**Designation: C 490 – 00a**

# 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 C 490; 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 SI units or inch-pound units are to be regarded as ~~the standard.~~

~~1.4 Values~~ standard. The values in ~~SI units~~ each system may not be exact equivalents; therefore, each system shall be ~~obtained by measurement in SI units or by appropriate conversion, using~~ used independently of the ~~Rules for Conversion and Rounding given~~ other. Combining values from the two systems may result in ~~IEEE/ASTM SI 10, of measurement made in other units.~~ nonconformance with the standard.

## 2. Referenced Documents

2.1 *ASTM Standards:*

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

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C 511 Specification for Moist Cabinets, Moist Rooms, and Water Storage Tanks Used in the Testing of Hydraulic Cements and Concretes[2]

C 1005 Specification for Reference Masses and Devices for Determining Mass and Volume for Use in the Physical Testing of Hydraulic Cements[2]

~~IEEE/ASTM SI 10 Standard for Use of the International System of Units (SI): The Modern Metric System[3]~~

## 3. Terminology

3.1 *length change*—an increase or decrease in the linear dimension of a test specimen, measured along the longitudinal axis, due to causes other than applied load.

## 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 C 1005.

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 ~~1~~ 25 by ~~1~~ 25 by ~~11¼-in.~~ 285-mm prisms having a ~~10-in.~~ 250-mm gage length, or for ~~25~~ 1 by ~~25~~ 1 by ~~285-mm~~ 11¼ –in. prisms having a ~~250-mm~~ 10–in. gage 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 gage length. In some routine tests, ~~1~~ 25 by ~~1~~ 25 by ~~6¼-in.~~ 160-mm specimens with a gage length of ~~5 in.~~ 125 mm, or ~~25~~ 1 by ~~25~~ 1 by ~~106-mm~~ 6¼ –in. specimens with a gage length of ~~125 mm~~ 5-in. are permitted, but in case of dispute, results obtained with specimens of ~~10-in. (250-mm)~~ 250-mm [10-in]. gage length shall govern.

5.2.1 The gage length shall be considered as the nominal length between the innermost ends of the gage 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 ~~±0.03 in.~~ ±0.7 mm. For the molds shown in Fig. 2, the tolerance on dimension A is ~~±0.7 mm.~~ ±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 gage studs shown in Fig. 1 or Fig. 2. The gage studs shall be of American Iron and Steel Institute (AISI)[3] Type 316 stainless steel or other

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[2] *Annual Book of ASTM Standards*, Vol 04.01.

~~*Annual Book of ASTM Standards*, Vol 14.04.~~

[3] Details on this material are available from the American Iron and Steel Institute, 1133 15th St. N.W., Washington, DC 20005.

