



Designation: **C485 – 09 C485 – 16**

Standard Test Method for Measuring Warpage of Ceramic Tile¹

This standard is issued under the fixed designation C485; 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 test method covers procedures for measuring ~~diagonal—the corner, diagonal,~~ and edge warpages of the following categories of ceramic tile:

1.1.1 *Square Tile*, 2 by 2 in. (51 by ~~51 mm~~) 51 mm or larger, that are nominally flat, of uniform overall thickness, and have a smooth face of one of the types: unglazed, bright glazed, matte glazed, or finely crystalline glazed.

1.1.2 *Oblong Tile*, no facial dimension smaller than 2 in. (51 mm), that are flat, of uniform overall thickness, and have a smooth face of one of the types: unglazed, bright glazed, matte glazed, or finely crystalline glazed.

1.1.3 *Square and Oblong Tile*, no facial dimension smaller than 2 in. (51 mm), that are flat, but have an irregular face such as embossed, sloped, bumpy, wavy, coarsely crystalline, or wire-cut textured.

1.1.4 *Nonrectilinear Tile*, larger than ~~4 in.~~ 4 in. ² (~~26 cm~~) (26 cm²), that are flat and of uniform body thickness with smooth or irregular face, such as hexagonal, diamond, Spanish type, and so forth.

1.1.5 *Trim Tile* meeting one of the descriptions in 1.1.1 – 1.1.4 except that only a part of the tile surface is flat. (Surface trim tile should be treated as flat tile whenever possible.)

1.1.6 *Square or Oblong Tile* with facial area less than 4 in.² (26 cm²) and at least two straight sides equal to or greater than 1.0 in. (25 mm) long. (Modular 1- by 1-in. tile are not in the scope of this test method.)

1.2 This test method is not applicable to tile having embossed surfaces that are not flat, or that have a combination of variable body thickness and an irregular face.

1.3 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards*:²

C242 Terminology of Ceramic Whitewares and Related Products

2.2 *ASTM Adjuncts*:

Warpage Gage for Ceramic Tile³

3. Terminology

3.1 *Definitions*:

3.1.1 *contact warpage device, n*—consisting of a fixture that has reference pins, contact gauges, and zero blank plates. The device can be specific to a tile size or adjustable. Typically the tile rests on the pins and the zero plane is fixed from these contact points.

3.1.2 *non-contact warpage device, n*—a device that uses some form of non-contact method to take measurements. An example would be laser measurement. These devices can use a fixed reference plane (zero with flat blanks) or calculate a theoretical reference plane.

¹ This method is under the jurisdiction of ASTM Committee C21 on Ceramic Whitewares and Related Products and is the direct responsibility of Subcommittee C21.06 on Ceramic Tile.

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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.

³ Three drawings showing construction details are available from ASTM Headquarters. Order ADJC0485.

3.1.3 *reference plane, n*—the zero plane from which tile planar deviations are measured.

3.1.4 *tile—tile, n*—see Definitions C242.

3.1.5 *warpage—warpage, n*—curvature of a flat tile measured as deviation of the tile surface from a true plane along the edges, at the corners, or the diagonals. The deviation is measured at the mid-length of an edge or diagonal, or at a corner, expressed as a percentage of the length of the edge, diagonal, or diagonal, corner, and called convex or concave with respect to the face of the tile.

4. Summary of Test Method

4.1 This test method consists of measuring the deviation from a straight line at the midpoint between reference points on the face or back of a tile. method calculates the deviation of a ceramic tile from a flat plane. Measurements are made along the edges of a tile or along the diagonals, or both. edges, diagonals, and corners of a tile. The deviation is expressed as convex (positive) or concave (negative) warpage in relation to the tile face, and its magnitude is calculated as a percentage of the length of the edge or diagonal face.

5. Significance and Use

5.1 This test method provides a means for determining whether or not a lot of ceramic tile meets the warpage requirements that may appear in specifications to assure satisfactory tile installations. In accordance with this test method, warpage is calculated as a percentage of the length of the edge or diagonal being tested. It is realized that the percentage values based on the overall edge length, or on the overall diagonal length of a tile will be slightly lower than those based on the distance between reference points. However, the ratio of the overall lengths to the distance between reference points will be practically constant for any particular size of tile and, therefore, the percentage values will be comparable and equally indicative of warpage.

