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METHOD OF TEST FOR EXPANSION IN WATER AND CONTRACTION IN AIR OF PORTLAND CEMENT MORTAR

A. SCOPE

This method is intended to measure the expansion in water and the contraction in air of mortar composed of portland cement and graded Ottawa sand.

B. REFERENCES

AASHTO T 160 - Length Change of Hardened Hydraulic Cement Mortar and Concrete
ASTM C 109/C 109M - Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens)
ASTM C 151/C 151M - Autoclave Expansion of Hydraulic Cement
ASTM C 157/C 157M - Length Change of Hardened Hydraulic-Cement Mortar and Concrete
ASTM C 305 - Mechanical Mixing of Hydraulic Cement Pastes and Mortars of Plastic Consistency
ASTM C 778 - Standard Sand

C. APPARATUS

1. Scales, glass graduates, tamper and trowel in accordance with ASTM C 109/C 109M.
2. Mixer, mixing bowl and paddle shall conform to the requirements of ASTM C 305.
3. Molds and length comparator shall conform to the requirements of ASTM C 151/C 151M. Knurled and threaded gauge studs shall be used.
4. A room equipped with suitable racks for storing test specimens during drying. The racks shall be designed to permit free circulation of air around specimens, except for necessary supports. The room shall be large enough to permit the use of a manually operated sling psychrometer. The temperature of the room or cabinet shall be maintained at $73^{\circ}\text{F} \pm 3^{\circ}\text{F}$ and the relative humidity at $50\% \pm 4\%$. Conditioned air shall be circulated continuously through the room at such a rate that evaporation of water from the atmometer described in Section C.6. is maintained at $3\text{ mL} \pm 0.5\text{ mL}$ per hour. Circulation of air shall be controlled by deflectors if necessary to result in equal rates of evaporation from the atmometer placed adjacent to specimens at different locations on the storage racks. The temperature and relative humidity of the room shall be measured with a sling psychrometer at least twice daily. The room shall be equipped with means of measuring and recording wet and dry bulb temperatures continuously. The recorded data shall be checked against the sling psychrometer and the results of the latter shall govern.
5. A supply of filter papers. The filter paper shall be white with a smooth surface texture. It shall be 6 in. in diameter and $0.050\text{ in.} \pm 0.003\text{ in.}$ thick. It shall have a

cotton fiber content of not less than 75 % by weight. The density shall be between 0.400 to 0.425 g/cc. The Mullen bursting strength shall not be less than 50 psi¹.

6. An atmometer constructed in accordance with Figure 1 of AASHTO T 160 or ASTM C 157/C 157M. Punch a central hole ½ in. in diameter in a filter paper and mount it on the atmometer and secure it in place while dry, by turning only the torque handle until it just starts to slip. Mount the atmometer on a stand with the filter paper in a horizontal position. Mount a 100 mL glass graduate so that the 100 mL mark is from 1 to 3 in. below the level of the filter paper. Connect glass and rubber tubing leading from the bottom of the graduate to the inlet of the atmometer. Fill the graduate with distilled or deionized water. Force water² into the atmometer until the filter paper is saturated and there are no air bubbles in the system. Adjust the level of water in the graduate to approximately the 100 mL mark. Permit evaporation of water from the filter paper for one hour before recording the time and initial reading of the graduate. (This waiting period may be omitted during subsequent use of the atmometer provided the filter paper does not become dry.) Change the filter paper whenever it shows signs of contamination, but not less frequently than once each two weeks.

D. MATERIALS

Graded Ottawa sand conforming to the requirements of ASTM C 778.

E. TEMPERATURE AND HUMIDITY REQUIREMENTS

1. 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 68 to 82°F. The temperature of the mixing water, the moist closet or moist room, and the water in the storage pans shall not vary from 73°F ± 3°F.
2. The relative humidity of the workroom in which mortars are mixed and specimens are molded shall not be less than 50 %. The moist room or moist closet shall be so constructed as to provide storage facilities for test specimens at a relative humidity of not less than 90 %.

F. PREPARATION OF SPECIMEN MOLDS

Coat the interior surface of the mold with a thin film of automotive crankcase oil, grade SAE 30. The oil shall not be of the multigrade type. After this operation, set the gauge studs, being careful to keep them free of oil.

G. PREPARATION OF MORTAR

1. The batch of mortar shall consist of 750 g of cement, 1,500 g of graded Ottawa sand and water as follows:

<u>Cement Type</u>	<u>W/C Ratio</u>
II Mod, II PS, V	.375 ± .005
III	.390 ± .010

Mix the mortar in accordance with ASTM C 305.

