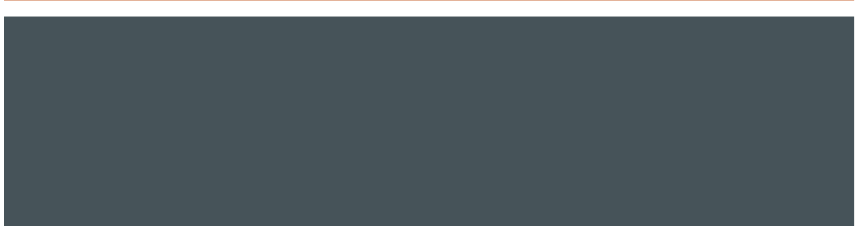
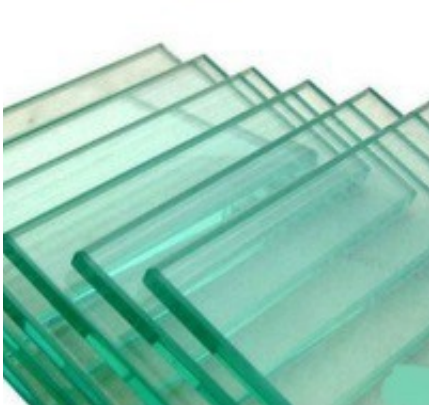




# CONSTRUCTION MATERIALS AND TESTING



# COURSE OUTLINE

**Lesson 1. INTRODUCTION TO CONSTRUCTION MATERIALS AND TESTING**

**Lesson 2. FAMILIARIZATION WITH APPARATUS & EQUIPMENT USED IN TESTING OF MATERIALS**

**Lesson 3. GENERAL PROPERTIES OF MATERIALS**

**Lesson 4. SPECIFIC WEIGHT, WATER ABSORPTION, ABRASION, DENSITY AND UNIFORMITY OF AGGREGATES**

**Lesson 5. PREPARATION AND CURING OF CONCRETE TEST SPECIMEN**

**Lesson 6. DETERMINATION OF SETTING TIME OF HYDRAULIC CEMENT**

**Lesson 7. FAMILIARIZATION WITH THE PARTS AND FUNCTIONS OF THE UNIVERSAL TESTING MACHINE**

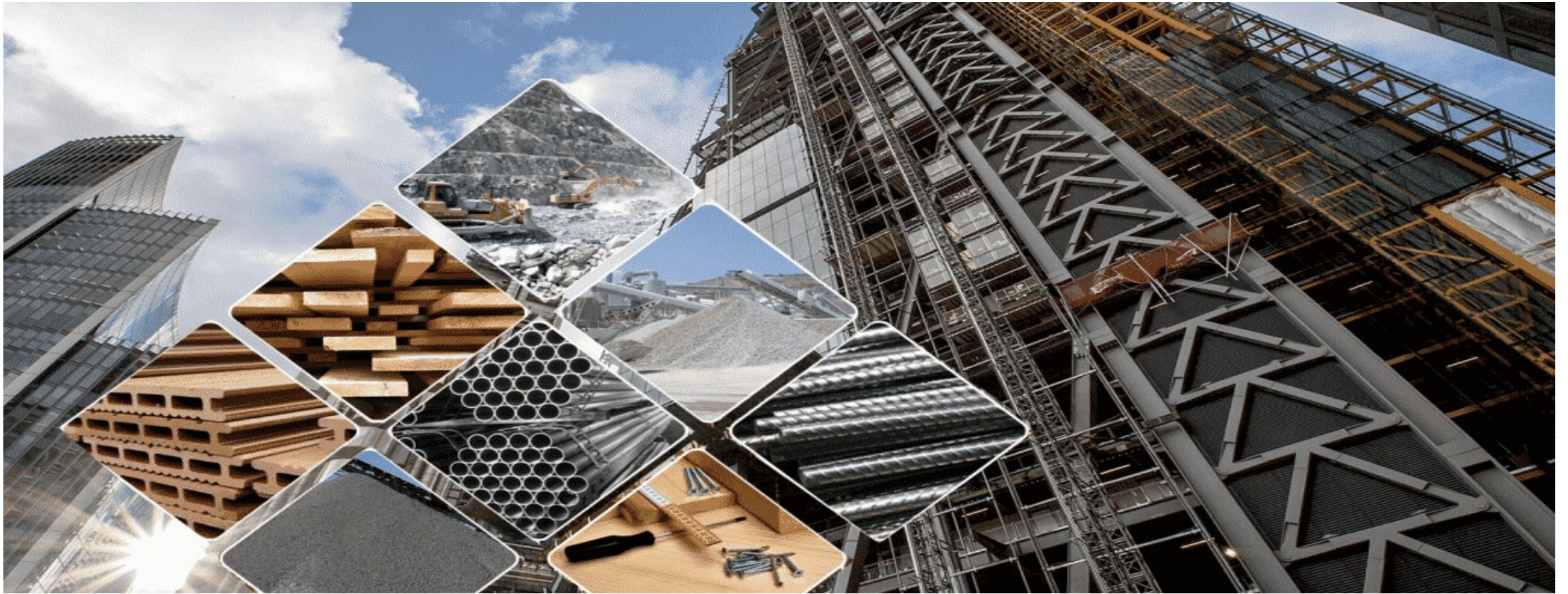
**Lesson 8. TESTING OF WOOD: SAMPLES OF BENDING, COMPRESSION, SHEAR, TENSION AND WATER CONTENT**

**Lesson 9. DETERMINE THE COMPRESSIVE STRENGTH OF CONCRETE HOLLOW BLOCKS**

**Lesson 10. DETERMINING THE TIME OF SETTING OF PORTLAND CEMENT**

**Lesson 11. TESTING THE TENSILE STRENGTH OF STEEL BARS**

**Lesson 12. FIELD TESTS OF CONSTRUCTION MATERIALS**



# INTRODUCTION TO CONSTRUCTION MATERIALS AND TESTING

## LESSON 1

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# CONSTRUCTION MATERIALS AND TESTING (CMT)

Construction materials testing (CMT) primarily involves testing structural materials used to build new projects from the ground up, materials and components used to construct new additions or new components being added to an existing facility.



# WHY CONSTRUCTION MATERIALS AND TESTING IMPORTANT?

Construction materials and testing is important because it is critical for the viability and safety of a construction project. It can reveal any number of issues related to construction quality. CMT can highlight future risks, help classify a building site, and assist with engineering decisions.

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# FAMILIARIZATION WITH APPARATUS AND EQUIPMENT USED IN TESTING OF MATERIALS

## LESSON 2

# APPARATUS AND EQUIPMENT USED IN TESTING OF MATERIALS

## ■ SIEVE SET

- device for separating wanted elements from unwanted material or for characterizing the particle size distribution of a sample of aggregates, sand and other soil particles



## ■ LOS ANGELES ABRASION MACHINE

- used to measure the degradation of mineral aggregate of standard gradings resulting from a combination of actions including abrasion or attrition, impact and grinding in a drum containing a number of steel



## ■ VOID CONTENT APPARATUS, COARSE AGGREGATES

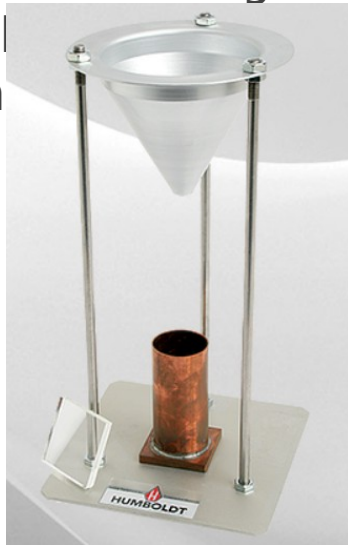
- Used to determine the void content of uncompacted coarse aggregates



# APPARATUS AND EQUIPMENT USED IN TESTING OF MATERIALS

## ■ VOID CONTENT APPARATUS, FINE AGGREGATES

- Used to determine the uncompacted void content of a fine aggregate sample. Indicates the angularity, and workability of aggregate in a mix.



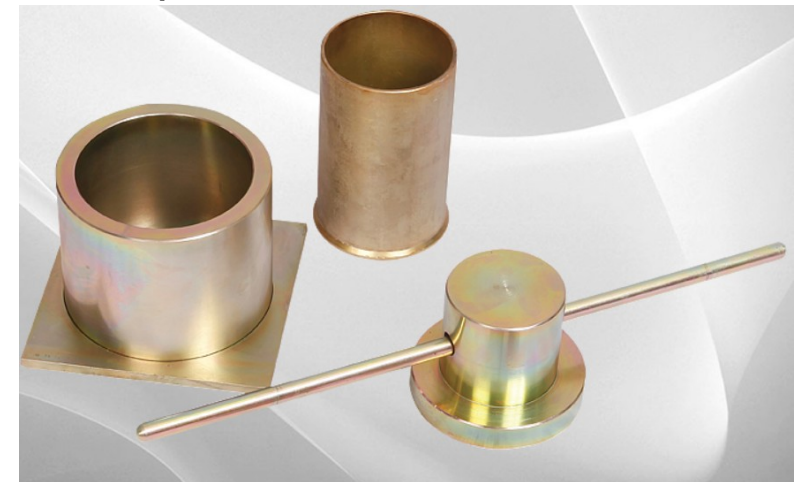
## ■ POINT LOAD TESTER

- used to determine the strength values of a rock specimen, both in the field and in the laboratory.



## ■ AGGREGATE CRUSHING VALUE DEVICE

- provides a relative measure of the resistance of an aggregate to crushing under a gradually applied compressive load.



# APPARATUS AND EQUIPMENT USED IN TESTING OF MATERIALS

## ■ SLUMP CONE

- a metal mold in the form of a truncated cone with a top diameter of 4" (102mm), a bottom diameter of 8" (203mm), and a height of 12" (305 mm), used to fabricate the test specimens.



## ■ HYDROMETER

- used to measure the specific gravity or relative density of fluids.



## ■ UNIVERSAL TESTING MACHINE

- capable of exerting a tensile, compressive, or transverse stress on a specimen.



# APPARATUS AND EQUIPMENT USED IN TESTING OF MATERIALS

## ■ LABORATORY OVEN

- specially designed for drying, baking, conditioning and moisture determination.



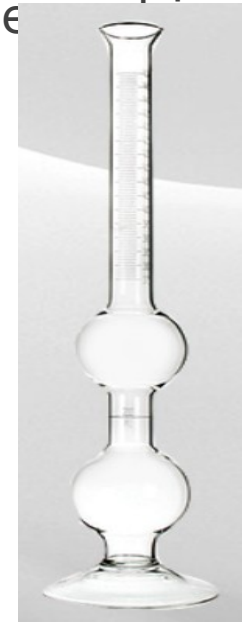
## ■ SIEVE SHAKER

- operated for sieves when perform sieving tests.



## ■ SPECIFIC GRAVITY FLASK (CHAPMAN)

- has a wide base and two bulbs and is used in the determination of moisture content in fine aggregate by displacement of water.



# APPARATUS AND EQUIPMENT USED IN TESTING OF MATERIALS

## ■ SPECIFIC GRAVITY FLASK (PHUNQUE FLASK)

- key element in a method for conducting specific gravity or absorption determination of aggregate



## ■ CONICAL MOLD AND TAMPER FOR FINE AGGREGATE

- Used for determination of bulk and apparent specific gravity of fine aggregate



- MICRO-DEVAL MACHINE
  - used to determine the quality of aggregates by abrasion.





# GENERAL PROPERTIES OF MATERIALS

## LESSON 3



# PROPERTIES OF MATERIALS

## PROPERTIES OF ENGINEERING MATERIALS

Possible classification of material properties:

### 1. PHYSICAL PROPERTIES

- A material undergoes transition under the influence of temperature and pressure.

(Example: Density, Porosity, Specific Gravity, etc.)

### 2. MECHANICAL PROPERTIES

- property of material which opposes the deformation or breakdown of material in presence of

external forces or load. (Example: Tensile Strength, Compressive Strength, Rigidity, etc.)

### 3. THERMAL PROPERTIES

- properties of a material which is related to its conductivity of heat. In other words, these are the properties which are exhibited by a material when the heat is passed through it. (Example: Heat Capacity, Thermal Expansion, Thermal Stress, etc.)

### 4. CHEMICAL PROPERTIES

- any of a material's properties that becomes evident during, or after, a chemical reaction; that is, any quality that can be established only by changing a substance's chemical identity.

# PROPERTIES OF MATERIALS

## 5. MECHANICAL PROPERTIES

- characteristics governing the behavior of material when external forces are applied are included in these properties. Some of the important mechanical properties are elasticity, hardness, plasticity, strength, etc.

## 6. AESTHETIC PROPERTIES

- make a product attractive to look at, or pleasing to experience. (Example: Color, Surface Smoothness, etc.)

## PHYSICAL PROPERTIES OF MATERIALS

1. **DENSITY ( $\rho$ )** – defined as mass per unit volume for a material  $\frac{kg}{m^3}$ .