6. Apparatus

6.1 *General Edge and Diagonal Apparatus*—The size and arrangement of the apparatus for measuring the warpages vary, depending on the size and shape of the tile to be measured. In general, the apparatus consists of two stationary pins (reference pins) spaced apart. The apparatus may be of contact $\frac{3}{4}$ in. (19 mm) less than the length of the edge or diagonal being tested, and a dial indicator tip midway between the stationary pins and in line with them. The pins and the dial indicator are mounted firmly on the same rigid metal bar. The pins may have a hemispherical tip, as described in or non-contact in type capable of being differentiate between the tile and a true flat plane. It must 6.2.2, or they may be conical to a point. A more versatile apparatus for standard sizes of tile consists of a metal plate having three movable reference pins, three movable registry stops, and the necessary number of dial indicators. See be able to measure the displacement (to 0.1 mm) from a true plane at the center of the tile edges and at the corners. This displacement is relative to Fig. 1 and a plane Fig. 2. fixed at reference points 10 mm from each tile corner.

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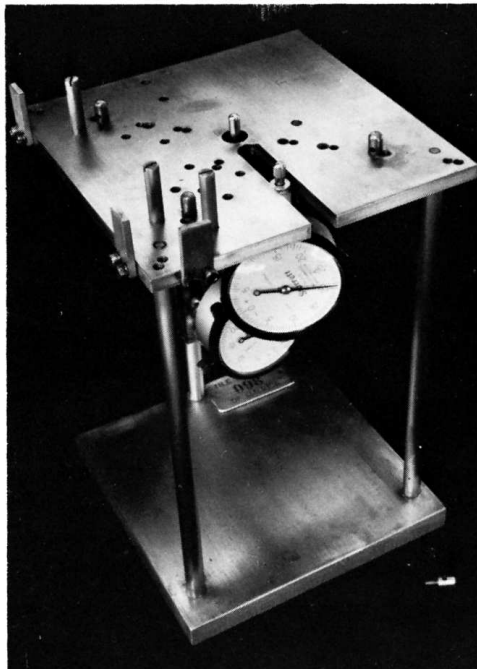


FIG. 1 Contact Apparatus for Square Tile, Set Up for Measurement of $4\frac{1}{4}$ - by $4\frac{1}{4}$ -in. (108- by 108-mm) Tile

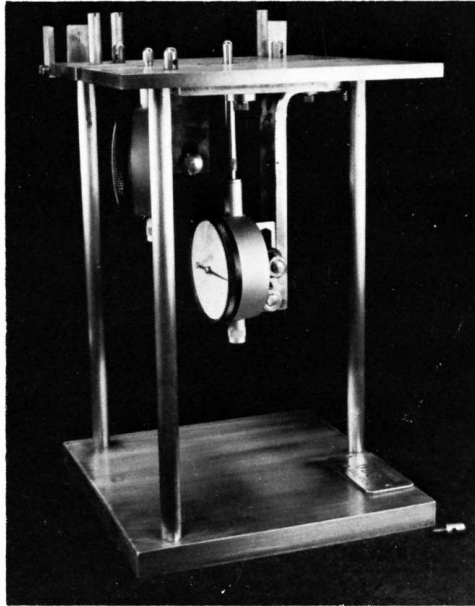


FIG. 2 Apparatus as Shown in Fig. 1, Fig. 1, Showing Arrangement of Stem Extender

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6.2 Apparatus for Square Tile.³

6.2.1 *Metal Plate*—A flat metal plate, 6 by 6 in. (152 by 152 mm) square and $\frac{1}{4}$ in. (6.4 mm) thick, with a $\frac{7}{16}$ -in. (11-mm) wide slot starting at the midpoint of one side and running at right angles to that side for a distance of $2\frac{5}{8}$ in. (67 mm) toward the center of the plate. The plate also has a $\frac{7}{16}$ -in. diameter hole in the exact center of the plate. One side of the plate has two $\frac{1}{8}$ -in. (3.2-mm) thick, $\frac{1}{2}$ -in. (13-mm) wide, and 1-in. (25-mm) high projections, located not more than $\frac{1}{2}$ in. from the corners, and a similar projection located on an adjacent side and not more than $\frac{1}{2}$ in. from one of the corners of the first side. These projections serve as permanent registry stops for 6- by 6-in. tile during measurement.

