. Insert the work piece in between the Platens (upper and lower) of the UTM and lower the upper platen to rest slightly on top of the work piece. Ensure that the work piece is properly position and well seated at the center of the platen before you proceed.

4. Load the program "MaxTest" on the PC.

5. Set test type to "Compression".

6. Enter specimen information by first setting the MODE -> Analyse Mode. Next, under DATA, click on the "insert specimen information" to enter all the required details of your work piece like length, diameter and area.

7. Enter other parameters like Displacement, Speed, and Load to control the movement of the machine during operation and clear your values to zero to avoid negative readings before, during and after the test.

8. Set the MODE -> Test Mode to start test.

9. After failure, the machine will stop and return on its own if its set to "Stop while destroy" and "Auto return", if not, stop the machine once failure occurs and the green arrow initially pointing upward, starts pointing downward. Click on the return button on "MaxTest" to return the machine to its original state.

Note: Remember to power off the machine after the test by clicking on the small red button on the control panel and open the "Oil Home Valve". Use the big red button for emergency stopping of the machine in case of accident.

Tabulation

(a) For 7 days strength:

Sl.No.	Length (L) in mm	Breadth (B) in mm	Load (P) in N	compressive strength in N/mm^2
1				
2				
3				

Average compressive strength =

(b) For 14 days strength:

Sl.No.	Length (L) in mm	Breadth (B) in mm	Load (P) in N	compressive strength in N/mm^2
1				
2				
3				

Average compressive strength =

(c) For 28 days strength:

Sl.No.	Length (L) in mm	Breadth (B) in mm	Load (P) in N	compressive strength in N/mm^2
1				
2				
3				

Average compressive strength =

Questions:

1. What is the grade of concrete?

2. Mention 5 safety precautions you observed during the test.

Result:

1. Compressive strength of concrete at 7 days = ………………………… N/mm^2

2. Compressive strength of concrete at 14 days = ……………………… N/mm^2

3. Compressive strength of concrete at 28 days = ……………………… N/mm^2