FORMULA:

$$\rho = \frac{m}{V} ; m = \text{mass of material}$$

$V = \text{volume of material}$

➤ **RELATIVE DENSITY** – ratio of density of the material to the density of a reference solution (usually water at 4°C)

# PHYSICAL PROPERTIES OF MATERIALS

TWO TYPES OF DENSITY:  
TWO TYPES OF DENSITY:

1.1 BULK DENSITY - ratio of material mass to total volume of material including spaces.

FORMULA:

$$\rho_b = \frac{M}{V} = \frac{M_s + M_w}{V_s + V_v}$$

Where:

$M_s$  = solid mass       $M_w$  = water mass

$V_s$  = volume of solids    $V_v$  = volume of voids

1.2 SOLID DENSITY - ratio of the mass of solid material to the volume of solid material without any space.

FORMULA:

$$\rho_s = \frac{M_s}{V_s}$$

2. UNIT WEIGHT ( $\gamma$ ) ratio of materials weight to the materials volume.

FORMULA:

$$\gamma = \frac{W}{V} \quad \text{or} \quad \gamma = \rho g$$

# PROPERTIES OF MATERIALS

3. **SPECIFIC GRAVITY ( $G_s$ )** - ratio of solid density of material and density of distilled water at a temperature of 4°C.

**FORMULA:**

$$G_s = \frac{\rho_s}{\rho_w}$$

4. **POROSITY ( $n$ )** - used to indicate the degree by which the volume of a material is occupied by pores.

**FORMULA:**

**FORMULA:**

$$n = \frac{V_v}{V} \quad ; \quad V_v = \text{volume of the spaces}$$

$V = \text{overall volume}$

5. **VOIDS RATIO** - ratio between the size of the voids to the volume of solid material.
6. **WATER ABSORPTION ( $W_w$  or  $W_p$ )** - denotes the ability of the material to absorb and retain water. It is expressed as percentage in weight or of volume of dry material.
7. **WEATHERING RESISTANCE** - of moisture. 1.4.7. Weathering resistance. It is the ability of a material to endure alternate wet and dry conditions for a long period without considerable deformation and loss of mechanical strength.

# PROPERTIES OF MATERIALS

8. WATER PERMEABILITY - the capacity of a material to allow water to penetrate under pressure. Materials like glass, steel and bitumen are impervious.
9. FROST RESISTANCE - denotes the ability of a water-saturated material to endure repeated freezing and thawing with considerable decrease of mechanical strength.

## MECHANICAL PROPERTIES

1. STRENGTH - ability of the material to resist failure under the action of stresses caused by loads.  
1. STRENGTH - ability of the material to resist failure under the action of stresses caused by loads.
2. STRESS ( $\sigma$ ) - force applied to the material divided by the material's cross-sectional area. (Several types of stress, Tension Stress, Shear Stress, etc.)  
2. STRESS ( $\sigma$ ) - force applied to the material divided by the material's cross-sectional area. (Several types of stress, Tension Stress, Shear Stress, etc.)
3. STRAIN ( $\epsilon$ ) - the deformation or displacement of material that results from an applied stress.  
3. STRAIN - the deformation or displacement of material that results from an applied stress.

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# SPECIFIC WEIGHT, WATER ABSORPTION, ABRASION, DENSITY AND UNIFORMITY OF AGGREGATES

## LESSON 4



# SPECIFIC WEIGHT

■ Also known as Unit Weight.

- The Bulk Density or Unit Weight of an aggregate is the mass or weight of the aggregate required to fill a container of a specified unit volume.
- Aggregates having low specific gravity are generally weaker than those with high specific gravity.
- Specific gravity of an aggregate is considered to be a measure of strength or quality of the material

# WATER ABSORPTION

- Used to determine the amount of water absorbed under specified condition.
- FACTORS AFFECTING WATER ABSORPTION INCLUDE:
  - Type of Plastic
  - Additives used
  - Temperature
  - Length of Exposure

# ABRASION

- Detachment of particles from material due to weak bond between particles.
- This can be prevented by better bonding between particles.

## EXAMPLE OF ABRASION:

- Removal of stones from bituminous roads due to tyre friction.

# DENSITY AND UNIFORMITY OF AGGREGATES

■ Bulk Density of aggregates depends upon the following 3 factors:

1. Degree of Compaction
2. Grading of Aggregates
3. Shape of Aggregate Particles



**IRREGULAR  
AGGREGATE  
S**



**FLANKY AND  
ELONGATED  
AGGREGATE**



**ROUND  
AGGREGATES**

---

# PREPARATION AND CURING OF CONCRETE TEST SPECIMEN

## LESSON 5



# CONCRETE TEST SPECIMEN

## SCOPE

This procedure covers the method for making, initially curing, and transporting concrete test specimens in the field in accordance with AASHTO T 23-08.

## APPARATUS AND TEST SPECIMENS

### ■ CONCRETE CYLINDER MOLDS

- Conforming to AASHTO M 205 with a length equal to twice the diameter ; standard specimens shall be 150 mm (6 in.) by 300 mm (12 in.) cylinders. Mold diameter must be at least three times the maximum aggregate size unless wet sieving is conducted according to the FOP for WAQTC TM 2. Agency specifications may allow cylinder molds of 100 mm (4 in.) by 200 mm (8 in.) when the nominal maximum aggregate size does not exceed 25 mm (1



# APPARATUS AND TEST SPECIMENS

## ■ BEAM MOLDS

- Molds shall produce length no more than 1.6 mm (1/16") shorter than that required (greater length is allowed). Maximum variation from nominal cross section shall not exceed 3.2 mm (1/8 in.). Ratio of width to depth may not exceed 1:5 ; the smaller dimension must be at least 3 times the maximum aggregate size. Unless otherwise noted in specifications, beam molds for casting specimens in the field shall result in specimens having width and depth of not less than 150 mm (6 inches). Specimens shall be cast and hardened with the long axes horizontal.



\* NOTE : Must be sufficiently rigid to resist warpage. Surfaces must be smooth.

# APPARATUS AND TEST SPECIMENS

## ■ STANDARD TAMPING ROD

- 16 mm (5/8 in.) in diameter and approximately 600 mm (24 in.) long, having a hemispherical tip of the same diameter as the rod for preparing 150mm (6 in.) x 300 mm (12 in.) cylinders.

## ■ SMALL TAMPING ROD

- 10 mm (3/8 in.) diameter and approximately 305 mm (12 in.) long, having a hemispherical tip of the same diameter as the rod for preparing 100 mm (4 in.) x 200 mm (8 in.) cylinders.



# APPARATUS AND TEST SPECIMENS

## ■ VIBRATOR

- At least 7000 vibrations per minute, with a diameter no more than  $\frac{1}{4}$  the diameter or width of the mold and at least 75 mm (3 in.) longer than the section being vibrated for use with low slump concrete.



## ■ SCOOP

- a receptacle of appropriate size so that each representative increment of the concrete sample can be placed in the container without spillage



# APPARATUS AND TEST SPECIMENS

- TROWEL OR FLOAT



- RIGID BASE PLATES AND COVER PLATES: may be metal, glass, or plywood.

- MALLET

- With a rubber or rawhide head having a mass of  $0.5 \pm 0.25 \text{ kg}$  ( $1.25 \pm 0.5 \text{ lb.}$ ).



- THERMOMETER

- Capable of registering both maximum and minimum temperatures during the initial cure.

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# PROCEDURE – MAKING SPECIMENS – GENERAL

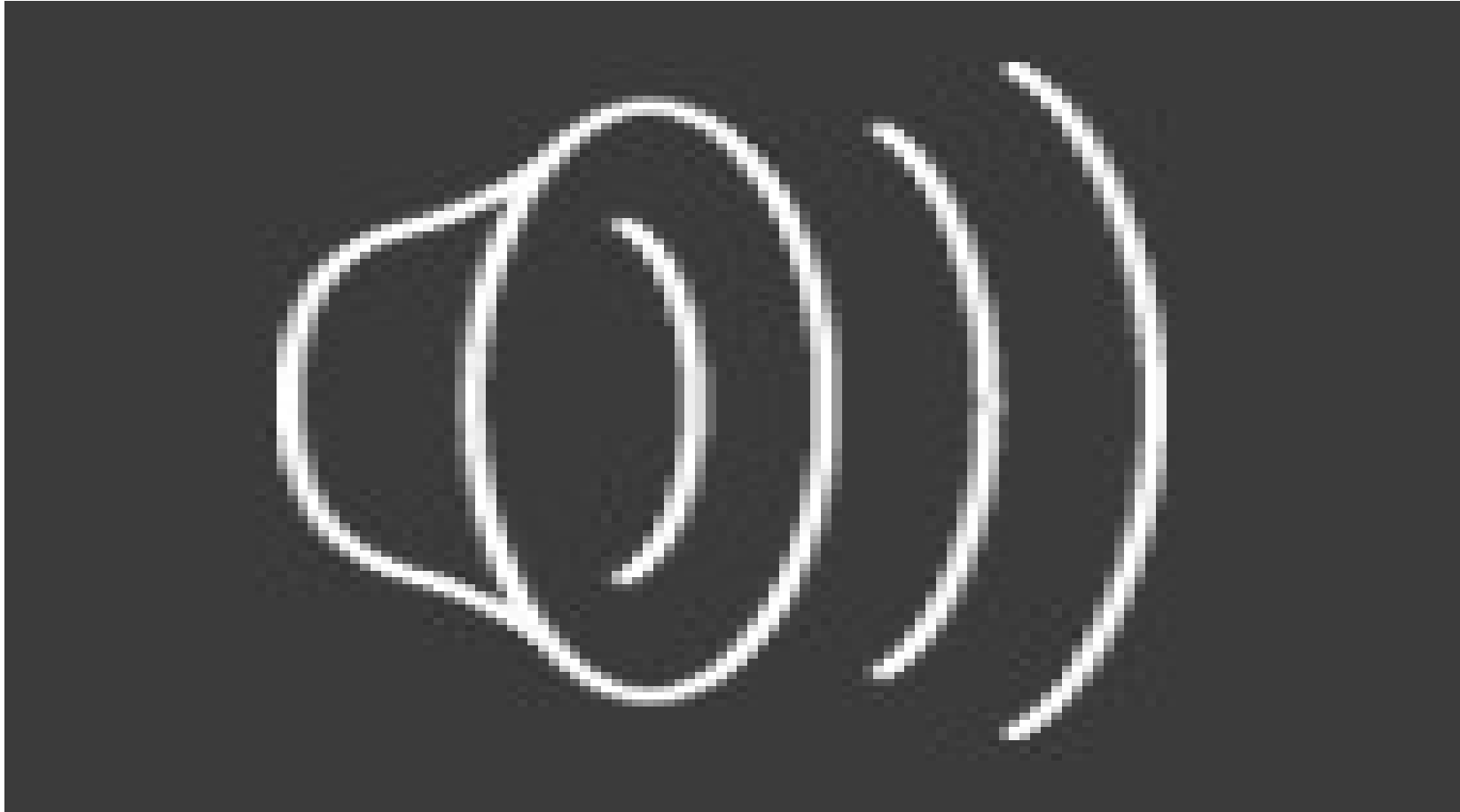
1. Obtain the sample according to the FOP for WAQTC TM 2.
2. Wet Sieving per the FOP for WAQTC TM 2 is required for 150 mm (6 in.) diameter specimens containing aggregate with a nominal maximum size greater than 50 mm (2 in.); screen the sample over the 50 mm (2 in.) sieve.
3. Remix the sample after transporting to testing location.
4. Begin making specimens within 15 minutes of obtaining the sample.

# PROCEDURE – MAKING SPECIMENS – GENERAL

5. Set molds upright on a level, rigid base in a location free from vibration and relatively close to where they will be stored.
6. Fill molds in the required number of layers, attempting to slightly overfill the mold on the final layer. Add or remove concrete prior to completion of consolidation to avoid a deficiency or excess of concrete.
7. There are two methods of consolidating the concrete – rodding and internal vibration. If the slump is greater than 25 mm (1 in.), consolidation may be by rodding or vibration. When the slump is 25 mm (1 in.) or less, consolidate the sample by internal vibration. Agency specifications may dictate when rodding or vibration will be used.

# PROCEDURE – MAKING CYLINDERS – RODDING

1. For the standard 150 mm (6 in.) by 300 mm (12 in.) specimen, fill each mold in three approximately equal layers, moving the scoop or trowel around the perimeter of the mold to evenly distribute the concrete. For the 100 mm (4 in.) by 200 mm (8 in.) specimen, fill the mold in two layers. When filling the final layer, slightly overfill the mold.
2. Consolidate each layer with 25 strokes of the appropriate tamping rod, using the rounded end. Distribute strokes evenly over the cross section of the concrete. Rod the first layer throughout its depth without forcibly hitting the bottom. For subsequent layers, rod the layer throughout its depth penetrating approximately 25 mm (1 in.) into the underlying layer
3. After rodding each layer, tap the sides of each mold 10 to 15 times with the mallet (reusable steel molds) or lightly with the open hand (single-use light-gauge molds).



## PREPARATION AND CURING OF CONCRETE TEST SPECIMEN

# PROCEDURE – MAKING CYLINDERS – INTERNAL VIBRATION

1. Fill the mold in two layers.
2. Insert the vibrator at the required number of different points for each layer (two points for 150 mm (6 in.) diameter cylinders; one point for 100 mm (4 in.) diameter cylinders). When vibrating the bottom layer, do not let the vibrator touch the bottom or sides of the mold. When vibrating the top layer, the vibrator shall penetrate into the underlying layer approximately 25 mm (1 in.)
3. Remove the vibrator slowly, so that no large air pockets are left in the material.

(NOTE: Continue vibration only long enough to achieve proper consolidation of the concrete. Over vibration may cause segregation and loss of appreciable quantities of intentionally entrained air. )

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# PROCEDURE – MAKING CYLINDERS – INTERNAL VIBRATION

4. After vibrating each layer, tap the sides of each mold 10 to 15 times with the mallet (reusable steel molds) or lightly with the open hand (single-use light-gauge molds).
5. Strike off the surface of the molds with tamping rod or straightedge and begin initial curing.