6.2.1.1 In addition, the plate has a series of tapped holes for insertion of removable reference pins and removable registry stops. The centers of the holes for the reference pins are located for each nominal size of tile near three of its corners, $\frac{3}{8}$ in. (9.5 mm) in from each side, when the tile is centered on the plate, except that for 2- by 2-in. (51- by 51-mm) tile the distance in from the edges is $\frac{1}{4}$ in. (6.4 mm). To receive the three registry stops, the centers of two holes are located for each nominal size of tile $\frac{1}{2}$ in. (13 mm) from the corners of one side and $\frac{1}{8}$ in. (3.2 mm) from the edge of the tile, while the center of a third hole is located on an adjacent side, $\frac{1}{2}$ in. from one of the corners of the first side and $\frac{1}{8}$ in. from the edge of the tile.

6.2.2 *Reference Pins*—Three movable reference pins $\frac{5}{8}$ in. (16 mm) high and $\frac{1}{4}$ in. (6.4 mm) in diameter, with the free end ground to a hemispherical tip and the other end threaded for a distance of $\frac{1}{4}$ in. The reference pins are inserted in the metal plate to support the tile during measurement.

6.2.3 *Registry Stops*—Three $\frac{1}{4}$ -in. (6.4-mm) diameter and $1\frac{1}{4}$ -in. (32-mm) high, movable, flat top registry stops with a $\frac{1}{16}$ -in. (1.6-mm) wide and $\frac{1}{8}$ -in. (3.2-mm) deep slot on one end for the insertion of a screwdriver and threaded on the other end for a distance of $\frac{1}{4}$ in. The registry stops are inserted in the metal plate to fix the horizontal position of the tile during measurement.

6.2.4 *Dial Indicators*—Two adjustable dial indicators, reading in 0.001-in. (0.025-mm) increments and accurate to ± 0.001 in. One is inserted from the bottom through the $\frac{7}{16}$ -in. (11-mm) hole in the center of the plate, permanently fastened to the underside of the metal plate, and used for measuring diagonal warpage. The other is inserted into the slot in the plate and fastened in any one of four positions which represent midpoints between reference pins on one side of each of the different nominal sizes of tile. This dial indicator is used for determining edge warpage.

6.2.5 *True Reference Plates*—Four $\frac{3}{8}$ -in. (9.5-mm) thick plates of true plane surface, made of steel or polished glass, one each of the same dimensions as the four nominal sizes of tile which can be measured on this apparatus.

6.2 Apparatus for Oblong Tile: Corner Warpage Apparatus—

6.3.1 *Metal Plate*—A flat rectangular metal plate $8\frac{1}{2}$ by $4\frac{1}{4}$ in. (216 by 108 mm) and $\frac{1}{4}$ in. (6.4 mm) thick, having two $\frac{7}{16}$ -in. (11-mm) wide slots. One slot should start at the midpoint of one $4\frac{1}{4}$ -in. side and run at right angles to that side for a distance of $2\frac{3}{4}$ in. (70 mm) towards the center of the plate. The other slot should start at the midpoint of one $8\frac{1}{2}$ -in. side and run at right angles to that side for a distance of $1\frac{3}{4}$ in. (45 mm) towards the center of the plate. These slots are used for inserting the two dial indicators necessary to measure the edge warpage of one long and one short dimension of the tile simultaneously. There is also a $\frac{7}{16}$ -in. hole in the exact center of the plate for insertion of the third dial indicator, which is used for measuring diagonal warpage. One side

of the plate has two $\frac{1}{8}$ -in. (3.2-mm) thick, $\frac{1}{2}$ -in. (13-mm) wide, and 1-in. (25-mm) high projections, located not more than $\frac{1}{2}$ in. from the corners and a similar projection located on an adjacent side and not more than $\frac{1}{2}$ in. from one of the corners of the first side. These projections serve as permanent registry stops for $8\frac{1}{2}$ by $4\frac{1}{4}$ -in. tile during measurement.

