Designation: C490/C490M – 17

Standard Practice for Use of Apparatus for the Determination of Length Change of Hardened Cement Paste, Mortar, and Concrete[1]

This standard is issued under the fixed designation C490/C490M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 This practice covers the requirements for the apparatus and equipment used to prepare specimens for the determination of length change in hardened cement paste, mortar, and concrete, the apparatus and equipment used for the determination of these length changes, and the procedures for its use.

1.2 Methods for the preparation and curing of test specimens, conditions of testing and curing, and detailed procedures for calculating and reporting test results are contained in applicable test methods.

1.3 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C219 Terminology Relating to Hydraulic Cement

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

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

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of terms used in this test method, refer to Terminology C219.

4. Significance and Use

4.1 This practice is intended to provide standard requirements for apparatus common to many test methods used in connection with cement and concrete and standardized procedures for its use. The detailed requirements as to materials, mixtures, specimens, conditioning of specimens, number of specimens, ages at which measurements are to be made, interpretation of results, and precision and bias are left to be dealt with in specific test methods.

5. Apparatus

5.1 *Reference Masses and Devices for Determining Mass and Volume,* shall conform to the requirements of Specification C1005.

5.2 *Molds,* shall have either one or two compartments and shall be constructed as shown in Fig. 1 or Fig. 2. Molds for test specimens used in determining the length change of cement pastes and mortars shall provide for 25 by 25 by 285-mm prisms having a 250-mm gauge length, or for 1 by 1 by 11¼-in. prisms having a 10–in. gauge length. Molds for test specimens used in the length change of concretes shall provide for prisms of the desired cross section having a 10-in. or 250-mm gauge length. In some routine tests, 25 by 25 by 160-mm specimens with a gauge length of 125 mm, or 1 by 1 by 6¼-in. specimens with a gauge length of 5-in. are permitted, but in case of dispute, results obtained with specimens of 250-mm [10-in.] gauge length shall govern.

5.2.1 The gauge length shall be considered as the nominal length between the innermost ends of the gauge studs. The parts of the molds shall be tight fitting and firmly held together when assembled, and their surfaces shall be smooth and free of pits. The molds shall be made of steel or other hard metal not readily attacked by the cement paste, mortar, or concrete. The sides of the molds shall be sufficiently rigid to prevent spreading or warping. For the molds shown in Fig. 1, the tolerance on dimension A is ±0.7 mm. For the molds shown in Fig. 2, the tolerance on dimension A is ±0.03 in.

5.2.2 Each end plate of the mold shall be equipped to hold properly in place, during the setting period, one of the gauge studs shown in Fig. 1 or Fig. 2. The gauge studs shall be of

[1] This practice is under the jurisdiction of ASTM Committee C01 on Cement and is the direct responsibility of Subcommittee C01.95 on Coordination of Standards.

