EXPERIMENT NO.- 6

a) Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 50-mm) Cube Specimens).
   - **ASTM C109**

b) Standard Test Method for Direct Tensile Strength of Cement

6 (a) Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 50-mm) Cube Specimens). - **ASTM C109**

INTRODUCTION

- The mechanical strength of hardened cement is the property of this material which is, perhaps, the most important one for its structural use.
- Tests for strengths are not made on a neat cement paste because of difficulties in moulding and testing with consequent large variations in results.
- The strength of cement is usually determined from tests on mortars.

INTRODUCTION CONT'D

- Several tests are performed to determine the tensile, compressive and shear strength of cement mortar of a certain proportion.
- This test method covers determination of the compressive strength of hydraulic cement mortars, using 2-in or 50-mm cube specimens.

The standard requirements of minimum compressive strength as per ASTM C150 for Ordinary Portland Cement (Type I) are as follows:

Table 7.1: Minimum Compressive Strength of OPC

*Age (*Days)	*Minimum Compressive Strength* , psi (MPa)
3	1740 (12)
7	2760 (19)
28	**4060 (28)**

MECHANICAL AND PHYSICAL REQUIREMENTS

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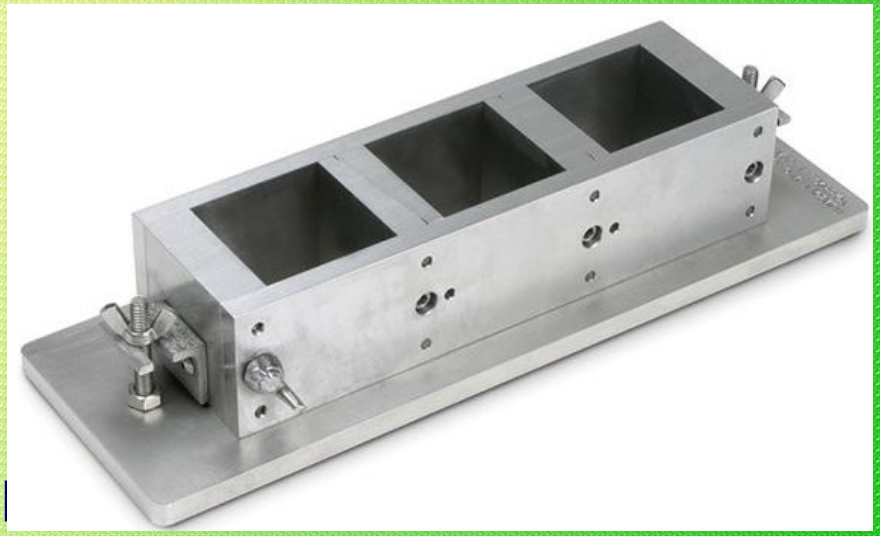
Table 2 — Mechanical and physical requirements given as characteristic values

Strength class	Compressive strength MPa				Initial setting time	Sound-ness (expan-sion)
	Early strength		Standard strength			
	2 days	7 days	28 days		min	mm
32,5 N	–	≥ 16,0	≥ 32,5	≤ 52,5	≥ 75	≤ 10
32,5 R	≥ 10,0	–				
42,5 N	≥ 10,0	–	≥ 42,5	≤ 62,5	≥ 60	
42,5 R	≥ 20,0	–				
52,5 N	≥ 20,0	–	≥ 52,5	–	≥ 45	
52,5 R	≥ 30,0	–				

APPARATUS

- **Balance:** Sensitive to 0.1 gm
- **Graduated measuring jar:** 25-ml capacity
- **Cube molds:** Two sets of 2- in with base plates
- **Mixing pans**
- **Tamper wood**
- **Trowels**
- **Compression Testing**



MATERIALS

The sand used for making test specimens shall be natural silica sand conforming to the requirements for graded standard sand (Natural silica sand conforming **ASTM C778**) in the following specifications:

Table 7.2: Grading of Sand

Sieve	*Accumulative % Retained*	*% Retained*
No. 16	None	0
No. 30	2±2	25
No. 40	30±5	-
No. 50	75±5	50
No. 100	98±2	25

CONDITIONING

- The temperature of the air in the vicinity of the mixing slab, the dry materials, molds, base plates, and mixing bowl, shall be maintained between 20 and 26^{0}C.
- The temperature of the mixing water, moist closet or moist room, and water in the storage tank shall be set at 23^{0}C and shall not vary from this temperature by more than ±2^{0}C.
- The relative humidity of the laboratory shall be not less than 50%.
- The moist room shall be so constructed as to provide storage facilities for test specimens at a relative humidity of not less than 95%.

