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Designation: C 482 – 02

Standard Test Method for Bond Strength of Ceramic Tile to Portland Cement Paste[1]

This standard is issued under the fixed designation C 482; 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] This test method is under the jurisdiction of ASTM Committee C-21 on Ceramic Whitewares and Related Products and is the direct responsibility of Subcommittee C21.06 on Ceramic Tile.

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1. Scope

1.1 This test method covers the determination of the ability of glazed ceramic wall tile, ceramic mosaic tile, quarry tile, and pavers to be bonded to portland cement paste. This test method includes both face-mounted and back-mounted tile.

1.2 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.

1.3 *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:*

C 150 Specification for Portland Cement[2]

C 185 Test Method for Air Content of Hydraulic Cement Mortar[2]

C 207 Specification for Hydrated Lime for Masonry Purposes[2]

C 242 Terminology of Ceramic Whitewares and Related Products[3]

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of the types of tile listed in 1.1, refer to Terminology C 242.

4. Summary of Test Method

4.1 This test method consists of bonding tile under controlled conditions to a pure portland cement paste bond coat, supported by a cement mortar bed.

4.2 After proper cure of the test assembly, a load is applied to one edge of the tile and the load increased at a definite rate until the bond between tile and bond coat is broken.

4.3 Because the laboratory method of applying shear stress rapidly loads both tile and setting bed in compression, a stronger than normal setting bed for the test specimens is specified. This avoids failure of the setting bed before the desired failure at the tile-bond coat interface occurs. In real tile installations with portland cement paste an entirely different loading mechanism, usually generated primarily by shrinking of the setting bed or structural backing, results in mild tension in setting bed and mild compression in the tile, but the same type of shear stress occurs between tile and bond coat as does in response to the laboratory loading method. The finding of an adequate bond strength under the conditions of this test method can be taken as proof that the tested tile could be permanently bonded in a properly installed conventional installation using the lean, low-shrinkage mortars customarily specified for this particular purpose.

4.4 To maintain practical sample size and limit maximum breaking load, tile larger than nominal 4¼ in. (108 mm) on a side must be cut to 4 in. (102 mm).

5. Significance and Use

5.1 This test method provides a means of determining whether or not tile of the types indicated in 1.1 can be bonded with adequate strength to portland cement paste. Tile specifications can refer to this test method in order to establish minimum bond

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

[3] *Annual Book of ASTM Standards*, Vol 15.02.

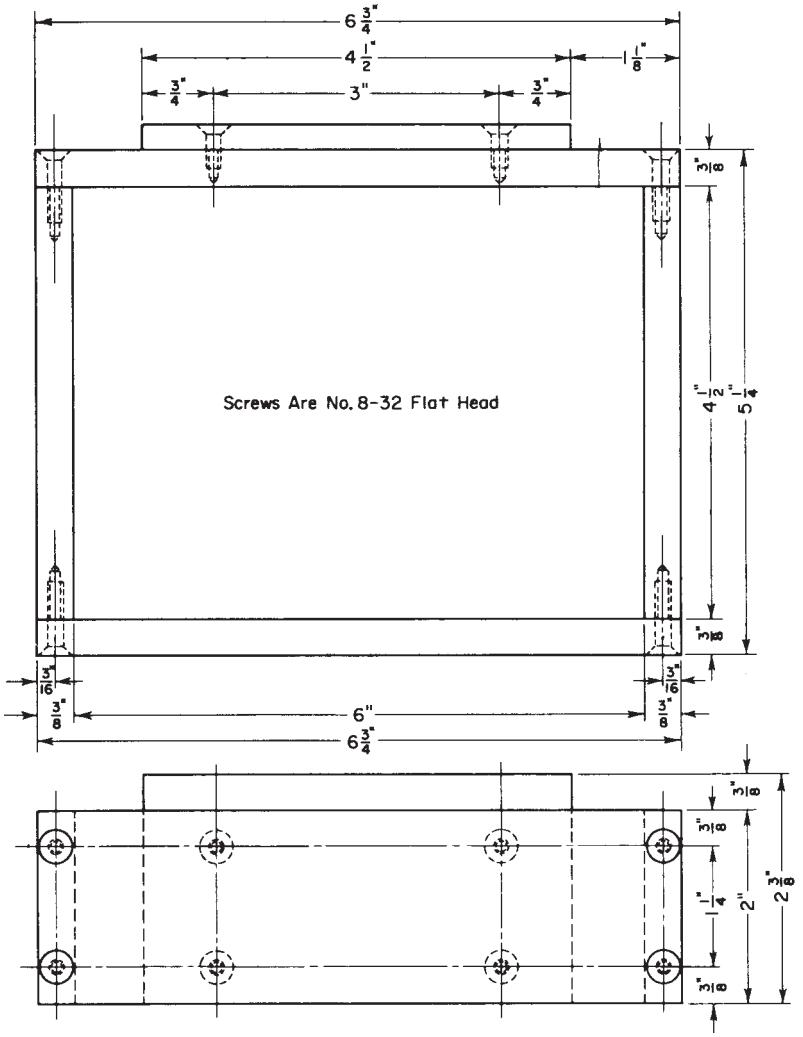
strength limits appropriate to the service conditions that are anticipated.