# PROCEDURE – MAKING FLEXURAL BEAMS – RODDING

1. Fill the mold in two approximately equal layers with the second layer slightly overfilling the mold.
2. Consolidate each layer with the tamping rod once for every 1300 mm<sup>2</sup> (2 in<sup>2</sup>) using the rounded end. Rod each layer throughout its depth, taking care to not forcibly strike the bottom of the mold when compacting the first layer. Rod the second layer throughout its depth, penetrating approximately 25 mm (1”) into the lower layer.
3. After rodding each layer, strike the mold 10 to 15 times with the mallet and spade along the sides and end using a trowel.
4. Strike off to a flat surface using a float or trowel and begin initial curing.

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# PROCEDURE – MAKING FLEXURAL BEAMS – VIBRATION

1. Fill the mold to overflowing in one layer.
2. Consolidate the concrete by inserting the vibrator vertically along the centerline at intervals not exceeding 150 mm (6 in.). Take care to not over-vibrate, and withdraw the vibrator slowly to avoid large voids. Do not contact the bottom or sides of the mold with the vibrator.
3. After vibrating, strike the mold 10 to 15 times with the mallet.
4. Strike off to a flat surface using a float or trowel and begin initial curing.

# PROCEDURE – INITIAL CURING

- When moving cylinder specimens made with single use molds support the bottom of the mold with trowel, hand, or other device.
- For initial curing of cylinders, there are two methods, use of which depends on the agency. In both methods, the curing place must be firm, within  $\frac{1}{4}$  in. of a level surface, and free from vibrations or other disturbances.
- Maintain initial curing temperature of 16 to 27°C (60 to 80°F) or 20 to 26°C (68 to 78°F) for concrete with strength of 40 MPa (6000 psi) or more.
- Prevent loss of moisture.

---

# METHOD 1 – INITIAL CURE IN A TEMPERATURE CONTROLLED CHEST-TYPE CURING BOX

1. Finish the cylinder using the tamping rod, straightedge, float, or trowel. The finished surface shall be flat with no projections or depressions greater than 3.2 mm (1/8 in.).
2. . Place the mold in the curing box. When lifting light-gauge molds be careful to avoid distortion (support the bottom, avoid squeezing the sides).
3. Place the lid on the mold to prevent moisture loss.
4. Mark the necessary identification data on the cylinder mold and lid.

---

# METHOD 2 – INITIAL CURE BY BURYING IN EARTH OR BY USING A CURING BOX OVER THE CYLINDER

1. Move the cylinder with excess concrete to the initial curing location.
2. Mark the necessary identification data on the cylinder mold and lid.
3. Place the cylinder on level sand or earth, or on a board, and pile sand or earth around the cylinder to within 50 mm (2 in.) of the top.

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# METHOD 2 – INITIAL CURE BY BURYING IN EARTH OR BY USING A CURING BOX OVER THE CYLINDER

4. Finish the cylinder using the tamping rod, straightedge, float, or trowel. Use a sawing motion across the top of the mold. The finished surface shall be flat with no projections or depressions greater than 3.2 mm (1/8 in.).
5. If required by the agency, place a cover plate on top of the cylinder and leave it in place for the duration of the curing period, or place the lid on the mold to prevent moisture loss.

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# PROCEDURE – TRANSPORTING SPECIMENS

- After 24 to 48 hours of initial curing, the specimens will be transported to the laboratory for a final cure. Specimen identity will be noted along with the date and time the specimen was made and the maximum and minimum temperatures registered during the initial cure.
- While in transport, specimens shall be protected from jarring, extreme changes in temperature, freezing, or moisture loss.
- Cylinders shall be secured so that the axis is vertical.
- Transportation time shall not exceed 4 hours.

# FINAL CURING

- Upon receiving cylinders at the laboratory, remove the cylinder from the mold and apply the appropriate identification.
- For all specimens (cylinders or beams), final curing must be started within 30 minutes of mold removal. Temperature shall be maintained at  $(73 \pm 3^\circ\text{F})$ . Free moisture must be present on the surfaces of the specimens during the entire curing period. Curing may be accomplished in a moist room or water tank conforming to AASHTO M 201.
- For cylinders, during the final 3 hours prior to testing the temperature requirement may be waived, but free moisture must be maintained on specimen surfaces at all times until tested.
- For cylinders, during the final 3 hours prior to testing the temperature requirement may be waived, but free moisture must be maintained on specimen surfaces at all times until tested.
- Final curing of beams must include immersion in lime-saturated water for at least 20 hours prior to testing.
- Final curing of beams must include immersion in lime-saturated water for at least 20 hours prior to testing.

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# DETERMINATION OF SETTING TIME OF HYDRAULIC CEMENT

## LESSON 6



# DETERMINATION OF SETTING TIME OF HYDRAULIC CEMENT

## SCOPE:

- These test methods determine the time of setting of hydraulic cement by means of the Vicat needle. Two test methods are given; **Method A is the Reference Test Method using the manually operated standard Vicat apparatus**, while **Method B permits the use of an automatic Vicat machine** that has, in accordance with the qualification requirements of this method, demonstrated acceptable performance.
- The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

## REFERENCED DOCUMENTS

### ➤ ASTM Standards

C150 : Specification for Portland Cement

C151 : Test Method for Autoclave Expansion of Hydraulic Cement

C183 : Practice for Sampling and the Amount of Testing of Hydraulic Cement

C187 : Test Method for Normal Consistency of Hydraulic Cement

C219 : Terminology Relating to Hydraulic Cement

C266 : Test Method for Time of Setting of Hydraulic Cement Paste by Gillmore Needles

# DETERMINATION OF SETTING TIME OF HYDRAULIC CEMENT

## ➤ ASTM Standards (Continuation)

**C305** : Practice for Mechanical Mixing of Hydraulic Cement Pastes and Mortars of Plastic Consistency

**C511** : Specification for Mixing Rooms, Moist Cabinets, Moist Rooms, and Water Storage Tanks used in the Testing of Hydraulic Cements and Concretes

**C595** : Specification for Blended Hydraulic Cements

**C1005** : Specification for Reference Masses and Devices for Determining Mass and Volume for use in the Physical Testing of Hydraulic Cements

**C1157** : Performance Specification for Hydraulic Cement

**C1193** : Specification for Reagent Water

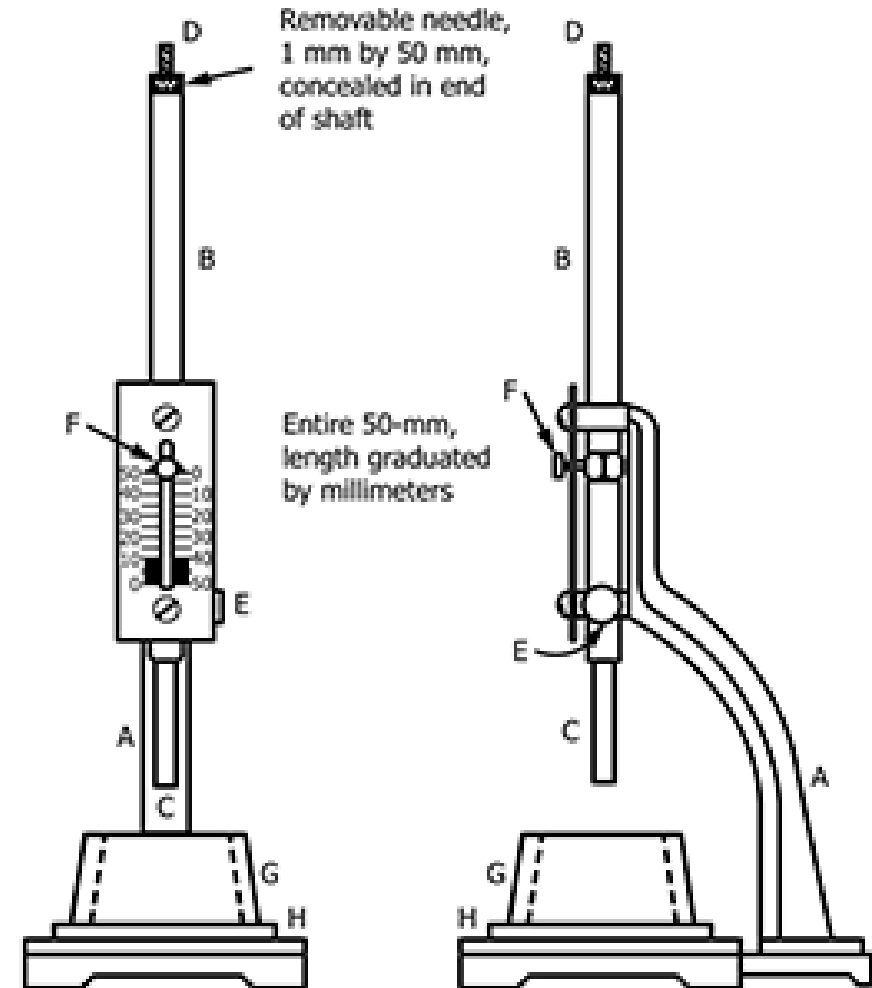
## SUMMARY OF TEST METHOD

- A paste that is proportioned and mixed to normal consistency, as described in the Test Method **C187**, is molded and placed in a moist cabinet and allowed to start setting. Periodic penetration tests are performed on this paste by allowing a 1-mm Vicat needle to settle into this paste. The Vicat initial time of setting is the time elapsed between the initial contact of cement and water and the time when the penetration is measured or calculated to be 25 mm. The Vicat final time of setting is the time elapsed between initial contact of cement and water and the time when the needle does not leave a complete circular impression in the paste surface.

# APPARATUS

## VICAT APPARATUS

- Vicat apparatus for this test shall have a removable rod, B, of mass 100 g.
- The end of the rod used for measuring penetration shall have a straight steel removable needle with a diameter of 1.0 mm and length no less than 50 mm.
- The needle end that contacts the specimen shall be flat, plane, and at right angles to the axis of the rod.
- The needle end that contacts the specimen shall be flat, plane, and at right angles to the axis of the rod.



# APPARATUS

- REFERENCE MASSES AND DEVICES FOR DETERMINING MASS, conforming to the requirements of Specification C1005.
  - The devices for determining mass shall be evaluated for precision and accuracy at a total load of 1000 g.
- GLASS GRADUATES, 200 or 250 mL capacity, and conforming to the requirements of Specification C1005.
- PLANE NON-ADSORPTIVE PLATE, 100 square of similar planeness, corrosivity, and absorptivity to that of glass
- FLAT TROWEL, having a sharpened, straight-edged steel blade 100 to 150 mm in length. The edges when placed on parallel surfaces shall not depart from straightness by more than 1 mm
- CONICAL RING, made of a rigid, non-corroding, non-adsorbent material and having a height of  $m$  and an inside diameter at the top of  $m$  and an inside diameter at the bottom of  $m$
- MIXER, BOWL, AND PADDLE, conforming to Practice C305.
- MIXER, BOWL, AND PADDLE, conforming to Practice C305.

# APPARATUS

## ■ AUTOMATIC VICAT NEEDLE APPARATUS FOR METHOD B

- The apparatus shall be equipped with a Vicat needle with a diameter of  $1.00 \pm 0.05 \text{ mm}$  and length no less than 50 mm. The needle end that contacts the specimen shall be flat, plane, and at right angles to the axis of the rod.

- The total mass supported by the needle tip at the time of measurement shall be  $300 \pm 0.5 \text{ g}$ .

- The instrument shall be capable of automatically completing and recording penetration measurements of a test specimen at predetermined time intervals not exceeding 10 min and make each penetration test at least 5 mm away from any previous penetration and at least 10 mm away from the inner side of the mold.

## ■ SPECIMEN MOLD FOR METHOD B

- The cement paste is held in a conical ring with the ring width of  $10 \pm 1 \text{ mm}$  and a removable base plate.

■ The test surface shall have a minimum diameter of  $60 \pm 5 \text{ mm}$ .

# DETERMINATION OF SETTING TIME OF HYDRAULIC CEMENT

## CONDITIONING :

- Maintain the temperature of the air in the vicinity of the mixing slab, the dry cement, plates, and base plates at  $23.0 \pm 2.0^{\circ}\text{C}$ .
- Maintain the temperature of the mixing water at  $23.0 \pm 2.0^{\circ}\text{C}$ .
- The relative humidity of the mixing room shall be not less than 50 %
- The moist cabinet or moist room shall be in accordance with Specification C511.

## PREPARATION OF CEMENT PASTE

- The cement paste used for the determination of the time of setting is obtained from one of the following methods:
  1. Prepare a new batch of paste by mixing 650 g of cement with the percentage of mixing water required for normal consistency (Test Method C187), following the procedure described in Practice C305.
  2. For method A, at the option of the tester, use the test specimen used for determining normal consistency (The specimen used for the determination of the normal consistency will have an irregular surface, making it unsuitable for method B.)

# DETERMINATION OF SETTING TIME OF HYDRAULIC CEMENT

## PREPARATION OF CEMENT PASTE (CONTINUATION):

3. At the option of the tester, use the paste remaining from the batch used for the autoclave specimen (Test Method C151) or (Test Method C151) or from the normal Test Method C187). determination (Test Method C187).

## CALCULATION:

### CALCULATION :

$$\left( \left( \frac{H-E}{C-D} \right) (C - 25) \right) + E$$

Where:

$E$   $\equiv$  time in minutes of last penetration greater than 25 mm

$H$   $\equiv$  time in minutes of first penetration less than 25 mm,

$C$   $\equiv$  penetration reading at time E

$D$   $\equiv$  penetration reading at time H.