PROCEDURE

Composition of Mortar

- The proportions of cement to sand is 1:2.75 by weight.
- Water–cement ratio of 0.485 for all Portland Cements
- The quantities of materials to be mixed at one time in the batch of mortar for making six and nine test specimens shall be as follows:

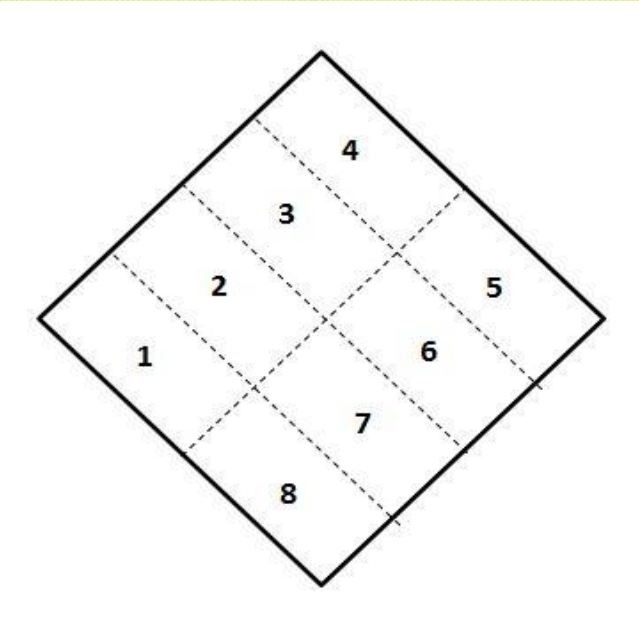
Table 7.3: Composition of Mortars

		Number of Specimens	
		6	**9**
Cement, gm		500	740
Sand, gm		1375	2035
Water, ml	Portland (0.485)	242	359
	Air-entraining (0.46)	230	354

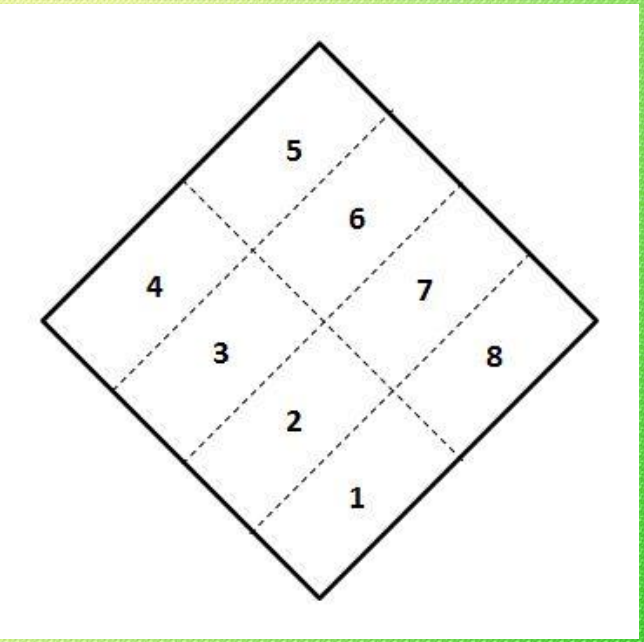
Preparation of Mortar

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

Molding Test Specimens



Rounds 1 and 3



Rounds 2 and 4

Figure 7.1Order of tamping in Molding of test specimens

Molding Test Specimens (Contd..)

- Place a layer of mortar about 1 in (25mm) (approximately one half of the depth of the mold) in all of the cube compartments.
- Tamp the mortar in each cube compartment 32 times in about 10 sec in 4 rounds, each round to be at right angles to the other and consisting of eight adjoining stokes over the surface of the specimen, as illustrated in figure 7.1.
- The tamping pressure shall be just sufficient to ensure uniform, filling of the molds.
- The 4 rounds of tamping (32 strokes) of the mortar shall be completed in one cube before going to the next.
- When the tamping of the first layer in all of the cube compartments is completed, fill the compartments with the remaining mortar and then tamp as specified for the first layer.
- During tamping of the second layer, bring in the mortar forced out on to the tops of the molds after each round of tamping by means of gloved fingers and the tamper upon completion of each round and before starting the next round of tamping.

Molding Test Specimens (Contd..)

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

Storage of Test Specimens

- Immediately upon completion of molding, place the test specimens in the moist closet or moist room.
- Keep all the test specimens, immediately after molding, in the molds on the base plates in the moist closet or moist room from 20 to 24 hours with their upper surfaces exposed to the moist air but protected from crippling water.
- If the specimens are removed from the mold before 24 hours, keep them on shelves of the moist closet or moist room until they are 24 hours old, and then immerse the specimens, except those for the 24 hours test, in saturated lime water in storage tanks constructed of non-corroding materials.
- Keep the storage water clean by changing as required.

Determination of Compressive strength

- Test the specimens immediately after their removal from the moist closet in the case of 24 hours specimen, and from storage water in the case of all other specimens.
- All the test specimens form a given test age should be broken under compressive force within the permissible time tolerance prescribed in table 7.4.
- If more than one specimen at a time is removed from the moist closet for the 24 hours tests, keep those specimens covered with a damp cloth until the time of testing.
- If more than one specimen at a time is removed from the storage water for testing, keep these specimens in water at a temperature of 23±2^{0}C and of sufficient depth to completely immerse each specimen until the time of testing.

Determination of Compressive strength (Contd..)