5.2 Separation between bond coat and setting bed, or breakage of the setting bed itself shall not be considered failures of tile bond.

6. Apparatus

6.1 *Molds*—Five frame-type molds having inside dimensions 6 by 4½ by 2 in. (152 by 114 by 51 mm) in depth. The molds shall be made of ⅜-in. (9.5-mm) thick rigid material such as brass, and the inside faces of the molds shall present a smooth surface. They shall be constructed in such a manner that they can be taken apart without damage to the molded cement block. Diagrams of suitable molds are shown in Fig. 1.

6.2 *Compression Testing Machine*—The testing machine may be either a hydraulic or screw type, with an accuracy of ±1.0 %. It shall be capable of applying a uniformly distributed shearing load at a rate of 200 ± 20 psi/min (1.4 ± 0.1 MPa/min) to the tile being tested. To obtain the actual loading rate in lbf/min (kgf/min) for a particular tile size, multiply the bonded area of the tile in square inches by 200 ± 20 (in pascals by 1.4 ± 0.1).



Metric Equivalents

Letter	in.	mm
A	3/16	4.8
B	3/8	9.5
C	6	152
D	6¾	171
E	4½	114
F	5¼	133
G	1¼	32
H	2	51

FIG. 1 Mold for Mortar Block (Five Required)

6.3 *Fixture*, for holding the specimen assembly in an upright position to prevent tilting while the specimen assembly is under load. The construction of such a fixture is shown in Fig. 2.

6.4 *Keys*—Differently sized keys, each for use with a different size range of tile, to be inserted between the edge of the bonded tile and the head of the compression testing machine. Their exact dimensions are shown in Fig. 3. Specially dimensioned keys may be required for unusual tile thicknesses.

7. Materials

7.1 *Portland Cement*—Type I of Specification C 150.

7.2 *Hydrated Lime*—Type S of Specification C 207.

7.3 *Standard Sand*—Dry, Standard Ottawa sand con-forming to the requirements given in Section 9 of Test Method C 185.

8. Test Sample

8.1 *Size of Sample*—The number of tile comprising a sample varies according to the size of the tile (see Table 1).