# METHOD A—MANUAL VICAT NEEDLE APPARATUS

- **MOLDING TEST SPECIMEN** — Quickly form the cement paste, prepared as described in the section on preparation of cement paste, into a ball with gloved hands and toss six times from one hand to the other, maintaining the hands about 150 mm (6 in.) apart. Press the ball, resting in the palm of the hand, into the larger end of the conical ring, G, [Fig. A1.1](#), 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. Place the ring on its larger end onto the non absorptive plate, H, and slice off the excess paste at the smaller end at the top of the ring by a single oblique stroke of the trowel held at a slight angle with the top of the ring. Smooth the top of the specimen, if necessary, with one or two light touches of the pointed end of the trowel. During the operation of cutting and smoothing, take care not to compress the paste. Immediately after molding, place the test specimen in the moist cabinet or moist room and allow it to remain there except when penetration measurements are being made. The specimen shall remain in the conical mold, supported by the non-absorptive plate throughout the test period.

# METHOD A—MANUAL VICAT NEEDLE APPARATUS

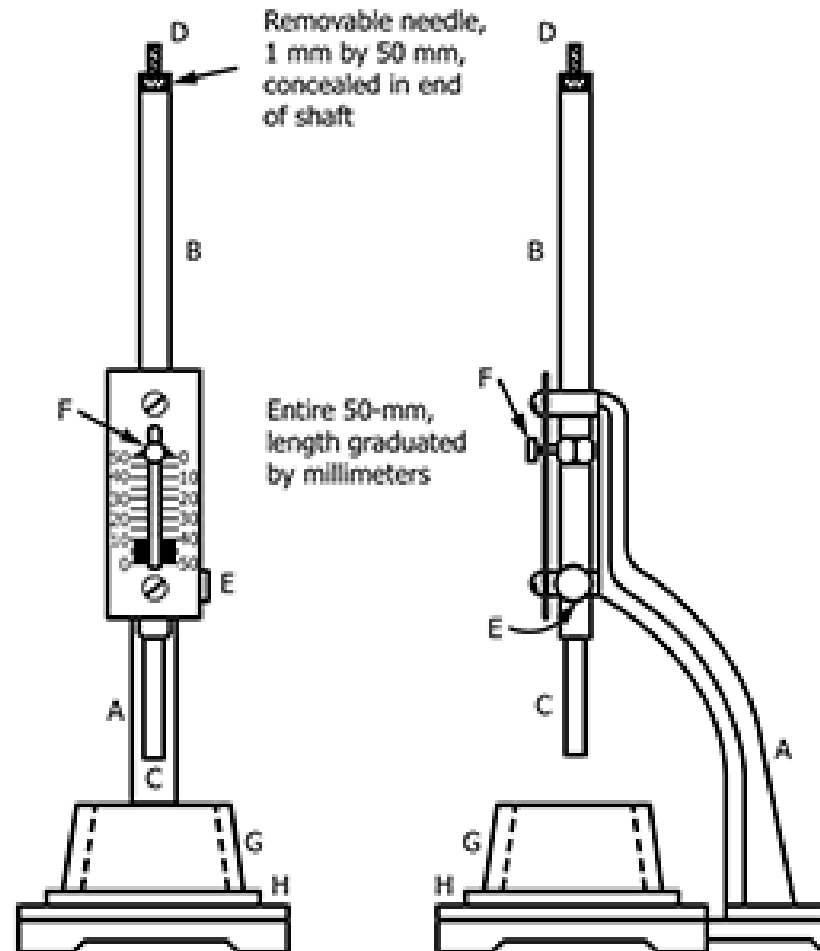


FIG. A1.1 Vicat  
Apparatus

# METHOD A—MANUAL VICAT NEEDLE

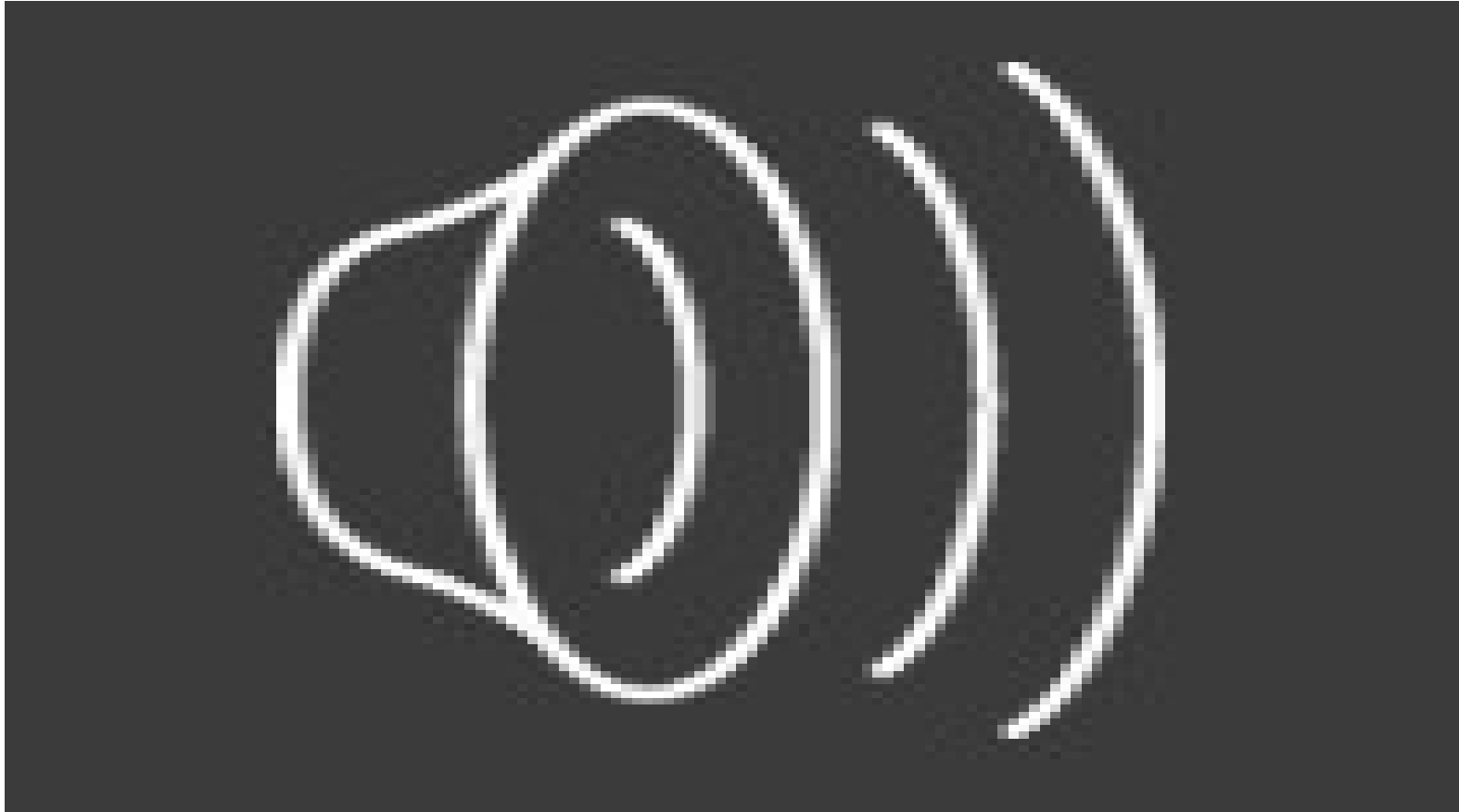
## APPARATUS

- **TIME OF SETTING DETERMINATION** — Allow the time of setting specimen to remain in the moist cabinet or moist room for 30 min after molding without being disturbed. Determine the penetration of the 1-mm needle at this time and every 15 min thereafter (every 10 min for Type III cements) until a penetration of 25 mm or less is obtained. Perform the penetration test by lowering the needle D of the rod B until it rests on the surface of the cement paste. Tighten the setscrew, E, and set the indicator, F, at the upper end of the scale, or take an initial reading. Release the rod quickly by releasing the set screw, E, and allow the needle to settle for 30 s; then take the reading to determine the penetration. At the option of the tester, if the paste is obviously quite soft on the early readings, retard the fall of the rod to avoid bending the 1-mm needle, but when actual penetration measurements to determine the time of setting are made, release the rod only by the setscrew. Make each penetration test at least 5 mm away from any previous penetration and at least 10 mm away from the inner side of the mold. Record the results of all penetration tests and, by interpolation, determine the time when a penetration of 25 mm is obtained. The elapsed time between the initial contact of cement and water and the penetration of 25 mm is the Vicat time of setting or Vicat initial time of setting.

---

# METHOD A—MANUAL VICAT NEEDLE APPARATUS

- Determine the Vicat final time of setting end point to be the first penetration measurement that does not mark the specimen surface with a complete circular impression. Verify final set by performing two additional penetration measurements on different areas of the specimen surface. Obtain verification measurements within 90 s of the first “final set” measurement. The elapsed time between the initial contact of cement and water and the end point determination above is the Vicat final time of setting.
- **PRECAUTIONS**—Keep all the apparatus free from vibration during the penetration test. Keep the 1-mm needle straight and clean. The needle must be kept clean to prevent cement from adhering to the sides of the needle and decreasing penetration, and to prevent cement from adhering to the point and increasing penetration.



## SETTING TIME OF HYDRAULIC CEMENT

# METHOD B—AUTOMATIC VICAT

## PROCEDURE

- **MOLDING THE SPECIMEN** — Quickly form the cement paste, prepared as described in the section on preparation of cement paste, into a ball with gloved hands and toss six times from one hand to the other, maintaining the hands about 150 mm apart. Press the ball, resting in the palm of the 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. Place the ring on its larger end on the base plate. Use a trowel to remove the excess paste at the top of the mold. Holding the trowel at about a 30° incline with the leading edge raised and starting near the center of the mold, level the paste by drawing the trowel across the top of the mold using a sawing motion; repeat the procedure for the other half of the surface. Then smooth the surface level to the top of the mold making steady and complete strokes across the entire surface with the trailing edge of the trowel. Repeat the cutting and smoothing steps but at 90° from the previous cut. Repeat the steps as required to produce a surface level with the top of the mold. Usually the paste is level within two cycles, but occasionally three will be required. Avoid excessive strokes and compaction. Since the automatic Vicat device references to the top edge of the mold, it is imperative that the top surface of the paste be uniform and level with the top of the mold.

# METHOD B—AUTOMATIC VICAT

- **TIME OF SETTING DETERMINATIONS** — Follow the manufacturer’s instructions and complete the required instrument calibration and zero procedures. Set the instrument to measure no less frequently than every 10 min (Automatic devices are usually capable of measurement more frequently than once every 10 min and more frequent measurement minimizes interpolation.). . Position the molded specimen in the automatic Vicat apparatus and initiate the measurements (The initial time of setting according to Method A is determined as the elapsed time required to achieve a penetration of 25 mm and the final time of setting as the total time elapsed until the needle does not leave a complete circular impression in the paste surface. The end points established by a qualified automatic Vicat test method may deviate significantly from end points specified in Method A, and require standardization to correct bias.)
- Determine the range of applicability of the method from the range of the average time of setting of the cements used for qualification and standardization, and limit that range to 30 min greater than the maximum, and 30 min less than the minimum
- Performance Requirement (Qualification) for Automatic Vicat Instrument:
  - ❑ When time of setting results from the automatic Vicat apparatus are to be used for acceptance or rejection of cement, the method used shall comply with the qualification requirements covered in Annex A2.

# PERFORMANCE REQUIREMENT (QUALIFICATION) FOR AUTOMATIC VICAT INSTRUMENT

1. **SCOPE** — When time of setting results from the automatic Vicat apparatus are to be used for acceptance or rejection of cement, the method used shall comply with the qualification requirements of this section. A method is considered to consist of the specific instrument and the molding procedure meeting the requirements of this standard, and used in a consistent manner by a given laboratory.
  
2. **HYDRAULIC CEMENT SAMPLES REQUIRED**—Select three cements that comply with requirements of Specifications **C150**, **C595**, or **C1157**, and that when tested in accordance with Method A, shall include the following:
  - ❑ One cement that has an initial time of setting of less than 110 min.
  - ❑ One cement with an initial time of setting of greater than 150 min.
  - ❑ One cement with a final time of setting of less than 180 min
  - ❑ One cement with a final time of setting of greater than 210 min (Laboratories are advised to reserve sufficient cement for future qualification and standardization.)

# PERFORMANCE REQUIREMENT (QUALIFICATION) FOR AUTOMATIC VICAT

## 3. TESTS

Using the method to be qualified and including the standardization formula described in the section on standardization, make single determinations of the times of initial and final setting on each of the three cements. On the same day, conduct companion time of setting determinations according to Method A. Make single determinations of the normal consistency on each cement, and use that amount of water for all replicate batches. Complete three rounds of tests on different days, repeating all the steps of the methods. Conduct the qualification tests on specimens prepared separately from the standardization testing.

**4. CALCULATIONS**—Calculate the three-round averages for initial and final time of setting for each cement and method. A method complies with the initial time of setting qualification requirements if the difference between the initial time of setting average values for Method A and the corresponding average values of Method B is not greater than 25 min for any sample, and the range for any three replicate tests by Method B does not exceed 30 min. Likewise, a method complies with the final time of setting qualification requirements if the difference between the final time of setting average values for Method A and corresponding average values for Method B is not greater than 45 min for any sample, and the range for any three replicate tests by Method B does not exceed 30 min. Example qualification data are given in Appendix X1.