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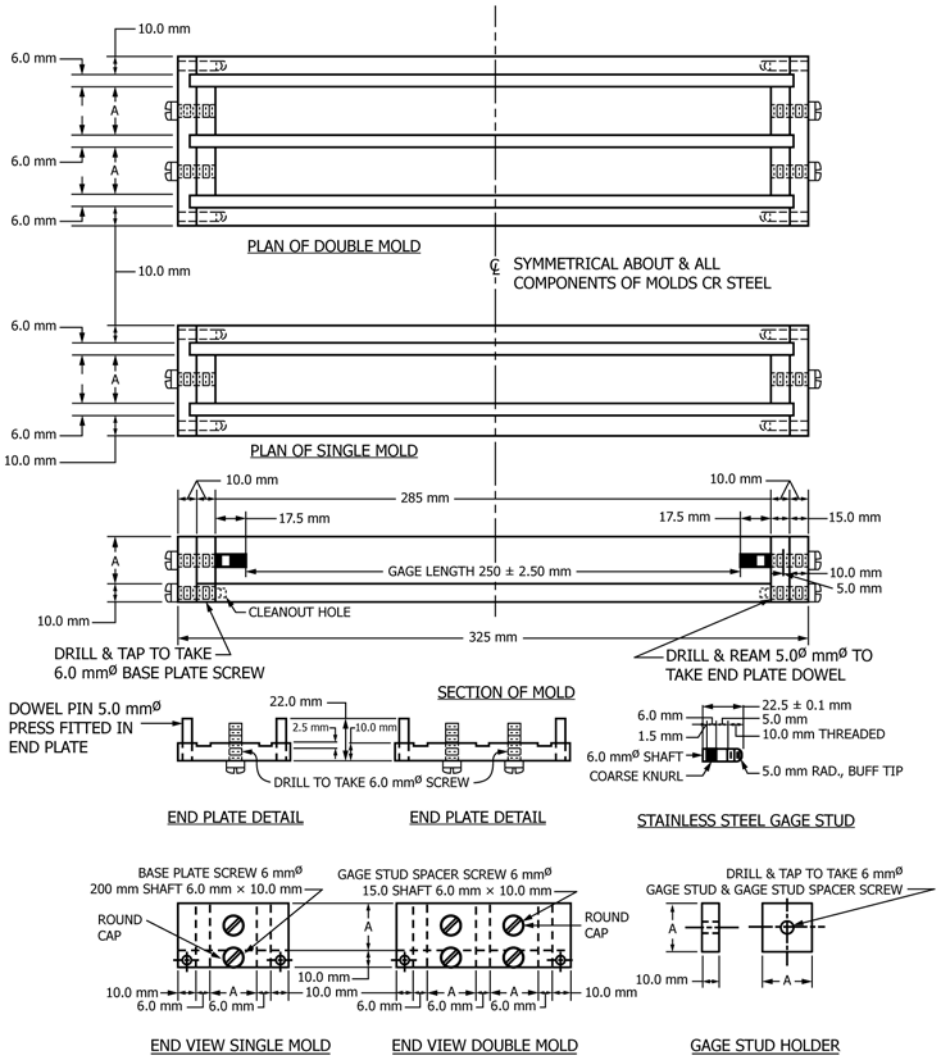
[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

*A Summary of Changes section appears at the end of this standard



NOTE 1—Dimension A to be specified by the purchaser.

FIG. 1 Molds (SI Units)

American Iron and Steel Institute (AISI)[3] Type 316 stainless steel or other corrosion-resistant metal of similar hardness. Gauge studs of Invar or similar metal shall be used when specimens are tested at widely different temperatures. To prevent restraint of the gauge studs before demolding of the specimen, the device for holding the gauge studs in position shall be so arranged that, if necessary, it can be partially or completely released after the compaction of the paste or mortar into place in the mold. The gauge studs shall be set so that their principal axes coincide with the principal axis of the test specimen. For the molds shown in Fig. 1, gauge studs shall extend into the specimen 17.5 ± 0.5 mm and the distance between the inner ends of the gauge studs shall be 250.0 ± 2.5 mm and 250 mm shall be considered the gauge length for calculating length change. For the molds shown in Fig. 2, gauge studs shall extend into the specimen 0.625 ± 0.025 in. and the distance between the inner ends of the gauge studs shall be 10.00 ± 0.10 in. and 10 in. shall be considered the gauge length for calculating length change.

5.3 *Length Comparator,* for determining length change of specimens, shall be designed to accommodate the size of specimen employed and to provide or permit a positive means of contact with the gauge studs and the convenient and rapid obtaining of comparator readings (Note 1).

5.3.1 The comparator for determining length changes of specimens produced in the molds shown in Fig. 1 shall provide a dial micrometer or other measuring device graduated to read in 0.002-mm units or less, accurate within 0.002 mm in any 0.020-mm range, and within 0.004 mm in any 0.200-mm range, and sufficient range (at least 8.0 mm) in the measuring device to allow for small variations in the actual length of various specimens. The terminals of the comparator shall be plane, polished and heat-treated. They shall be fitted with collars held in place with set screws. The collars shall extend 1.5 ± 0.1 mm beyond the plane face of the terminal. The

[3] Details on this material are available from American Iron and Steel Institute (AISI), 1140 Connecticut Ave., NW, Suite 705, Washington, DC 20036, http://www.steel.org.