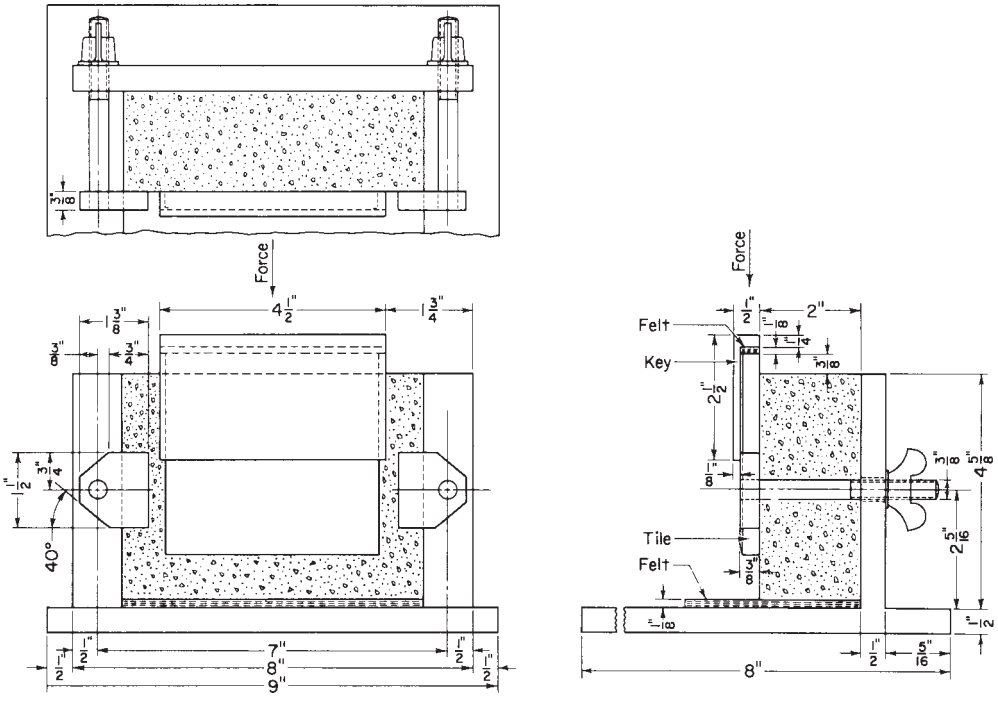
8.2 *Selection and Preparation*:

8.2.1 Tile in the number specified in 8.1 shall be selected at random from the lot to be tested.

8.2.2 Mounted tile shall be separated from one another by mechanical means, but water or other solvent shall not be used to remove the mounting media, except as directed in 8.2.4. (It is not necessary to remove mounting media completely, provided it does not interfere with the methods prescribed in either 8.2.4 or Section 9.)

8.2.3 If any dimension between opposite edges of a tile exceeds nominally 4¼ in. (108 mm), the tile shall be cut on a diamond or abrasive saw, so that the dimension is reduced to 4 in. (102 mm). Any tile that has lugs or other protuberances on its edges, or that does not have a straight, square edge, shall be trimmed with a saw ¼ in. (6.4 mm) in from an edge, and preferably, perpendicular to any directional back-pattern, to provide one smooth, straight edge.

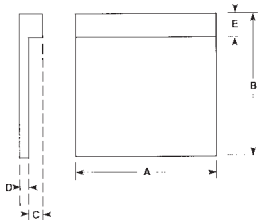
8.2.4 Tile that are cut on a saw requiring that they be wetted with water shall subsequently be thoroughly washed, rinsed at least once in clean water, and dried in an oven at a temperature of 225 ± 10°F (107 ± 5°C) for 4 h. They shall be allowed to cool to room temperature before they are set on a mortar bed. Tile cut dry shall be brushed with a dry cloth to remove dust from the bonding surface.



Metric Equivalents

Letter	in.	mm	Letter	in.	mm
A	⅜	9.5	H	9	229
B	1⅜	35	I	¼	6.4
C	¾	19	J	⅛	3.2
D	1½	38	K	2	51
E	½	13	L	1⁵⁄₁₆	33
F	7	178	M	2⁵⁄₁₆	59
G	8	203	N	4½	114

FIG. 2 Fixture for Bond Strength Test



Metric Equivalents

Tile Size, in. (mm)	A	B	C	D	E
1 1/16 (27) and smaller	3/4 (19)	1 1/8 (29)	3/16 (4.8)	1/8 (3.2)	3/8 (9.5)
1 1/8 (29) to 1 9/16 (40)	1 1/8 (29)	1 1/8 (29)	3/16 (4.8)	1/8 (3.2)	3/8 (9.5)
2 5/8 (41) to 2 1/4 (57)	1 5/8 (41)	1 3/4 (44)	3/16 (4.8)	1/8 (3.2)	3/8 (9.5)
2 5/16 (59) to 3 1/2 (88)	2 1/2 (64)	1 3/4 (44)	3/16 (4.8)	1/8 (3.2)	3/8 (9.5)
3 9/16 (90) to 4 1/4 (108) (1/4 (6.4) to 3/8 (9.5) thick)	4 1/4 (108)	2 1/2 (76)	1/4 (6.4)	1/8 (3.2)	3/8 (9.5)
3 3/4 (94) to 4 1/4 (108) (over 3/8 (9.5) thick)	4 1/4 (108)	2 1/2 (76)	3/8 (9.5)	1/8 (3.2)	3/8 (9.5)