# PERFORMANCE REQUIREMENT (QUALIFICATION) FOR AUTOMATIC VICAT

## INSTRUMENT

### APPENDIX

(Nonmandatory Information)

#### XI. SAMPLE QUALIFICATION RESULTS

TABLE X1.1 Time of Initial Setting, min

Cement	Round No.	Initial C191 Method A	Initial Auto Method B	Diff. Avg. (Spec. 25 Max.)
A	1	95	105	...
A	2	90	105	...
A	3	95	90	...
Range (Spec. 30 Max.)		5	15	...
Average		93.3	100.0	6.7
B	1	100	120	...
B	2	105	95	...
B	3	85	95	...
Range (Spec. 30 Max.)		20	25	...
Average		96.7	103.3	6.7
C	1	155	170	...
C	2	155	160	...
C	3	145	155	...
Range (Spec. 30 Max.)		10	15	...
Average		151.7	161.7	10.0

**5. STANDARDIZATION**—When standardization is required in order to achieve agreement between Method A and Method B, it can be applied to either the initial time of setting, final time of setting, or both. A standardization formula shall be based on a comparison of test results obtained using Method A and the chosen method using the automatic instrument (Method B). Results of tests from at least five different hydraulic cements shall be required for standardization. The cements shall have a minimum range of 60 min initial time of setting, and a minimum range of 90 min final time of setting when tested in accordance with Method A. If desired, the three cements used for instrument qualification may be used, but make new determinations. Use the same method as used for instrument qualification, including all the same steps. Valid standardization formulas shall be mathematically derived and applied to all samples (Generally, the automatic instruments are computer operated and easily adapted to standardization calculations.)

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# FAMILIARIZATION WITH THE PARTS AND FUNCTIONS OF THE UNIVERSAL TESTING MACHINE

## LESSON 7



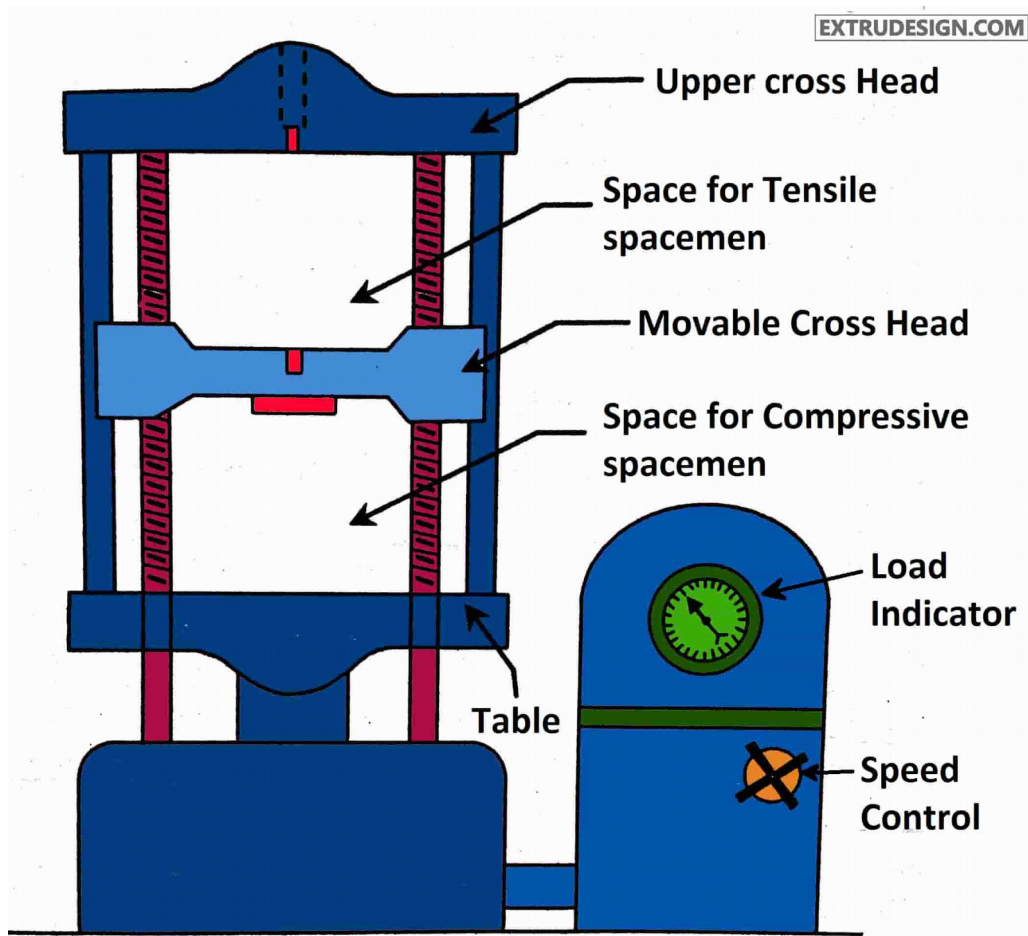
# UNIVERSAL TESTING MACHINE

## UNIVERSAL TESTING MACHINE (UTM)

- used to test the mechanical properties (tension, compression etc.) of a given test specimen by exerting tensile, compressive or transverse stresses.
- The machine has been named so because of the wide range of tests it can perform over different kind of materials. Different tests like peel test, flexural test, tension test, bend test, friction test, spring test etc. can be performed with the help of UTM.



# COMPONENTS OF UNIVERSAL TESTING MACHINE



UNIVERSAL TESTING MACHINE CONSISTS OF TWO MAIN PARTS :

- ❑ Loading Unit
  - ❑ Control Unit
- The arrangement of the test specimen and the exertion of the load is held in the **Loading Unit**.
  - The variations in the application of the load and the corresponding test result are obtained from the **Control Unit**.

# COMPONENTS OF UNIVERSAL TESTING MACHINE

## LOADING UNIT

➤ The Loading Unit of a Universal Testing Machine consist of the following components:

1. Load Frame
2. Upper Crosshead and Lower Crosshead
3. Elongation Scale

### 1. LOAD FRAME

- Load frame of a universal testing machine can be made either by single support or by double support.

- Consists of a table (where the specimen is placed for the compression test), upper crosshead, and lower crosshead.

# COMPONENTS OF UNIVERSAL TESTING MACHINE

## 2. UPPER CROSSHEAD AND LOWER CROSSHEAD

- Upper crosshead is used to clamp one end of the test specimen.

- lower crosshead in the load frame is the movable crosshead whose screws can be loosened for height adjustment and tightened.

- Both the crossheads have a tapered slot at the center. This slot has a pair of raked jaws that is intended to grip and hold the tensile test specimen.

## 3. Elongation Scale

- relative movement of the lower and upper table is measured by an elongation scale which is provided along with the loading unit.

# COMPONENTS OF UNIVERSAL TESTING MACHINE

## CONTROL UNIT

➤ The main components of the Control Unit in a Universal Testing Machine are:

1. Hydraulic Power Unit
2. Load Measuring Unit
3. Control Devices

### 1. HYDRAULIC POWER UNIT

- consists of an oil pump that provides non-pulsating oil flow into the main cylinder of the load unit. This flow helps in the smooth application of load on the specimen.

- the oil pump in a hydraulic power unit is run by an electric motor and sump.

# COMPONENTS OF UNIVERSAL TESTING MACHINE

## 2. LOAD MEASURING UNIT

- This unit has a pendulum dynamometer unit that has a small cylinder with a piston which moves with the non-pulsating oil flow.
- The pendulum is connected to the piston by pivot lever.
- The pivot lever deflects based on the load applied to the specimen. This deflection is converted to the load pointer and displays as the load on the dial.
- The range of load application can be adjusted by means of a knob in the load measuring unit (0-100 kN; 0-250 kN; 0-500 kN and 0-1000 kN). The accuracy of measuring unit controls the overall accuracy of the machine.

## 3. CONTROL DEVICES

- control devices can be electric or hydraulic
- Electric control devices make use of switches to move the crossheads and switch on/off the unit.
- A hydraulic control device consists of two valves, Right Control Valve and Left Control Valve or Release Valve.
- A right control valve is used to apply load on the specimen. The left control valve is used to release the load application

# FUNCTIONS OF UNIVERSAL TESTING MACHINE

➤ The main functions of Universal Testing Machine are to test the mechanical properties of materials. The standard test performed by Universal Testing Machine are:

1. Tensile Test
2. Compression Test
3. Adhesion Tests
4. Pull-Out Tests
5. Bending Test
6. Hysteresis Test

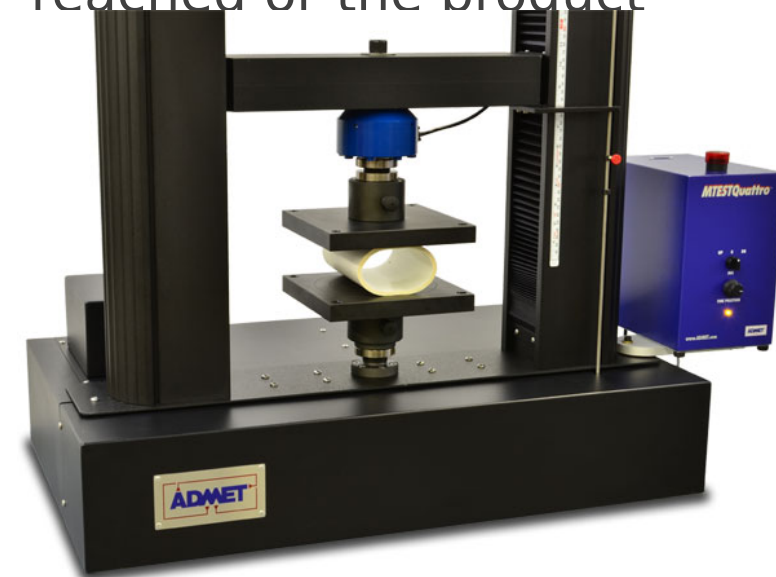
## TENSILE TEST

- Clamp a single piece of anything on each of its ends and pull it apart until it breaks. This measures how strong it is (tensile strength) how stretchy it is (elongation), and how stiff



## COMPRESSION TEST

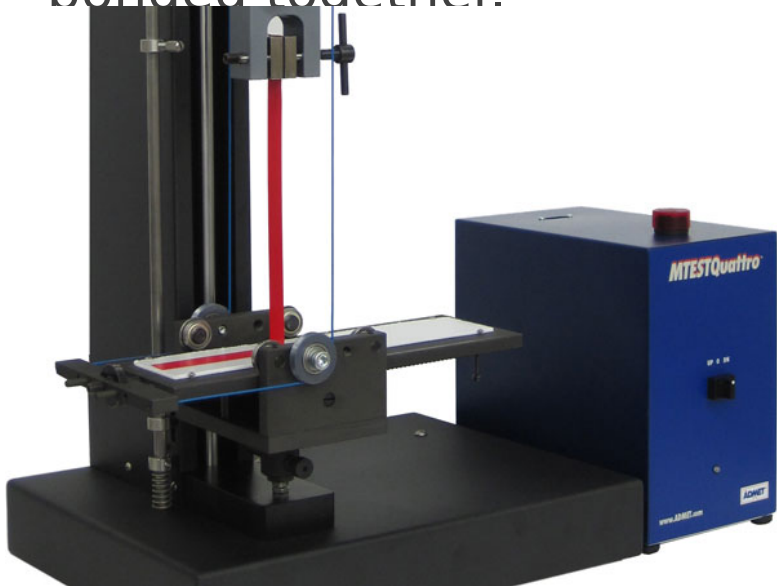
- The exact opposite of a tensile test. This is where you compress an object between two level plates until a certain load or distance has been reached or the product



# FUNCTIONS OF UNIVERSAL TESTING MACHINE

## PEEL TEST

- Similar to a tensile test. However, instead of pulling apart a single piece, you pull apart two materials that have been bonded together.



## BEND TEST

- This is a compression test where you support a length of material by spanning it across two supports on each end. There is nothing supporting the middle portion underneath of it.

- This test measures how strong the material in flexure (flexural strength) and how stiff it is (flexural modulus).



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# TESTING OF WOOD: SAMPLES FOR BENDING, COMPRESSION, SHEAR, TENSION AND WATER CONTENT

## LESSON 8



# TESTING OF WOODS

## PRINCIPLES OF WOOD TESTING

- Wood is composed of elongated, round, or rectangular tube-like cells that are much longer than they are wide. Within in the wall there are several layers made out of microfibrils, which are bundles of cellulose polymers.
- Microfibril chains are aligned in distinct directions inside the walls' layers. The middle wall with its chains aligned along the longer dimension of the cell provides most of the strength to the cell, while the inner and outer walls' diagonal chains provide stability. Lignin binds together the cellulose polymers as well as the microfibril chains and the walls' cells. The bundling effect of many cells together
- Due to its cellular makeup, wood is an orthotropic material, having different properties along the longitudinal and, respectively, the transversal axes with respect to the grain direction.
- The cellular makeup of wood also accounts for the free water inside the cell cavities and water bound to the cell walls. In consequence, ***moisture content is a key parameter in determining wood strength***, and, in general, moisture reduction will result in an increase in strength.

# COMPRESSION TEST ON WOOD (PROCEDURE)

1. Obtain nominal 3-1/2" compression cube specimens of three different woods (Southern pine, spruce, and oak for example). The cubes can be cut from a 4x4 section but should be clear wood. Ensure that the surfaces are to be parallel to one another. One set of specimens should be tested with the load applied parallel to the grain, and the other set of specimens should be tested with the load applied perpendicular to the grain. The number of test repetitions within a set depends on the desired confidence limits. Only one test per set will be run as part of this laboratory, as its objectives are to demonstrate the techniques and not to develop large robust data sets for engineering design.
2. Measure the cross-sectional dimensions (width and thickness) of each test specimen to the nearest 0.002 in. using a caliper. Measure the total length (in the direction of loading) for the compression specimens. As the specimens may vary slightly in dimensions throughout their length, take several measurements, and record the approximate average for each measured dimension.