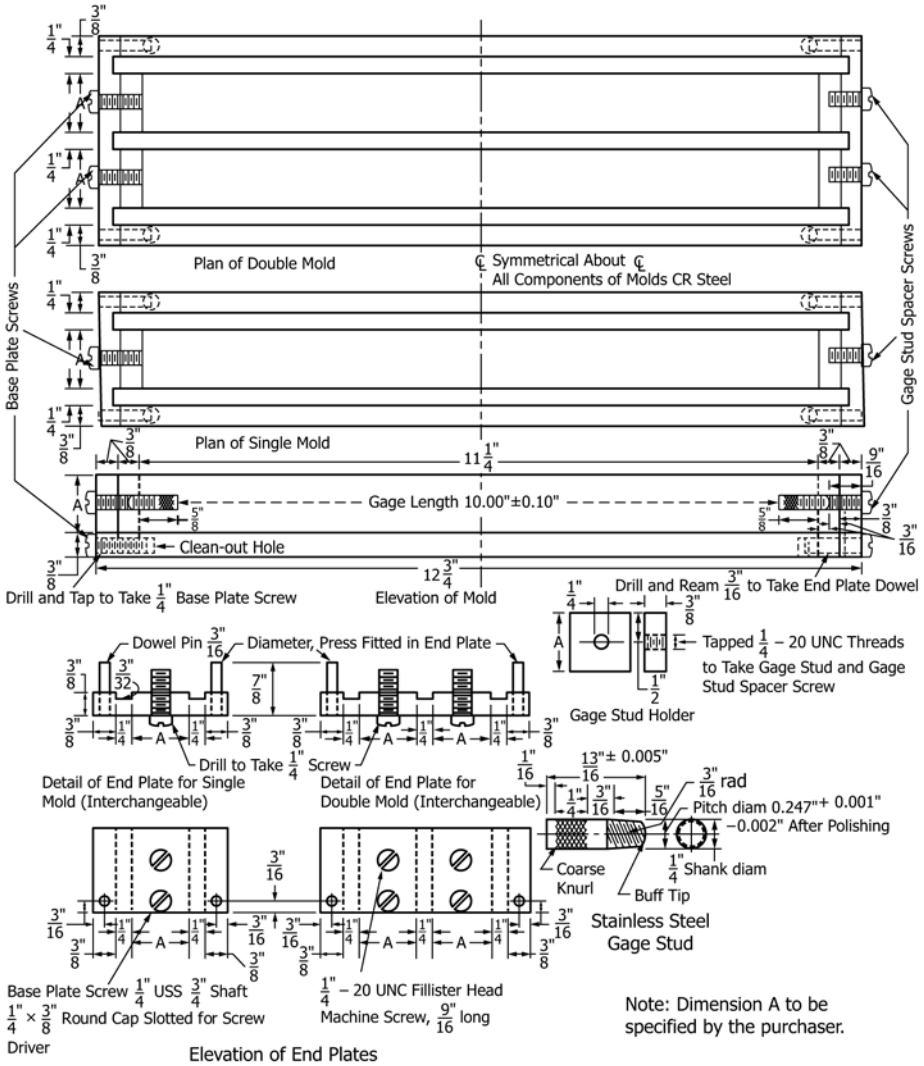


FIG. 2 Molds (Inch-Pound Units)

collars shall allow free rotation of the gauge stud tips that fit inside the collars and have an inside diameter no more than 0.5 mm larger than the average diameter of that portion of the gauge stud tips that fit into the collars.

NOTE 1—One type of instrument that has been found satisfactory for use with small prisms is shown in Fig. 3. A horizontal comparator should be used with prisms with a cross section greater than 9 in.^{2} or 58 cm^2.