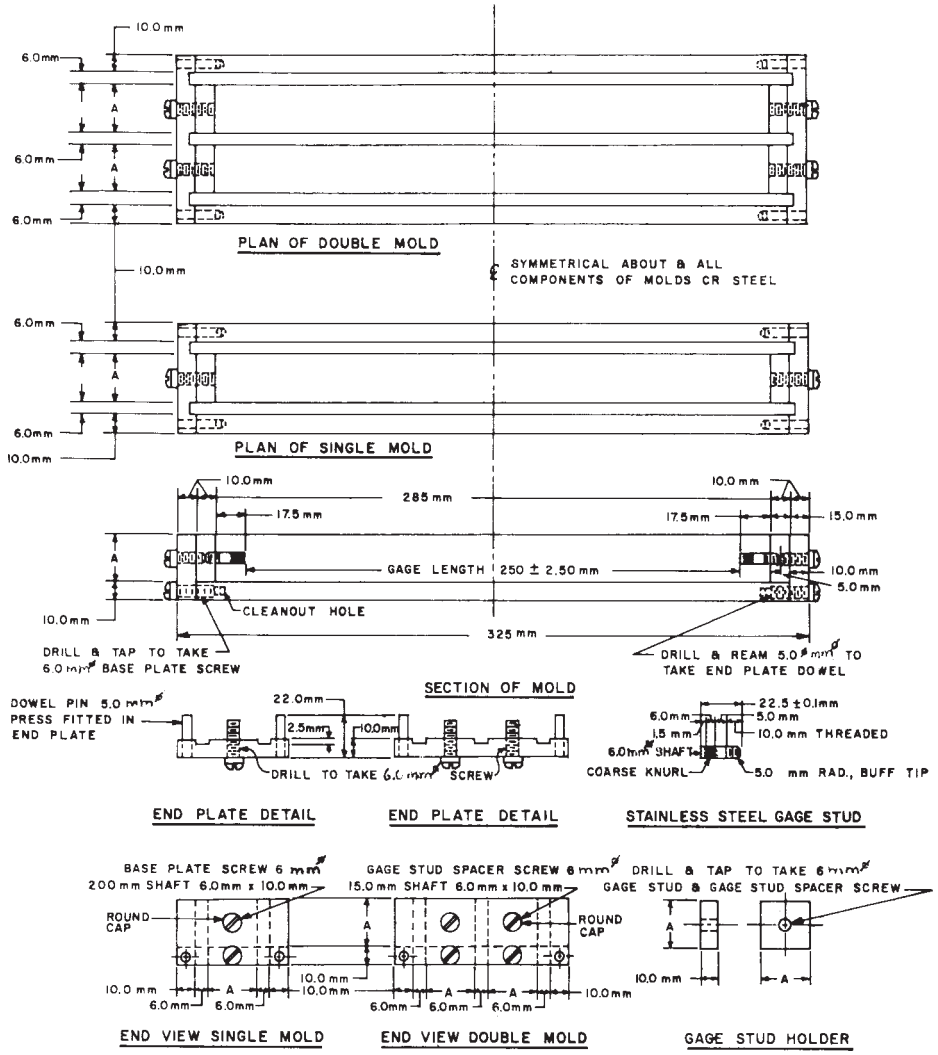


**FIG. 1 Molds (SI Units)**

corrosion-resistant metal of similar hardness. Gage studs of Invar or similar metal shall be used when specimens are tested at widely different temperatures. To prevent restraint of the gage studs before demolding of the specimen, the device for holding the gage 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 gage 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, gage studs shall extend into the specimen ~~0.625~~ 17.5 ~~± 0.025 in.~~ 0.5 mm and the distance between the inner ends of the gage studs shall be ~~10.00~~ 250.0 ~~± 0.10 in.~~ 2.5 mm and ~~10 in.~~ 250 mm shall be considered the gage length for calculating length change. For the molds shown in Fig. 2, gage studs shall extend into the specimen ~~17.5~~ 0.625 ~~± 0.5 mm~~ 0.025 in. and the distance between the inner ends of the gage studs shall be ~~250.0~~ 10.00 ~~± 2.5 mm~~ 0.10 in. and ~~250 mm~~ 10 in. shall be considered the gage 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 gage 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 ~~0.0001-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 and have an inside diameter 0.02 in. greater than the average diameter of the portion of the gage studs that must fit into the collars.~~

~~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 0.001 or~~ 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