---

# COMPRESSION TEST ON WOOD (PROCEDURE)

3. After setting up the universal testing machine (see first manuscript on this series: Materials Constants), carefully center the specimen on the compression platen and lower the crosshead until a slight load is applied. Use the fine controls to back the load off to as close to zero as possible.
4. Apply the compressive load slowly with a loading rate between 20 psi to 50 psi per second.
5. The compression test may continue for several minutes with the load continually increasing and with significant strain seen in the specimen. Continue the test until a maximum load is obviously reached.
6. Record the maximum load from the screen.



## COMPRESSION TEST ON WOOD

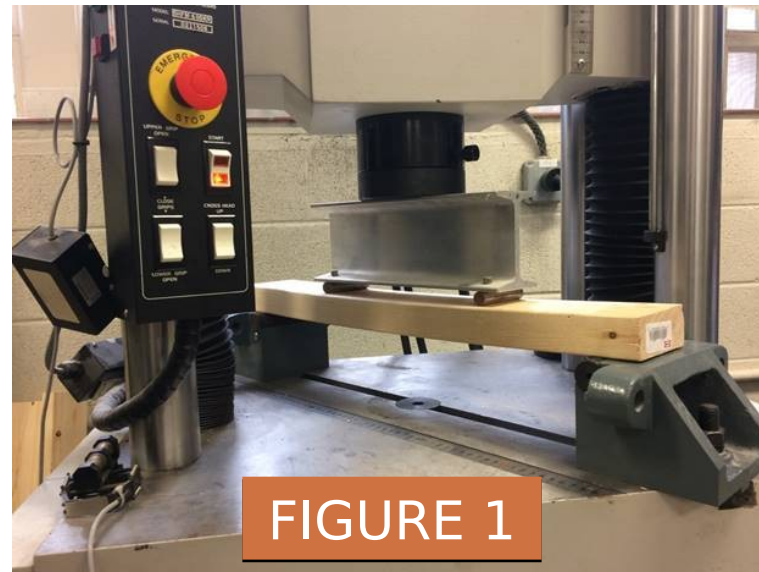
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# TENSION TEST ON WOOD (PROCEDURE)

1. Obtain dog-bone specimens of three different woods (Southern pine, spruce, and oak for example). One set of specimens should be tested with the load applied parallel to the grain, and the other set of specimens should be tested with the load applied perpendicular to the grain. Note that these are not the specimen type required for ASTM tests on wood, as the intent is to demonstrate tensile behavior and not to develop a database for design.
2. Proceed as normal with the usual tension test machine (see second manuscript on this series: Tensile Tests on Steel).

# BENDING TEST ON WOOD (PROCEDURE)

1. Obtain a 2x4 about 24 in. long of dense Southern pine.
2. Install a four-point bending test apparatus on the universal testing machine (Fig. 1).



3. Start the testing machine and associated software. Make sure the software is set to capture the maximum load and record the loads and crosshead values

# BENDING TEST ON WOOD (PROCEDURE)

4. Install the 2x4 into the apparatus and lower the upper crosshead until the apparatus just begins to make contact with the wood beam.
5. Apply the load slowly (around 2000 lbs per minute) until the beam fractures (Fig. 2).



FIGURE 2

6. Record the failure load.



# BENDING TEST ON WOOD

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# DETERMINE THE COMPRESSIVE STRENGTH OF CONCRETE HOLLOW BLOCKS

## LESSON 9



# COMPRESSIVE STRENGTH OF CONCRETE HOLLOW BLOCKS

## CONCRETE HOLLOW BLOCKS (CHB)

- One of the most extensively used walling materials in the Philippines. It is cheaper compared to other materials.
- Concrete Hollow Blocks are very weak against lateral loads (pushing or pulling forces from typhoon or earthquake).
- Adding steel reinforcing bars vertically and horizontally inside the Concrete Hollow Blocks can increase their resistance to lateral loads.

## CONCRETE MASONRY BLOCKS

- usually rectangular and are used in construction of masonry structure. They are available in solid and hollow forms.

- Concrete Masonry blocks are made up of:
  - ❑ Cement
  - ❑ Aggregates
  - ❑ Water

# COMPRESSIVE STRENGTH OF CONCRETE HOLLOW BLOCKS

## NOMINAL DIMENSIONS OF CONCRETE MASONRY BLOCK VARY AS FOLLOWS:

- Length: 400 or 500 or 600mm
- Width: 200 or 100mm
- Height: 50, 75, 100, 150, 200, 250 or 300mm



## TESTS ON CONCRETE MASONRY BLOCK UNITS

- Blocks of same mix shall be taken and divide them as follows to conduct the following tests :
1. Dimension measurement (All blocks)
  2. Density of block (3 blocks)
  3. Compressive strength of block (8 blocks)

# COMPRESSIVE STRENGTH OF CONCRETE HOLLOW BLOCKS

## DIMENSION MEASUREMENT

- All blocks should be checked in this step.
- The length, width and height are measured with steel scale. If it is a hollow block, then the web thickness and face shell are measured with caliper ruler.
- Prepare a report of average length, width and height of block and average minimum face shell and minimum web thickness using recorded dimensions.

## DENSITY OF CONCRETE MASONRY BLOCK

- 3 blocks shall be taken to conduct this test.
- 3 blocks shall be taken to conduct this test.
- First heat the block in the oven to 100°C and then cooled it to room temperature, to determine the density of the block.
- First heat the block in the oven to 100°C and then cooled it to room temperature, to determine the density of the block.

$$\text{Density of Block} = \frac{\text{mass}}{\text{volume}} \left( \frac{\text{kg}}{\text{m}^3} \right)$$

# DENSITY VALUES OF DIFFERENT GRADES OF BLOCKS SHOULD BE AS FOLLOWS :

Type of unit	Grade	Density of block (kg/m <sup>2</sup> )
Hollow type unit	A(3.5)	>= 1500
	A(4.5)	>=1500
	A(5.5)	>=1500
	A(7.0)	>=1500
	A(8.5)	>=1500
	A(10.0)	>=1500
	A(12.5)	>=1500
	A(15.0)	>=1500
	B(3.5)	1100-1500
	B(5.0)	1100-1500
Solid type unit	C(5.0)	>=1800
	C(4.0)	>=1800

---

# COMPRESSIVE STRENGTH TESTS ON CONCRETE MASONRY BLOCKS

- Eight blocks are taken to determine the average compressive strength of concrete masonry block
- The blocks should be tested within 3 days after collected in lab. The age of each block shall be 28 days.
- Bearing area of concrete masonry units are capped with the Sulphur and granular materials coating or gypsum plaster capping.
- If the bearing area of masonry unit is more than the bearing area of steel blocks, then separate steel plates are used. The plates are arranged on steel blocks in such a way that the centroid of masonry unit coincide with the center of thrust of

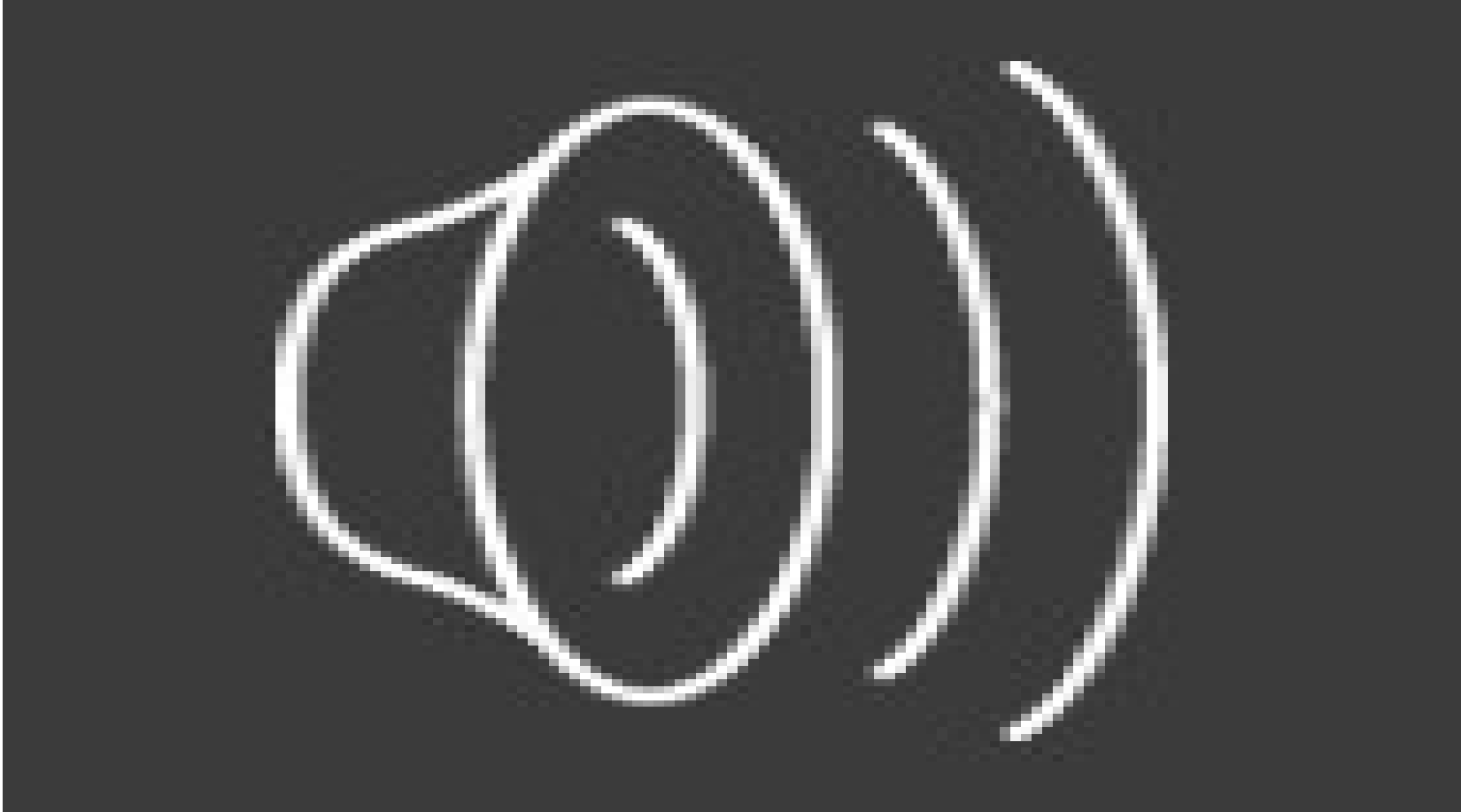
# COMPRESSIVE STRENGTH TESTS ON CONCRETE MASONRY BLOCKS

- Compressive strength testing machine consist of two steel bearing blocks, one is in rigid position on which the masonry unit is placed and another one is movable which transmit the load to the masonry unit when applied.
- After placing the unit in testing machine, one-half of the expected maximum load is applied at a constant rate, and the remaining load is applied in not less than 2 minutes.
- Note down the load at which masonry unit fails and the maximum load divided by gross sectional area of unit will give the compressive strength of block.
- Similarly, test the remaining 7 blocks and the average of 8 blocks strength is the final compressive strength of concrete masonry



# VALUE OF MINIMUM AVERAGE COMPRESSIVE STRENGTH OF INDIVIDUAL UNITS

Type of unit	Grade	Min average compressive strength of individual units (N/mm <sup>2</sup> )
Hollow type concrete masonry unit	A(3.5)	2.8
	A(4.5)	3.6
	A(5.5)	4.4
	A(7.0)	5.6
	A(8.5)	7.0
	A(10.0)	8.0
	A(12.5)	10.0
	A(15.0)	12.0
	B(3.5)	2.8
	B(5.0)	4.0
Solid type unit	C(5.0)	4.0
	C(4.0)	3.2



COMPRESSIVE  
STRENGTH TESTS  
ON CONCRETE  
HOLLOW BLOCKS



# DETERMINING THE TIME OF SETTING OF PORTLAND CEMENT

## LESSON 10



# SETTING TIME OF PORTLAND CEMENT

## SETTING TIME OF CEMENT

- **When cement is mixed with water, it hydrates and makes cement paste.** This paste can be molded into any desired shape due to its plasticity. Within this time cement continues with reacting water and slowly cement starts losing its plasticity and set harden. **This complete cycle**

## INITIAL SETTING TIME OF CEMENT

- The time to which cement can be molded in any desired shape without losing its strength.
- Time at which **cement starts hardens and completely loses its plasticity**

## INITIAL SETTING TIME OF CEMENT

- Time available for mixing the cement and placing it in position is an Initial Setting Time of cement. If delayed further, cement loses its strength.
- For Ordinary Portland Cement, the Initial Setting Time is 30 minutes.

## FINAL SETTING TIME OF CEMENT

- Time at which **cement completely loses its plasticity and became hard.**
- Time taken by cement to gain its entire strength
- For Ordinary Portland Cement, the Final Setting Time is 600 minutes (10hrs).

# SETTING TIME OF PORTLAND CEMENT

## APPARATUS REQUIRED

Vicat's Apparatus

Balance

Measuring Cylinder

Stop watch

Glass Plate

Enamel Tray

Trowel



# SETTING TIME OF PORTLAND CEMENT

## INITIAL PREPARATION

1

Consistency test to be done before starting the test procedure to find out the water required to give the paste normal consistency (P).