- Wipe each specimen to a surface-dry condition; remove any loose sand grains or incrustations from the faces that will be in contact with the bearing blocks of the testing machine.
- Check these faces by applying a straightedge. If there is appreciable curvature, grind the face or faces to plane surfaces or discard the specimen.
- A periodic check of the cross –sectional area of the specimens should be made.

Table 7.4 Permissible Time Tolerance

Test Age	Permissible Tolerance
24 hours	±0.5 hours
3 days	±1 hours
7 days	±3 hours
28 days	±12 hours

Determination of Compressive strength (Contd..)

- Apply the load to specimen faces that were in contact with the true plane surfaces of the mold.
- Carefully place the specimen in the testing machine below the center of the upper bearing block.
- Prior to the testing of each cube, it shall be ascertained that the spherically seated block is free to tilt.
- Use no cushioning or bedding materials.
- An initial loading up to one half of the expected maximum loads for specimens having expected maximum loads of more than 3000 lbf (13.3 kN) may be applied at any convenient rate.
- Apply no initial loading to specimens having expected maximum loads of less than 3000 lbf (13.3 kN).
- Adjust the rate of load application so that the remainder of the load (or the entire load in case of expected maximum loads of less than 3000 lbf (13.3 kN) is applied, without interruption, to failure at such a rate that the maximum load will be reached in neither in less than 20 sec nor in more than 80 sec from the start of loading.
- Make no adjustment in the controls of the testing machine while a specimen is yielding prior to failure.

CALCULATION

- Record the total maximum load indicated by the testing machine and calculate the compressive strength in pounds per square inch (or Pascal).
- If the cross-sectional area of a specimen varies more than 1.5% from the nominal, use the actual area for the calculation of compressive strength.
- Draw the strength vs. age curve on the plain graph paper.
- Report the result to the nearest 10 psi (70 kPa)

QUESTIONS??

- Compare your results with standard strength requirement of ordinary Portland cement as specified by ASTM. If you observed any deviation from the standard requirement, discuss different factors that might be responsible for this.
- What is the range of temperature for curing water?
- How the load is to be applied in the test?

SAMPLE GRAPH

SAMPLE DATA SHEET

Age (days)	Specimen No.	Crushing Load	Specimen Area	Compressive Strength, MPa	Average Compressive Strength, MPa
03					
07					
28					

REPORT

The Report shall include the following information:

- Type of Cement (e.g. OPC, CEM I)
- Brand name of Cement
- Report 3, 7 and 28 days average Compressive strength in **MPa** up to one decimal point

5 (b) Standard Test Method for Direct Tensile Strength of Cement

INTRODUCTION

- Cement mortar of concrete gives a compressive strength of about **ten times** its tensile strength.
- Sand should be passing of #16 sieve and retained on #30 sieve.

APPARATUS

1. Briquette Mould

APPARATUS

2. Briquette Testing Machine

PROCEDURE

1. Place 300 gm cement on top of 900 gm saturated surface dry sand in a mixing pan to mold 6 briquettes of mortar. (Cement : Sand = 1:3)
2. Mix Cement and aggregate thoroughly and form a crater in the center. Then the measured and add amount of water to this crater using a water cement ratio from Note-1 by weight

Note-1:

Percentage of water to cement, $y = \left[\frac{2}{3}\frac{P}{n+1} + 6.5\right](1+n)$

n = parts of sand to 1 part of cement = 3

P = normal consistency in percentage

PROCEDURE CONT'D

3. Turn the materials at the outer edge into the crater within 30 second and complete the mixing with vigorous and continuous turning and mixing about 2 minutes.

4. Immediately after mixing, fill the briquette molds heaping full without compaction. The molds are to be kept on a metal base plate. Press the mortar firmly using both thumbs simultaneously and applying a moderate pressure on the whole surface.

Note-2:

Natural silica sand from Ottawa, using finer than, sieve # 20 and coarser than sieve #30

PROCEDURE CONT'D

5. Place additional mortar on the surface if required and after repeating step 4 smooth off the top surface with a trowel. The trowel should be the lightly drawn off the surface.

6. Place an oiled base plate on top to cover all the molds and turn the whole thing over. Repeat step 4 and 5.

7. During the final finishing of the briquettes take care that their thickness is exactly equal to the 1-inch depth of the molds.

PROCEDURE CONT'D

8. Mark the specimens giving group number and date and keep them underwater after about 24 hours.

9. Test two sets of specimens (3 in each set) at the age of 7 and 28 days (or as instructed) in a briquette testing machine. Measure the width and thickness of each specimen at the middle to the nearest 0.01 inch before testing.

Note-3:

Rate of loading 600 ± 25 pound/minute. The strength is expressed in pounds per square inch (psi) in round figure.

CALCULATION

- Record the total maximum load indicated by the testing machine and calculate the compressive strength in pounds per square inch (or Pascal).
- Report the result in round figure.

QUESTIONS?

- What are the other methods of determining the tensile strength of cement mortar?

REPORT

The Report shall include the following information:

- Type of Cement (e.g. OPC, CEM I)
- Brand name of Cement
- Report tensile strength of cement in psi round figure