CONCRETE TECHNOLOGY LABORATORY

DEPARTMENT OF CIVIL ENGINEERING
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Tested by ..... ID No. .....
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TEST No. C-3

PROPERTIES OF HYDRAULIC CEMENT MORTAR AND EFFECTS OF CHEMICAL ADMIXTURE

Part A Flow Test of Hydraulic Cement Mortar

Objective — To determine the relative workability as indicated by flow value of mortar with and without chemical admixture.

Materials — Cement, sand and chemical admixture to produce the required cement mortar.

References — TIS (Thai Industrial Standard) 15 Part 19
ASTM Designation : C 109, C 185, C 230
JIS (Japan Industrial Standard) R 5201

Apparatus
(1) Flow table
(2) Flow cone
(3) Tamping rod
(4) Trowel

Procedures

1. Mixing of Cement Mortar[1]

1.1 By Mechanical Mixer

a) Fix the mixing bowl and paddle at mixing position and pour specified quantity of water.

b) Start the mixer with low speed (approximately 140 ± 5 rpm) and put the specified amount of cement in 30 sec while rotating the paddle.

c) Put the specified amount of sand in the next 30 sec while continuing mixing. After subsequent mixing for 60 sec, pause for 20 sec. Scrape off the adhered mortar to the mixing bowl and paddle using a spoon while in the pause. Further mix the mortar by spoon in such a manner to scrape the mortar upwards from the bottom of the mixing bowl.

d) After completion of the pause, start mixer again and continue mixing for 2 min at medium speed (approximately 285 ± 10 rpm). After the mixing has finished, remove the mixing bowl from the mixer.

1.2 By Hand Mixing

a) Put the specified quantities of cement and sand upon a smooth nonabsorbent surface and mix thoroughly with spoon or trowel for 2 min.

b) Form a crater in the center and pour the specified quantity of water in the crater. Use the trowel to turn the particles from the outside edge into the crater in 30 sec. Leave the sample to absorb the water for further 30 sec and mix thoroughly with spoon or trowel for another 3 min.

2. Flow Determination

a) Carefully wipe the flow table top clean and dry. Pack the mortar, which has been mixed either mechanically or manually, in two layers (each layer is about 25 mm in thickness) into the flow cone which has been placed at the center of the flow table.

b) Tamp each layer on all over its surface 20 times each[2], so that the end of the tamping rod can reach to the depth approximately 1/2 the depth of the layer.

c) Cut off the mortar to a plane surface, flush with the top of the mold by drawing the straight edge of a trowel with a sawing motion across the top of the mold.

d) Remove the cone correctly upwards, then impart 25 times[3]of falling motion in 15 sec. The flow is the resulting increase in average base diameter of the mortar mass, measured on at least four diameters at approximately equal spaced intervals, expressed as a percentage of the original base diameter.

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[1] Mixing by mechanical mixer is strongly recommended.

[2] 15 times is required for JIS

[3] 15 times is required for JIS

e) The mortar used in the flow test shall not be used neither in the strength test nor in the next trial of the flow test.

Part B Compressive Strength of Hydraulic Cement Mortar

Objective — To determine the compressive strength of hydraulic cement mortar with a certain mix proportion by the use of 2 in cube specimens.

Materials — Cement, standard sand and chemical admixture.

References — TIS (Thai Industrial Standard) 15 Part 12
ASTM Designation : C 109
BS (British Standard) 4550
JIS (Japan Industrial Standard) R 5201

Apparatus
(1) Balance
(2) Sieves
(3) Glass graduate
(4) 2 in (50 mm) cube molds
(5) Flow table and flow mold
(6) Tamper
(7) Trowel

Procedures

1. The sand used for making test specimens shall be natural silica sand graded as follows:

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

2. The proportions of materials for the standard mortar shall be one part of cement to 2.75 parts of graded standard sand by weight[4]. Use a water-cement ratio of 0.485 for all portland cement and 0.460 for all air-entraining portland cements[5].

[4] According to JIS, the standard mortar can be obtained by one part of cement to 2 parts of standard sand and w/c is 0.65.

[5] The amount of mixing water for other than portland and air-entraining portland cement shall be such as to produce a flow of 110 ± 5 as determined by the method explained in Part A.