2

Take 400 g of cement and prepare a neat cement paste with 0.85P of water by weight of cement.

3

Gauge time is kept between 3 to 5 minutes. Start the stop watch at the instant when the water is added to the cement. Record this time ( $T_1$ ).

4

Fill the Vicat mold, resting on a glass plate, with the cement paste gauged as above. Fill the mold completely and smooth off the surface of the paste making it level with the top of the mold. The cement block thus prepared is called test block.

# SETTING TIME OF PORTLAND CEMENT

## TEST FOR INITIAL SETTING TIME

1

Place the test block confined in the mold and resting on the non-porous plate, under the rod bearing the needle.

2

Lower the needle gently until it comes in contact with the surface of test block and quick release, allowing it to penetrate into the test block.

3

In the beginning the needle completely pierces the test block. Repeat this procedure i.e. quickly releasing the needle after every 2 minutes till the needle fails to pierce the block for about 5 mm measured from the bottom of the mold. Note this time ( $T_2$ )

# SETTING TIME OF PORTLAND CEMENT

## TEST FOR FINAL SETTING TIME

1

For determining the final setting time, replace the needle of the Vicat's apparatus by the needle with an annular attachment.

2

The cement is considered finally set when upon applying the final setting needle gently to the surface of the test block; the needle makes an impression thereon, while the attachment fails to do so. Record this time ( $T_3$ ).

# SETTING TIME OF PORTLAND CEMENT

## CALCULATIONS:

$$\text{Initial Setting Time} = T_2 - T_1$$

$$\text{Final Setting Time} = T_3 - T_1$$

Where:

$T_1$  = time at which water is first added to cement

$T_2$  = time when needle fails to penetrate 5mm to 7mm from bottom of the mold

$T_3$  = time when needle makes an impression but the attachment fails to do so

# SETTING TIME FOR DIFFERENT CEMENT

Cement Type	Initial Setting Time, min (min.)	Final Setting Time, min (max.)
OPC(33)	30	600
OPC(43)	30	600
OPC(53)	30	600
SRC	30	600
PPC	30	600
RHPC	30	600
PSC	30	600
High alumina	30	600
Super sulphated	30	600
Low heat	60	600
Masonry cement	90	1440
IRS-T-40	60	600



# TESTING THE TENSILE STRENGTH OF STEEL BARS

## LESSON 11



# TESTING THE TENSILE STRENGTH OF STEEL BARS

## REINFORCING BARS (REBAR)

- Used in concrete construction to enhance tensile strength, complementing concrete's excellent compressive properties.
- Also helps maintain structural integrity as concrete cracks from expansion and contraction cycles.

## DIMENSIONS OF REINFORCING BAR

- Steel bars should be made straight and ends should be plain surface perpendicular to the longitudinal axis before measuring weight and length.

## DIMENSIONS OF REINFORCING BAR

- Length should be sufficient (provided it does not exceed the capacity of balance) for rods of large diameter for better result.

FORMULA:

FORMULA:

$$\text{Average bar diameter (mm)} = 12.736 \left( \frac{W}{L} \right)$$

Where:

$W = \text{weight (gm)}$

$L = \text{length (mm)}$

# DIMENSIONS OF STANDARD REINFORCING BARS

Nominal Diameter		Actual Diameter		Cross Sectional Area		Perimeter		Mass / Unit-Length	
mm	(in)	mm	(in)	mm <sup>2</sup>	(in <sup>2</sup> )	mm	(in)	kg/m	(lb/ft)
6	( <sup>1</sup> / <sub>4</sub> )	6.350	(0.250)	32.26	(0.05)	20.07	(0.79)	0.248	(0.167)
10	( <sup>3</sup> / <sub>8</sub> )	9.525	(0.375)	70.79	(0.11)	29.97	(1.18)	0.560	(0.376)
12	( <sup>1</sup> / <sub>2</sub> )	12.700	(0.500)	129.03	(0.20)	39.88	(1.57)	0.994	(0.668)
16	( <sup>5</sup> / <sub>8</sub> )	15.875	(0.625)	200.00	(0.31)	49.78	(1.96)	1.552	(1.043)
19	( <sup>3</sup> / <sub>4</sub> )	19.050	(0.750)	283.87	(0.44)	59.94	(2.36)	2.235	(1.502)
22	( <sup>7</sup> / <sub>8</sub> )	22.225	(0.875)	387.10	(0.60)	69.85	(2.75)	3.042	(2.044)
25	(1)	25.400	(1.000)	509.68	(0.79)	79.76	(3.14)	3.973	(2.670)
29	(1 <sup>1</sup> / <sub>3</sub> )	28.575	(1.128)	645.16	(1.00)	89.92	(3.54)	5.059	(3.400)
32	(1 <sup>1</sup> / <sub>4</sub> )	32.260	(1.270)	819.35	(1.27)	101.35	(3.99)	6.403	(4.303)

# TESTING THE TENSILE STRENGTH OF STEEL BARS

## TENSILE REQUIREMENTS

1. The material, as represented by the test specimens, shall conform to the requirements for tensile properties prescribed in Table 11.1.4 (metric) and in Table 11.1.5 (FPS).
2. The percentage of elongation shall be as prescribed in Table 11.1.4

**Table 11.1.4** Tensile requirements as per ASTM A 615-M (Metric Units)

Parameter	Requirements	
	Grade 300	Grade 400
Tensile Strength (minimum), Mpa	500	600
Yield Strength (minimum), Mpa	300	400
Elongation (minimum) in 200 mm gauge, %, for the bar size of:		
#10	11	9
#15	12	9
#20	-	8
#25	-	7
#30	-	7
#35	-	7
#45	-	-
#55	-	-

Note. Grade 300 bars are furnished only in sizes 10 through 20.

**Table 11.1.5** Tensile requirements as per ASTM A 615-M (FPS Units)

Parameter	Requirements		
	Grade 40	Grade 60	Grade 75
Tensile Strength (minimum), psi	70,000	90,000	100,000
Yield Strength (minimum), psi	40,000	60,000	75,000
Elongation (minimum) in 8 inch gauge, %, for the bar size of:			
#3	11	9	-
#4, 5, 6	12	9	-
#7, 8	-	8	-
#9, 10	-	7	-
#11, 14, 18	-	7	6

Note. Grade 40 bars are furnished only in sizes 3 through 6.

Grade 75 bars are furnished only in sizes 11, 14 and 18.

# TESTING THE TENSILE STRENGTH OF STEEL BARS

## PERMISSIBLE VARIATION IN MASS

- Reinforcing bars are evaluated on the basis of nominal mass. In no case shall the overpass of any bar be the cause for rejection.
- Permissible variation shall not exceed 6% under nominal mass.

## FINISH

1. The bars shall be free of detrimental surface imperfections.

## FINISH (CONTINUATION)

2. Rust, seams, surface irregularities, or mill scale shall not be cause for rejection, provided the mass, dimensions, cross-sectional area, and tensile properties of a hand wire brushed test specimen are not less than the requirements of this specification.
3. Surface imperfections other than those specified above shall be considered detrimental when specimens containing such imperfections fail to conform to either tensile or bending requirements.

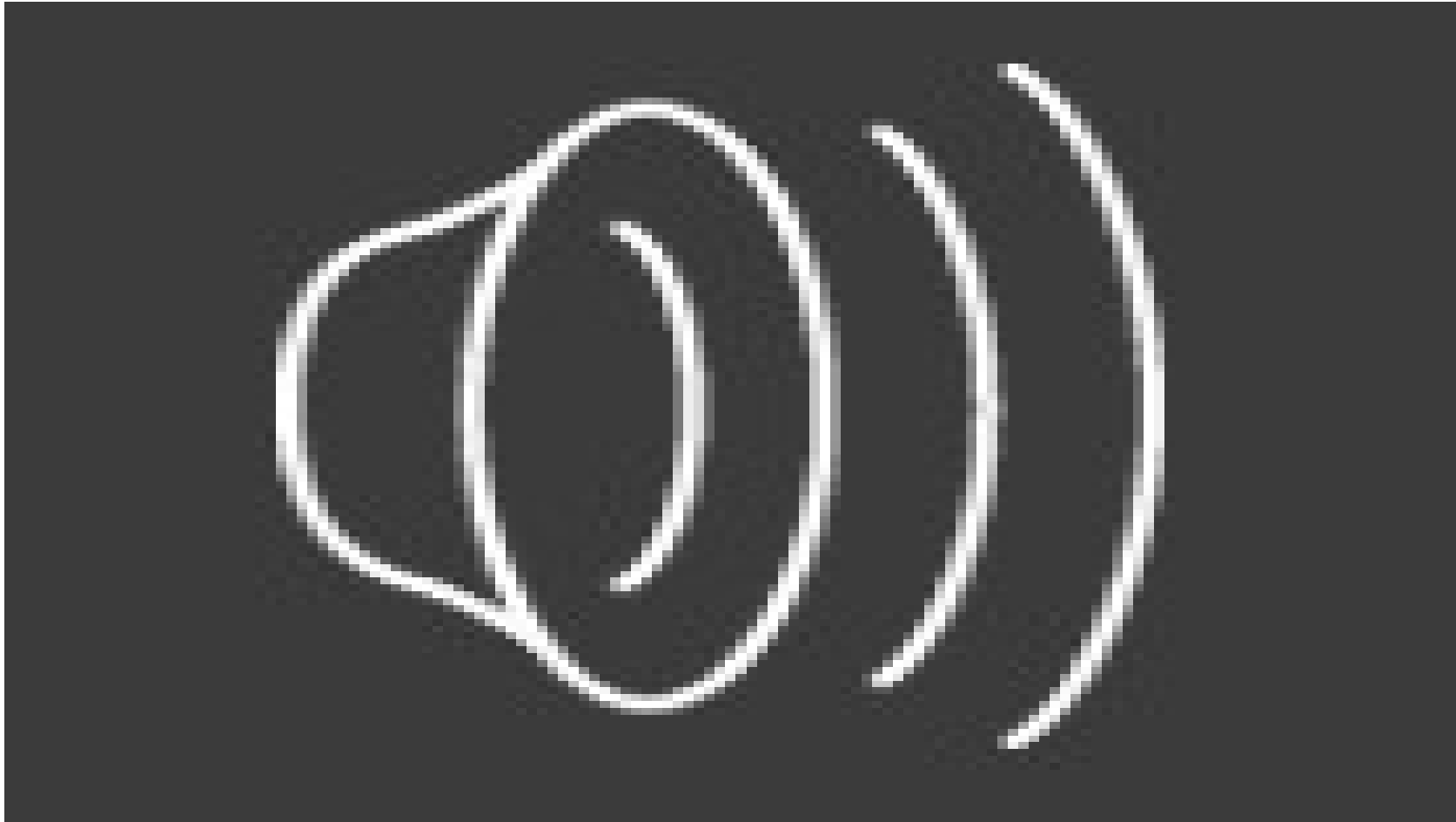
# TESTING THE TENSILE STRENGTH OF STEEL BARS

## TEST SPECIMENS

1. For round reinforcing bars, full size test specimens should be used. The total length of the specimen shall be at least equal to the gauge length plus the length required for the full use of the grips employed. The test specimen must be straight.
2. Orientation of test specimen for longitudinal test : The lengthwise axis of the specimen should be parallel to the direction of the greatest extension of the steel during rolling or forging. The stress applied to a longitudinal tension test specimen is in the direction of greatest extension. The unit stress determination shall be based on the nominal bar cross-sectional area.

## NUMBER OF TESTS

- For bar size no. 10 to 35, inclusive, one tension test and one bend test shall be made of the largest size rolled from each batch. If however, material from one batch differs by three or more designation numbers, one tension and one bend test shall be made from both the highest and lowest designation number of the deformed bars rolled.
- For bar sizes nos. 45 and 55, one tension test and one bend test shall be made of each size rolled from each batch.



## TESTING THE TENSILE STRENGTH OF STEEL BARS



# FIELD TESTS OF CONSTRUCTION MATERIALS

## LESSON 12



# FIELD TESTS OF CONSTRUCTION MATERIALS

## **SIMPLE FIELD TESTING OF CONSTRUCTION MATERIALS:**

1. Test for Organic Impurities in Fine Aggregate
2. Test for Silt Content of Fine Aggregate
3. t for Moisture Content of Concrete Aggregate
4. Test for Bulking of Sand
5. Test for Specific Gravity of Aggregate
6. Test For Bulk Density of Aggregate
7. Determination of Weight Per Cubic Meter and Air Content of Freshly Mixed Concrete

# 1. TEST FOR ORGANIC IMPURITIES IN FINE AGGREGATE

- The aggregate must be checked for organic impurities such as decayed vegetations, humus, and coal dust, etc. Color test is a reliable indicator of the presence of harmful organic matter in aggregates except in areas where there are deposits of lignite.

## PROCEDURE :

1. Fill a 350 ml clear glass medicine bottle up to 75 ml mark with a 3% solution of caustic soda or sodium hydroxide.

A 3% solution of caustic soda is made by dissolving 3 gm of sodium hydroxide (which can be purchased from any local laboratory chemicals shop) in 100 ml of clean water (preferably distilled water). The solution should be kept in glass bottle tightly closed with a rubber stopper. Handling sodium hydroxide with moist hands may result in serious burns. Care should be taken not to spill the solution for it is highly injurious to clothing, leather and other materials.