6.3.1.1 In addition, the plate has a series of tapped holes for insertion of movable reference pins and movable registry stops. The center of the holes for the reference pins is located for each nominal size of tile near its four corners, $\frac{3}{8}$ in. (9.5 mm) in from each side, when the tile is centered on the plate. The centers of two of the holes to receive the three registry stops are located for each size of tile $\frac{1}{2}$ in. (13 mm) from the corners of one side and $\frac{1}{8}$ in. (3.2 mm) from the edge of the tile, while the center of the third hole is located on an adjacent side, $\frac{1}{2}$ in. from one of the corners of the first side and $\frac{1}{8}$ in. from the edges of the tile. This device may be contact or non-contact in nature capable of detecting deflection from a plane as indicated below. It must be able to measure the displacement 10 mm from corner and fixed 50 mm outside of a plane (to 0.1 mm) as illustrated below.

6.3.2 *Reference Pins*—See 6.2.2.

6.3.3 *Registry Stops*—See 6.2.3.

6.3.4 *Dial Indicators*—Three adjustable dial indicators, reading in 0.001-in. (0.025-mm) increments and accurate to ± 0.001 in. One of them, used for the determination of diagonal warpage, is permanently fastened on the underside of the plate, with its stem projecting through the $\frac{7}{16}$ -in. (11-mm) hole in the center of the plate. The other two, used for measuring edge warpage, are inserted, one into each of the two slots in the plate, and fastened in any one of the various positions representing midpoints between reference pins on the same side of the various nominal sizes of tile. Because two of the dial indicators are in one line for viewing, one of them must be arranged at a different elevation than the other by using a stem extender, so that both dials may be read simultaneously (Fig. 2).

6.3.5 *True Reference Plates*—See 6.2.5.

7. Test Specimens

7.1 At least ten tile specimens shall be selected at random from the lot to be tested. Brush the specimens to remove all adhering particles of clay or sand.

8. Procedure

8.1 *General*—For nominally square tile use the apparatus described under 6.2. For oblong tile use the apparatus described under 6.3.

8.1 *Procedure for Square Tile—Edge Warpage:*

8.1.1 Zero out the device to the reference plane (if needed).

8.1.2 Align the device with the face of the tile such that the plane measured conforms to Section 6.

8.1.3 Depending upon Measure the size of tile to be tested, insert the three registry stops and the three reference pins into the proper tapped holes in the metal plate and fasten them. Move and fasten the adjustable dial indicator in the slot so that its tip will fall at the midpoint between the two reference pins on the same side. Insert the proper reference plate and adjust the two dial indicators to zero reading when the reference plate rests on the reference pins and is in contact with the three registry stops. displacement of the edge at the center along the gauge length, with positive values being convex and negative values being concave with respect to the face of the tile.

8.1.4 Record the results.

8.1.5 Rotate the tile or device 90 degrees to measure the next side. Re-zeroing may be necessary if the tile is not square.

8.1.6 Insert a piece Repeat steps 8.1.2 – 8.1.5 of tile with its face resting upon the three reference pins and its edges in contact with the three registry stops. Read the two dial indicators, turn the tile 90° clockwise, and repeat the procedure until all four sides and the two diagonals have been are measured.

8.3 *Procedure for Oblong Tile:*

8.3.1 Both diagonals of oblong tile cannot be measured for warpage without changing one of the reference pins. Depending upon the size of tile to be tested, insert the three registry stops and the three reference pins into the proper tapped holes in the metal plate and fasten them. Insert the two movable dial indicators, one in each slot of the plate and located so that the stem of one is at the midpoint between reference pins of one short dimension and the stem of the other at the midpoint between reference pins of one long dimension. Using the proper reference plate so that it rests on the three reference pins and its sides are in contact with the registry stops, adjust the three dial indicators to zero reading.

8.3.2 Place a tile face down on the reference pins so that its edges are in contact with the registry stops and read the three dial indicators. Turn the tile 180° and read the edge warpage of the second short and second long dimension of the tile. In order to determine the warpage of the second diagonal, change one of the reference pins and read the warpage of the second diagonal, after first resetting the dial indicators to zero with the reference plate. (In practice it will be found more expedient to read the edge warpage and the warpage of one diagonal of all the tile in a sample before changing the one reference pin to determine the warpage of the second diagonal.)

8.4 *Procedure for Square or Oblong Tile with an Irregular Face*, as defined in 1.1.3.

8.4.1 Tile with an irregular face on which accurate warpage measurements can not be made must be measured on the back, if possible. If the back is also unsuitable, no warpage measurements can be made in accordance with this test method.