5.3.2 The comparator for determining length changes of specimens produced in the molds shown in Fig. 2 shall provide a dial micrometer or other measuring device graduated to read in 0.0001-in. units, accurate within 0.0001 in. in any 0.0010-in. range, and within 0.0002 in. in any 0.0100-in. range, and sufficient range (at least 0.3 in.) in the measuring device to allow for small variations in the actual length of various specimens. The terminals of the comparator shall be plane, polished and heat-treated. They shall be fitted with collars held in place with set screws. The collars shall extend 0.062 ± 0.003 in. beyond the plane face of the terminal. The collars shall allow free rotation of the gauge stud tips that fit inside the collars and have an inside diameter no more than 0.02 in. larger than the average diameter of that portion of the gauge stud tips that fit into the collars.

5.3.3 The design shall provide a means for checking the measuring device against a reference bar at regular intervals.

5.4 *Reference Bar*, shall have an overall length of 295 ± 3.0 mm or 170 ± 3.0 mm [11 ⅝ ± ⅛ in. or 6 ⅝ ± ⅛ in.], whichever is appropriate for the specimen in use. The bar shall be of a steel alloy having a coefficient of thermal expansion not greater than two millionths per degree Celsius. Each end of the reference bar shall be fitted with heat treated, hardened, and polished tips machined to the same shape as the contact end of the gauge studs used in test specimens. That portion of the bar that extends into the comparator's collar shall have a diameter of 6 ± 0.25 mm [0.250 ± 0.010 in.], and the length of that portion shall extend beyond the depth of the collar. Except for the tips, which are attached after heat treatment, no part of the reference bar shall be heat treated (Note 2). The central 100 mm [4 in.] of the length of the reference bar shall be covered by a rubber tube with a wall at least 3 mm [⅛ in.] thick

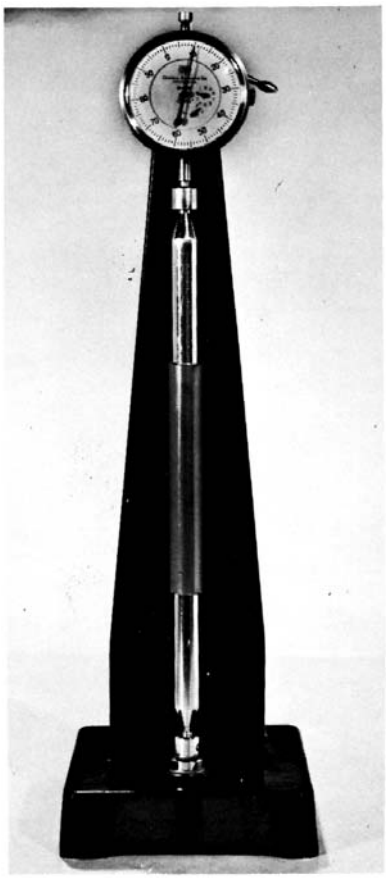


FIG. 3 Type of Suitable Apparatus for Measurement of Length Changes

to minimize the effect of temperature change during handling. The reference bar shall be provided near one end with a positioning mark.

NOTE 2—Alloys such as invar lose their low coefficient of thermal expansion properties when heat treated.

5.5 Check and document the bar mold dimensions, gauge stud projection into the mold interior, length comparator, and length measuring device for conformance to the design and dimensional requirements of this specification at least every 2½ years.

6. Procedure

6.1 *Preparation of Molds*—Prior to the molding of specimens, the outside joints of the mold and the contact lines of the mold and base plate shall be sealed to prevent loss of mixing water from a freshly molded specimen. Thinly cover the interior surfaces of the mold with mineral oil. After this operation, set the gauge studs, taking care to keep them clean, and free of oil, grease, and foreign matter.

6.2 *Use of Reference Bar*—For each reference reading taken, place the reference bar into the comparator with the positioning mark in the same orientation. With the bar in the comparator, rotate it slowly through at least one complete revolution while the gauge reading is being taken. Record the minimum (shortest) gauge reading (Note 3). Monitor and record the room temperature in which the comparator is used. Use the reference bar when the temperature difference is more than ±1.0°C of the previous use of the comparator apparatus, and at least at the beginning and end of the specimen readings made within a half day.