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# 1. TEST FOR ORGANIC IMPURITIES IN FINE AGGREGATE

2. The representative sands sample is next added gradually until the volume measured by the sandy layer is 125 ml. The volume is then made up to 200 ml by the addition of more of the solution. The bottle is then corked and shaken vigorously and allowed to stand for 24 hours.
3. At the end of this period, the color of the liquid will indicate whether the sand contains a dangerous amount of matter or not. A colorless liquid indicates clean sand free from organic matter. A straw-colored solution indicates some organic matter but not enough to be seriously objectionable. Darker color means that the sand contains injurious amounts and should not be used unless it is washed and a retest then shows that it is satisfactory.

## 2. TEST FOR SILT CONTENT OF FINE AGGREGATE

- If the aggregates are coated with dirt, silt or clay, it will result in a poor concrete because the dirt will prevent the cement from setting and also weaken the bond between the aggregates and the cement paste. So it is important to use clean aggregate for concrete.
- Further owing to their fineness and therefore large surface area, increases the amount of water necessary to wet all the particulars in the mix, this also resulted more shrinkage of concrete. As determine with the given field test, the **sand shall not contain more than 8% of silt.**

### PROCEDURE :

1. Fill a measuring cylinder with a representative sand (fine aggregate) sample up to 100 ml mark and add clean water up to 150 ml. To perform this test, more correctly better dissolve a little salt in the water (1 tea spoonful to 250 ml is the right proportion).

## 2. TEST FOR SILT CONTENT OF FINE AGGREGATE

2. Shake the sample vigorously for one minute and the last few shakes being in a side wise direction to level of the sand.
3. Allow the cylinder to stand for three hours during which time any silt present will settle in a layer on the top of the sand and its thickness can be read off on the cylinder itself. The sand shall not contain more than 8% of silt.

***NOTE : In performing this test the sand sample should not dry. Glass measuring cylinder capacity should be 200 ml.***

### 3. TEST FOR MOISTURE CONTENT OF CONCRETE AGGREGATE

- Various stages in which the aggregate may exist are (a) over dry (b) air dry (c) saturated surface dry (d) damp or moist.
- On the construction site, the sand (fine aggregate) usually carries some free moisture. Total internal moisture content of an aggregate in the saturated surface dry condition may be termed as “Absorption capacity” although it is sometimes referred to simply as the absorption.
- The amount of water required to bring an aggregate from the air dry condition to the saturated surface dry condition is termed as “effective absorption”.
- The absorption is determined by finding the weight of a surface dried sample after it has been soaked for 24 hours and again finding the weight after the sample has been dried. the difference in weights, expressed as a percentage of

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# 3. TEST FOR MOISTURE CONTENT OF CONCRETE AGGREGATE

## PROCEDURE :

1. Take about one kg of representative sample of sand (fine aggregate) in a suitable size tray. Fully immerse this sand sample in clean water for 24 hours.
2. After 24 hours of immersion take about 500 gm of representative wet sand sample. Dry this sand in saturated surface dry (SSD) condition either in air or heating in a fry pan. Take the weight (A) of SSD sand sample in fry pan and dry it fully in gentle heat. After drying take its weight (weight B).
3. Take about 500 gm representative site sand sample. Take its weight (weight C) and fully dry it in a fry pan. Take the dry weight (weight D).

# 3. TEST FOR MOISTURE CONTENT OF CONCRETE AGGREGATE

## CALCULATIONS ::

### 1. WATER ABSORPTION

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

### 2. TOTAL MOISTURE IN SITE SAND

$$\text{Total moisture in site sand (\%)} = \frac{C-D}{D \times 100}$$

### 3. SURFACE MOISTURE IN SITE SAND

### 3. SURFACE MOISTURE IN SITE SAND

$$\text{Surface moisture in site sand (\%)} = \text{Total moisture in site sand} - \text{Absorption of site sand}$$

# 3. TEST FOR MOISTURE CONTENT OF CONCRETE AGGREGATE

## CALCULATIONS (CONTINUATION) :

- If the result is in negative, it means the sample does not contain any surface moisture and in it balance absorbed water is to be added to make the site sand in SSD condition.

## **NOTE :**

- For obtaining the SSD condition of sand, it should be gently heated in a fry pan, mean while stirring with a glass rod until the surface moisture disappears. This is apparent when the sand loses its shining wet appearance and becomes dull, or when it just attains a free running condition. The end point of aggregate SSD condition could be found by practice. If the sand is heated beyond the SSD condition some of the absorbed moisture will also dry and then the SSD weight of aggregate will not be correct, and the obtained absorption result will not be correct.

## 4. TEST FOR BULKING OF SAND

- Dry and fully saturated sand does not bulk. As the sand becomes finer the bulking of the sand increases. The bulking of sand is caused by the film of moisture which tends to keep the particles of sand apart.

### PROCEDURE :

#### ➤ METHOD 1

- Put sufficient quantity of site sand loosely into a suitable container until it is about two-third full. Level off the top of the sand and push a steel rule vertically down through the sand at the middle to bottom, measure the height. Suppose this is `x` cm.

- Empty the sand out of the container into another container where none of it is lost. Half fill the first container with clean water. Put back about half the sand and rod it with a steel rod, about 6 mm in diameter, so that its volume is reduced to a minimum. Then add the remainder sand and level the top surface of the fully saturated sand. Measure its depth at the middle with the steel rule suppose this is `y` cm. Measure its depth at the middle with the steel rule suppose this is `y` cm.

### FORMULA:

$$\text{Percentage Bulking} = \frac{x}{y-1} (100)$$

## 4. TEST FOR BULKING OF SAND

### PROCEDURE (CONTINUATION) :

#### ➤ METHOD 2

- ☞ In a 250 ml measuring cylinder, pour the damp site sand, consolidate it by striking until it reaches the 200 ml mark.
- ☞ Then fill the cylinder with the clean water and stir the same well (the water shall be sufficient to submerge the sand completely), it will be seen that the sand surface is now below its original level. Suppose the surface is at the mark of  $y$  ml, the percentage of bulking of sand due to moisture shall be calculated from the formula.

FORMULA :

FORMULA :

$$\text{Percentage Bulking} = \frac{200}{y-1} (100)$$

# 5. TEST FOR SPECIFIC GRAVITY OF AGGREGATE

- The specific gravity of a substance is the ratio of the unit weight of the substance to the unit weight of water. A representative aggregate sample in SSD condition is obtained by quartering and the following weights are used in the tests for the various sizes of aggregates.
  - Less than 4.75 mm : 500 to 700 gm
  - 4.75 mm to 10 mm : 1000 to 1500 gm
  - 10 mm to 20 mm : 1500 to 2000 gm
  - 20 mm to 40 mm : more than 2000 gm

# 5. TEST FOR SPECIFIC GRAVITY OF AGGREGATE

## PROCEDURE :

1. Take a suitable size jar, the top open side of which have flange, so that a glass plate may be put on it.  
The jar should be filled with clean water upto the flange and slide on it the glass plate. If there is any air bubble, wipe it off. Take the weight of jar fully filled of glass plate, then the jar should be filled with more water. There should not be any air bubble. Take the weight of jar fully filled with water and upon it glass plate (weight A).
2. Take a suitable size jar, the top open side of which have flange, so that a glass plate may be put on it.  
The jar should be filled with clean water upto the flange and slide on it the glass plate. If there is any air bubble, wipe it off. Take the weight of jar fully filled of glass plate, then the jar should be filled with more water. There should not be any air bubble. Take the weight of jar fully filled with water and upon it glass plate (weight A).
3. About half empty the jar fill it with known weight of SSD aggregate sample weight (B). As mentioned at b, fill the jar up to the top and put glass plate on it. There should not be any air bubble. Take its weight (weight C).  
About half empty the jar fill it with known weight of SSD aggregate sample weight (B). As mentioned at b, fill the jar up to the top and put glass plate on it. There should not be any air bubble. Take its weight (weight C).

FORMULA: Specific gravity on SSD basis =  $\frac{B}{B-(C-A)}$

FORMULA:

## 6. TEST FOR BULK DENSITY OF AGGREGATE

- Bulk density is the weight of a unit volume of aggregate, usually stated in kg per liter on room dry basis in estimating quantities of materials and in mix computation, when batching is done on a volumetric basis.
- Concrete material proportion by weight can be converted to proportions by volume, by dividing with the bulk density of the materials available for use at site. The bulk density of cement may be taken 1.44 kg/lit.
- For determination of bulk density the container size shall be as given below:

<i>Size of particle</i>	<i>Nominal capacity (litres)</i>	<i>Inside dia (mm)</i>	<i>Inside height (mm)</i>	<i>Thickness of metal (min) (mm)</i>
4.75 mm and under	3	150	170	3.15
Over 4.75 mm to 40 mm	15	250	300	4.00
Over 40 mm	30	350	310	5.00

# 6. TEST FOR BULK DENSITY OF AGGREGATE

## PROCEDURE :

1. About 100 kg of aggregate sample should be dried in the room.
2. Take the weight in kg of empty container + glass plate (Weight A).
3. The container is to be filled with loose sand or loose aggregate i.e. sand or aggregate should be dropped in the container from about 5 cm height from top of container. Take the weight of container filled with sand or aggregate + glass plate (Weight B).

4. Empty the container filled with clean water up to water up to the top ridge. Then put the glass plate. There should not be any voids. Take the weight (Weight C). All weight should be taken in kg.

\* Loose bulk density in kg/lit on the basis

\* Loose bulk density in kg/lit on the basis

$$\text{Off room dry sand or aggregate} = \frac{B - A}{C - A}$$

$$\text{void percentage} = \frac{\text{Specific gravity} - \text{Bulk density}}{\text{Specific gravity}} (100)$$

## 7. DETERMINATION OF WEIGHT PER CUBIC METRE AND AIR CONTENT OF FRESHLY MIXED CONCRETE

- The measure shall be calibrated by determining the weight of water at room temperature required to fill it so that no meniscus is present above the rim.
- Accurate filling of the measure may be secured by the use of a glass cover plate. The capacity of the measure in cubic meters shall then be obtained by dividing the weight of water (in gms) required to fill the measure by the unit weight of water, 1000 g/l.

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DIMENSIONLA REQUIREMENTS FOR CYLINDRICAL MEASURES				
<i>Nominal size of coarse Aggregate</i>	<i>Nominal capacity</i>	<i>Inside Dia</i>	<i>Inside height</i>	<i>Minimum Thickness of metal</i>
<i>mm</i>	<i>Cu.m</i>	<i>Mm</i>	<i>mm</i>	<i>mm</i>
Upto 38	0.01	250	280	4
Over 38	0.02	350	285	5.5

## 7. DETERMINATION OF WEIGHT PER CUBIC METRE AND AIR CONTENT OF FRESHLY MIXED CONCRETE

### PROCEDURE :

- **DETERMINATION OF DENSITY.** The measure shall be filled with concrete as soon as practicable after mixing. The representative sample of concrete shall be filled into the measure in layers approximately 5 cm deep and each layer shall be compacted by 38 cm long steel bar which shall have a ramming face of 2.5 x 2.5 cm square. The number of strokes per layer required to produce the specified condition will vary according to the type of concrete, but in no case shall the concrete be subjected to less than 60 strokes per layer for the 0.01 m<sup>3</sup> measure or 120 strokes per layer for the 0.02 m<sup>3</sup> measure.
- The exterior surface of the cylinder shall be tapped smartly 5 to 10 times or until no large bubbles of air appear on the surface of the compacted layer.
- After consolidation of the concrete, the top surface shall be struck-off and finished smoothly with a flat cover plate using great care to leave the measure just level full. All excess concrete shall then be cleaned from the exterior and the filled measure weighted.

## 7. DETERMINATION OF WEIGHT PER CUBIC METRE AND AIR CONTENT OF FRESHLY MIXED CONCRETE

### CALCULATIONS: :

1. **WEIGHT PER CUBIC METRE.** The weight per cubic meter of concrete shall be calculated by dividing the weight of fully compacted concrete in the measure by the capacity of measure as determined above, and shall be recorded in kg/m<sup>3</sup>.

### 2. AIR CONTENT

### 2. AIR CONTENT

FORMULA:

$$A = \frac{V - V_A}{T} (100) \quad \text{or} \quad A = \frac{V - V_A}{V} (100)$$

or

Where:

A = Air content (percent of voids) in the concrete

W = Weight of concrete produced per batch in m<sup>3</sup>

T = Theoretical weight of the concrete, in kg/m<sup>3</sup>,

computed on an air free basis

V<sub>A</sub> = Total absolute volume of the component ingredients in the batch, in cubic meter

## 7. DETERMINATION OF WEIGHT PER CUBIC METRE AND AIR CONTENT OF FRESHLY MIXED CONCRETE

### CALCULATIONS (CONTINUATION):

**NOTE:** The determination of the theoretical weight per cubic meter ( $T$ ) should be carried out whose value is assumed to be constant for all batches made using identical component ingredients and proportions. It is calculated from the formula:

$$T = \frac{W}{V_A}$$

where:

$T$  = Theoretical weight of concrete in  $\text{kg/m}^3$  computed on an air free basis

$T$  = Theoretical weight of concrete in  $\text{kg/m}^3$  computed on an air free basis

$W_i$  = Total weight in kg of the component ingredient in the batch, and

$W_i$  = Total weight in kg of the component ingredient in the batch, and

$V_A$  = Total absolute volume of the component ingredients in the batch in  $\text{m}^3$

- The absolute volume of each ingredient is equal to the weight of that ingredient divided by its specific gravity. For the aggregate components, the bulk specific gravity and weight should be based on the saturated surface dry condition.
- For the cement, a value of 3.15 may be used unless the actual specific gravity is determined by a recognized inert liquid method.

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