3. Mix the test mortar with required composition with the mixing method described in Part A. The amount of mortar shall be sufficient not only for molding the test specimens but also for flow test.

4. Immediately determine the flow value according to the test method explained in Part A. Quickly scrape down into the batch the mortar that may have collected on the side of the bowl and then remix the entire batch at medium speed (285 ± 10 rpm) for 15 sec. Upon completion of mixing, the mixing paddle shall be shaken to remove excess mortar into the mixing bowl.

5. Start molding the specimens within a total elapsed time of not more than 2½ min. Place a layer of mortar about one half of the depth of the mold in all cube compartments. Tamp the mortar in each cube compartment 32 times in about 10 sec in 4 rounds. The tamping pressure shall be just sufficient to ensure uniform filling of the molds. The 4 rounds tamping shall be completed in one cube before going to the next.

6. When the tamping of the first layer in all cube compartments is completed, fill the compartments with the remaining mortar and then tamp as specified for the first layer. On completion of the tamping, the tops of all cubes should extend slightly above the tops of the molds. Then smooth off the cubes by trowel.

7. Keep all test specimens, immediately after molding, in the moist closet or moist room from 20 to 24 hr with their upper surfaces exposed to the moist air.

8. At the end of 24 hr, remove the specimens from the molds and immerse them in clean water in storage tanks. Keep the storage water clean by frequent changing.

9. Test the specimens, immediately after their removal from storage water and wipe dry as follows:

Number of specimens	Test age
3	3 days ± 1 hr.
3	7 days ± 3 hr.
3	28 days ± 12 hr.

Part C Tensile Strength of Hydraulic Cement Mortar

Objective — To determine the tensile strength of hydraulic cement mortar with a certain mix proportion by the use of briquet specimens.

Materials — Cement, standard sand and chemical admixture.

Reference — ASTM Designation : C 190
ASTM Specification : C 150

Apparatus
(1) Balance
(2) Sieves
(3) Glass graduate
(4) Briquet molds
(5) Flow table and flow mold
(6) Tamper
(7) Trowel

Significance and Use

1. Researchers in the field of hydraulic cement and concrete technology, have recognized the need for improved tensile strength. This method allows for the determination of tensile strength of a hydraulic cement mortar by casting and testing briquet specimens. It is recommended that the tester be familiar with this method in order to obtain the best possible accuracy.

2. The minimum tensile strength values which were stated limits in ASTM Specification : C 150 for portland cement are shown in the following Table. The user of this method may be interested in comparing research results with these values when briquet composed of 1 part of cement to 3 parts of standard sand have been made. These values may not be appropriate for comparison when different proportions or proportions involving other than standard sand have been used.

Curing condition	Cement type	
	ASTM Type I	ASTM Type III
1 day in moist air, psi (ksc)	NA.	275 (19.4)
1 day in moist air, 2 days in water, psi (ksc)	150 (10.6)	375 (26.4)
1 day in moist air, 6 days in water, psi (ksc)	275 (19.4)	NA.
1 day in moist air, 27 days in water, psi (ksc)	350 (24.7)	NA.

Procedures

1. The sand used for making test specimens shall be natural silica sand graded as follows:

Sieve	Accumulative % Retained
No.30	95 - 100
No.20	≤ 15
No.16	None

2. The proportions of materials for the standard mortar shall be one part of cement to 3 parts of graded standard sand by weight. The percentage of water used in this test shall depend upon the percentage of water required to produce a neat cement paste of normal consistency from the same sample of cement. The following formula shall be used to determine the amount of water.

$$w = \frac{2}{3}\left(\frac{P}{n+1}\right) + K$$

where w is water required for the sand mortar (%), P is water required for neat cement paste of normal consistency (%), n is number of parts of sand to one of cement by weight and K is a constant which for the standard sand has the value of 6.5.

3. Mix the mortar with appropriate water content with the method explained in Part A.

4. Before being filled, the molds shall be thinly covered with a film of mineral oil. Then fill the mold with heaping full mortar without compacting. Press the mortar firmly with thumbs applying the force 12 times at points to include the entire surface. The force applied is only

sufficient to fill all the corners of the mold. Heap the mold again with mortar and smooth it off with trowel.