¹ E and D filter paper No. 652 manufactured by Eaton-Dikeman Company, Mt. Holly Springs, Pennsylvania, complies with these requirements.

² A working drawing of a device for supplying water to the filter paper is available upon request.

2. Upon completion of the mixing procedure outlined in ASTM C 305, the mixing paddle shall be shaken to remove excess mortar into the mixing bowl, and any mortar adhering to the sides of the bowl shall be quickly scraped down into the batch. Allow the mortar to stand in the mixing bowl 90 s, and then remix the entire batch 15 s at medium speed before starting the molding of the specimens.

H. MOLDING, STORING AND MEASURING SPECIMENS

1. Start molding 1 in. × 1 in. × 1 1/4 in. specimens within 2 min and 15 s after completion of the original mixing of the mortar batch. Mold four specimens. Fill the mold in two layers and compact each layer with the tamper. Work the mortar into the corners, around the gauge studs, and along the surfaces of the mold until a homogeneous specimen is obtained. After the top layer has been compacted, cut the mortar off flush with the top of the mold and smooth the surface with a few strokes of the trowel.
2. Store the specimens in their molds in the moist closet or moist room for 22 to 23 1/2 hr. Then remove them from the molds. Remove the specimens without striking or jarring them, using particular care not to exert pressure against the gauge studs. Use a device that will permit disengagement of the specimen from the molds without injury. Identify the specimens, using a soft carbon pencil or ink brush that deposits a mark that is essentially carbon without binder. Place them in water at 73°F ± 2°F for a minimum of 30 min prior to making the initial length measurement. Make the initial length measurement at the age of 24 hr ± 15 min from the time cement and water were mixed together. Remove the specimens from the water storage one at a time, wipe them with a damp cloth and then measure them for length as provided in ASTM C 151/C 151M.
3. Store the specimens in water at 73°F ± 2°F to the age of 72 hr ± 15 min computed from the time cement and water were mixed together. Remove the specimens from water and measure for length as provided above in Paragraph 2.
4. Place the specimens on racks in the drying room with at least 1 in. clear space between specimens. Remove the specimens at the age of 168 hr (7 d) ± 15 min computed from the time cement and water were mixed together. Measure promptly for length in accordance with ASTM C 151/C 151M.

I. COMPUTATIONS

1. Compute the expansion in water of each specimen as the length upon removal from water storage less the initial length measurement and express it as a percentage of 10 in.
2. Compute the contraction in air of each specimen as the length upon removal from the water storage less the length upon removal from the drying room and express it as a percentage of 10 in.
3. Report the average change in length of four specimens from the same batch of mortar as the percent expansion in water or the percent contraction in air provided the variability between specimens does not exceed the limits of acceptability as described below. If the results of 4 specimens do not meet the criterion for acceptability, but the results of any 3 of the specimens do meet the criterion, report the average of the measured length changes of the 3 specimens as the percent expansion in water or the percent contraction in air.

If the length changes of at least 3 specimens do not meet the criterion for acceptability, the results shall not be reported and the test shall be repeated.

4. Test results shall be considered acceptable if the standard deviation of the measured length changes of specimens does not exceed 0.0020 in expansion or contraction. The standard deviation shall be computed by the following formula:

$$\sigma = \frac{\sqrt{\sum (X_i - \bar{X})^2}}{n - 1}$$

Where:

- σ = the standard deviation
 X_i = a single observation
 \bar{X} = the arithmetic mean of all observations under consideration
 n = the number of observations under consideration
 \sum = the sign of summation

J. PRECAUTIONS

Exercise care to avoid use of an excessive amount of oil on the specimen molds. Apply the oil in the least amount that will prevent undue adherence of the hardened mortar to the mold.

Observe faithfully the time intervals between measurements and the protection of specimens against loss or gain of water.

Exercise care to avoid striking the gauge studs during handling. Do *not* change adjustments of the torque handle on the atmometer when the filter paper is wet, as this may reduce the rate of evaporation from the graduate.

K. REPORTING RESULTS

Report the results of this test on Form TL 528.

L. HEALTH AND SAFETY

It is the responsibility of the user of this test method to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. Prior to handling, testing or disposing of any materials, testers must be knowledgeable about safe laboratory practices, hazards and exposure, chemical procurement and storage, and personal protective apparel and equipment.

Caltrans Laboratory Safety Manual is available at:

http://www.dot.ca.gov/hq/esc/ctms/pdf/lab_safety_manual.pdf

End of Text
(California Test 527 contains 4 pages)