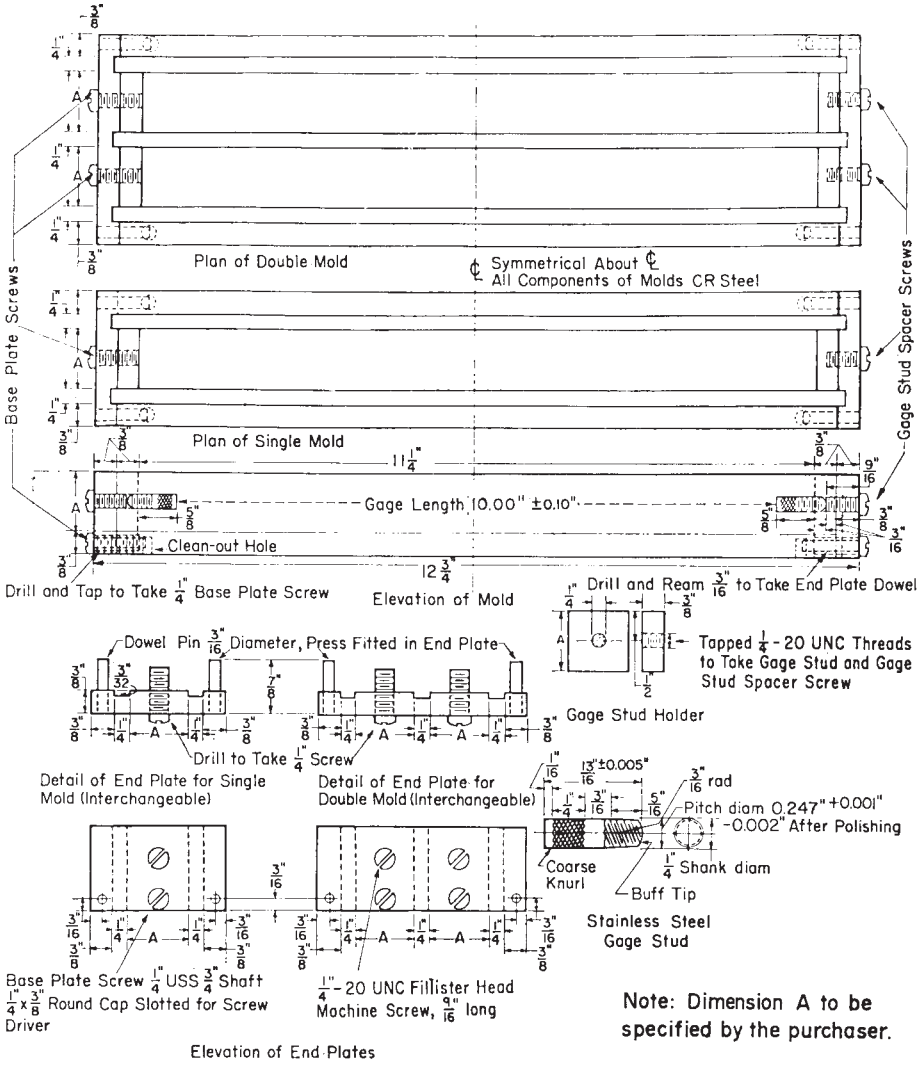


**FIG. 2 Molds (Inch-Pound Units)**

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 and have an inside diameter 0.5 mm greater than the average diameter of the gage studs that must 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 and have an inside diameter 0.02 in. greater than the average diameter of the portion of the gage studs that must 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. The reference bar shall have an overall length of 295 ± 3.0 mm or 170 ± 3.0 mm [11⅝ ± ⅛ in. or 6 ⅝ ± ~~in. (300 ± 1.5 mm or 170 ± 1.5 mm),~~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 gage studs used in test specimens. Except for the tips, which are attached after heat treatment, no part of the reference bar shall be heat treated. The central ~~4 in. (100 mm)~~ 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. (3 mm)~~ in.] thick to minimize the effect of temperature change during handling. The reference bar shall be provided near one end with a positioning mark.

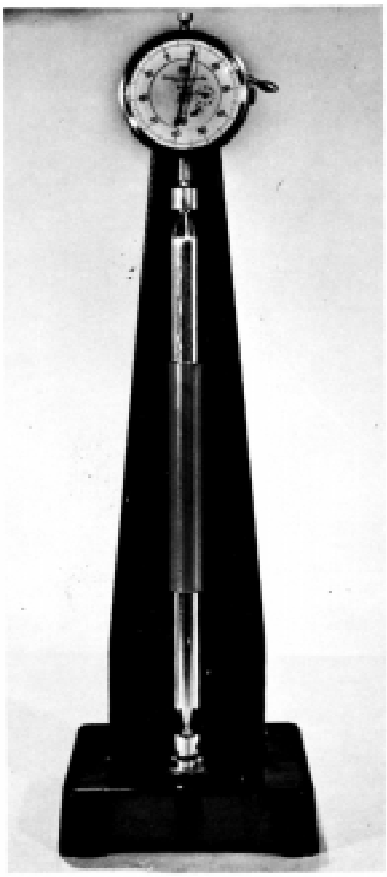

**FIG. 3 Type of Suitable Apparatus for Measurement of Length Changes**

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

## 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 gage studs, taking care to keep them clean, and free of oil, grease, and foreign matter.

6.2 *Use of Reference Bar*—Place the reference bar in the instrument in the same position each time a comparator reading is taken. Check the dial gage setting of the measuring device by use of the reference bar at least at the beginning and end of the readings made within a half day when the apparatus is kept in a room maintained at constant temperature. Check it more often when kept in a room where the temperature is not constant.

NOTE 3—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 gage 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 gage stud on the lower end of the bar fits (this hole tends to collect water and sand and should be cleaned after every reading). Read and record the comparator indication of the length of the reference bar. Take one bar out of immersion, blot the pins, put the bar in the comparator, read, and record the indication. Return the bar to immersion and clean the hole in the base of the comparator. Take out the second bar and treat it in a like manner. Return the second bar to immersion, record the reading, and clean the hole in the base of the comparator. Continue the procedure until all bars have been read, returned to immersion, and the readings recorded, cleaning the hole in the bottom of the comparator each time. After reading the last bar, clean the hole in the comparator base and read and record the reference-bar indication. Blot only around the pins (Note 4).

NOTE 4—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 ~~inches~~ millimetres when using Fig. 1 apparatus, in ~~millimetres~~ inches when using Fig. 2 apparatus,

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

$G$ = nominal gage length, ~~10~~ 250 when using Fig. 1 apparatus, ~~250~~ 10 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 20 and 27.5°C ~~(68~~ [68 and 81.5°F~~)~~]. The relative humidity shall be not less than 50 %. The temperature of the mixing water shall be 23.0 ± 2.0°C ~~(~~ [73.5± 3.5°F~~)~~].

8.2 *Moist Storage Facility*—The temperature and humidity of the air in the moist storage facility shall conform to the requirements of Specification C 511.

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