NOTE 3—The reference bar is used in the comparator to correct for changes occurring to the comparator apparatus and gauge that affect length readings. The reference bar is always placed in the same orientation in the comparator apparatus to minimize changes in reading due to differences in contact surfaces. Frequent use of the reference bar can result in significant wear of the tips, which affects the indicated length of the bar. Appropriate steps should be taken to monitor reference bar condition and replace as needed.

NOTE 4—The equation given in the section on calculation of length change contemplates that a comparator reading for the reference bar will be recorded each time the reference bar is used and a difference calculated for each test specimen reading. Alternatively, the dial gauge setting can be reset, if necessary, to its original setting with the reference bar in place each time the reference bar is read. Doing so simplifies the calculation of length change by canceling the comparator reading of the reference bar from the values of L_x and L_i. If this procedure is used, care should be taken to ensure that the dial set screw is tightened adequately each time the dial is reset.

6.3 *Obtaining Comparator Readings*—Rotate specimens slowly in the measuring instrument while the comparator reading is being taken. Record the minimum reading of the dial if the rotation causes a change in the dial reading. Place specimens in the instrument with the same end up each time a comparator reading is taken.

6.3.1 *Obtaining Comparator Readings of Specimens Stored Moist*—Clean the hole in the base of the comparator into which the gauge stud on the lower end of the bar fits before and after every reading. Read and record the comparator indication of the length of the reference bar and temperature of the room in which the comparator is being used (Note 4). Take one bar out of immersion, blot only around the pins, put the bar in the comparator, read, and record the indication (Note 5). Return the bar to immersion. Take out the second bar and treat it in a like manner. Return the second bar to immersion and record the reading. Continue the procedure until all bars have been read, returned to immersion, and the readings recorded. After reading the last bar, read and record the reference-bar indication and temperature of the room in which the comparator was used. Compare the two reference bar readings. If the difference in the reference bar readings is greater than 0.010 mm [0.0004 in.], then use the average of the beginning and ending values for the L_x and L_i factors in the formula in the calculations section. Otherwise use the beginning reading only.

NOTE 5—The purpose of the minimal blotting of the pins and no blotting of the bars is to avoid drying and shrinkage of the bars. It has been observed that if the pins are blotted, and the bar placed in the comparator and the dial read, and the bar is then wiped gently with a dry cloth, the bar will shrink measurably. Therefore, drying should be minimized.

7. Calculation of Length Change

7.1 Calculate the length change at any age as follows:

$$L = \frac{(L_x - L_i)}{G} \times 100$$

where:

L = change in length at x age, %,

L_x = comparator reading of specimen at x age minus comparator reading of reference bar at x age; in millimetres when using Fig. 1 apparatus, in inches when using Fig. 2 apparatus,

L_i = initial comparator reading of specimen minus comparator reading of reference bar at that same time; in millimetres when using Fig. 1 apparatus, in inches when using Fig. 2 apparatus, and

G = nominal gauge length, 250 mm when using Fig. 1 apparatus, 10 in. when using Fig. 2 apparatus.

7.2 Calculate length change values for each specimen to the nearest 0.001 % and report averages to the nearest 0.01 %.

8. Temperature, Humidity, and Time

8.1 *Molding Room*—The temperature of the molding room and dry materials shall be maintained between 23.0 ± 4°C. The relative humidity shall be not less than 50 %. The temperature of the mixing water shall be 23.0 ± 2.0°C.

8.2 *Moist Storage Facility*—The temperature and humidity of the air in the moist storage facility shall conform to the requirements of Specification C511.

8.3 *Time*—Comparator readings shall be taken at specified time intervals or ages. All intervals and ages shall be met within ±2 %.

9. Keywords

9.1 cement paste; comparator; concrete; length change apparatus; molds; mortar

SUMMARY OF CHANGES

Committee C01 has identified the location of selected changes to this standard since the last issue (C490/C490M – 11$^{\varepsilon 1}$) that may impact the use of this standard. (Approved March 15, 2017.)

(1) Revised Section 3.