5. Cover the mold with another metal plate oiled with mineral oil or glass plate and turn it over. Remove the top plate and repeat the operations of heaping, thumbing, heaping and smoothing off. No ramming or tamping is allowed at any time.

6. Place the moist cloth over the specimen and keep in the air for 20-24 hr. with their upper surface exposed to the moist air but protected from dripping water. After the period of 24 hr they will be removed from the molds and immersed in clean water until testing. The storage water shall be kept clean by frequent changing.

7. At the time of testing (age of 3, 7 and 28 days), wipe each sample to a surface-dry condition and remove any loose sand grains or incrustation from the surface. Carefully center the briquet in the clips and apply the load continuously at the rate of 270 ± 10 kg/min.

The tensile strength can be calculated from the maximum load and the cross-sectional area at failure of the specimen.

Part D Flexural Strength of Hydraulic Cement Mortar

Objective — To determine the flexural strength of hydraulic cement mortar with a certain mix proportion by the use of eithrt 40 by 40 by 160 mm or 25 by 25 by 250 mm prism.

Materials — Cement, standard sand and chemical admixture.

References — ASTM Designation : C 348
JIS (Japan Industrial Standard) R 5201

Apparatus
(1) Balance
(2) Sieves
(3) Glass graduate
(4) Mold for prism specimens
(5) Flow table and flow mold
(6) Tamper and tamper guide
(7) Trowel

Procedures

1. The proportioning, consistency and mixing of the standard mortar shall conform to the requirement specified in Part B. The amount of mortar shall be sufficient not only for molding the test specimens but also for flow test.

2. Immediately determine the flow value according to the test method explained in Part A. Quickly scrape down into the batch the mortar that may have collected on the side of the bowl and then remix the entire batch at medium speed (285 ± 10 rpm) for 15 sec. Upon completion of mixing, the mixing paddle shall be shaken to remove excess mortar into the mixing bowl.

3. Start molding the specimens, place a layer of mortar about one half of the depth of the mold in each of the molds which shall be uniformly distributed. Tamp the mortar in each mold

12 times in about 15 sec in 4 rounds. For each stroke hold the tamper face in horizontal position about 1 in above the mortar level and then thrust directly downward with sufficient force to squeeze out a small amount of mortar from under the tamping surface.

4. Fill the molds until full with the remaining mortar and then tamp as specified for the first layer. On completion of the tamping, remove the tamper guide and smooth off the specimens by drawing the flat side of the trowel along the length of the molds.

5. Keep all test specimens, immediately after molding, in the moist closet or moist room from 20 to 24 hr with their upper surfaces exposed to the moist air.

6. At the end of 24 hr, remove the specimens from the molds and immerse them in clean water in storage tanks. Keep the storage water clean by frequent changing.

7. Test the specimens, immediately after their removal from storage water and wipe dry[6], by center-point loading at the age as follows:

Number of specimens	Test age
3	3 days ± 1 hr.
3	7 days ± 3 hr.
3	28 days ± 12 hr.

8. Measure the failure section and determine the inertia of the failure section, I. The flexural, f_r strength can be calculated as:

$$f_r = \frac{Mc}{I}$$

where M is the external moment acting on the failure section which can be calculated from the experimental setup and c is the distance from the neutral axis of the failure section to the extreme fiber of tension face of the section.

[6] The flexural strength prisms is quickly affected by drying which produces skin tension in the specimens and yields low strengths.

Sketch all necessary figures about the test

Experimental Data and Results

Mix Proportion of Mortar

	Mix No. 1	Mix No. 2	Mix No. 3	Mix No. 4
Weight of cement (g)				
Weight of sand (g)				
Weight of water (g)				
Sand/Cement ratio				
Water/cement ratio				
Type of admixture				
Amount of admixture				

Part A Flow Test of Hydraulic Cement Mortar

Mix	s/c	w/c	D#1	D#2	D#3	D#4	Average	Flow (%)
Mix No. 1								
Mix No. 2								
Mix No. 3								
Mix No.4								

Sample of Calculations

Summary of Results (in Tabular Form), Discussion and Conclusion