FIG. 3 Key Detail for Fixture in Fig. 2

TABLE 1 Number of Tile per Sample

Facial Dimensions of Tile		Number of Tile per Sample
Over, in. (mm)	Not over, in. (mm)	
...	1 (25)	20
1 (25)	1 1/2 (38)	15
1 1/2 (38)	2 1/4 (57)	10
2 1/4 (57)	...	5

8.2.5 Immerse nonvitreous and semivitreous tile (tile with a water absorption over 3 %) in water for at least ½ h prior to use, and fully drain them of surface moisture before installation. Nonvitreous and semivitreous tile, mounted with water-soluble adhesive, must have mounting media and adhesive carefully and completely removed under running water before immersion to prevent contamination of the bonding surface.

9. Procedure

9.1 Lightly oil the inside surfaces of the molds to permit easy removal of the specimen assemblies after fabrication. Fill the molds, without voids, to an excess with one of the following mortars:

9.1.1 For nonvitreous tile (water absorption over 7 %): One part portland cement, 0.25 part hydrated lime, 3.30 parts dry standard sand, and 0.55 part potable water; all parts by mass.

9.1.2 For impervious, vitreous, or semivitreous tile (water absorption not over 7 %): One part portland cement, 3.30 parts standard sand, and 0.50 part potable water; all parts by mass.

9.2 Screed the surface of the mortar to receive the tile by drawing a straight-edge, resting on opposite sides of the mold, across the mold to remove the excess mortar placed therein; do not float, puddle, or trowel the surface. The prepared mortar beds must receive the tile not less than 1 h nor more than 1½ h after screeding. Use a freshly prepared, smooth paste of one part by weight of portland cement passing through a No. 200 (75-µm) sieve and 0.36 part by weight of potable water as a uniform bond coat on the surface of the prepared tile intended for bonding, in an amount sufficient to form a continuous layer not less than 1/32 in. (0.8 mm) or more than 1/16 in. (1.6 mm) over it, in addition to filling any depressions in it.

9.3 Place the tile on the mortar bed with one smooth, straight edge ¼ in. (6.4 mm) in from a 6-in. (152-mm) long edge of the mortar bed and parallel to it. Center one fifth of the tile in the sample along the edge of the mortar bed with a space between tile, when more than one tile is used, of ⅛ in. (3.2 mm) or more. Use a jig that will project over the edge of the mortar bed to facilitate placing the tile at the specified ¼ in. (6.4 mm) from, and parallel to, the edge.

9.4 Place prepared oblong tile (except nominally square tile with a trimmed edge) on the mortar bed so that their lengths will be vertical during loading. Place tile that are not rectangular so that they are loaded on a straight edge and are symmetrical about a vertical center line.

9.5 Place tile that have a directional back-pattern on the mortar bed with the direction of the back-pattern parallel to the direction of loading, except when there is conflict with the instructions in 9.4; those instructions shall take precedence.

9.6 Immediately after each tile is placed on the mortar bed in the proper position, tap it firmly to assure 100 % contact between the bond coat and the mortar bed, and then carefully remove all excess cement paste from around the edges and between the tile. Under no condition should the surface level of the mortar bed under the tile be disturbed.

9.7 Damp cure the five complete specimen assemblies in the molds for 16 to 24 h by covering them with moist cloths and polyethylene film. Remove them from the molds; cure for an additional 6 days at approximately 70°F (21°C) and at least 90 %

relative humidity prior to testing. Ninety percent relative humidity shall be obtained by wrapping the specimen assemblies immediately after removal from the molds in an impervious film or foil.

9.8 Immediately upon removing the specimen assembly from the film or foil (after 7 days total curing time), place it on edge into the holding fixture with the edge of the mortar bed from which the tile are recessed ¼ in. (6.4 mm) facing upward and the opposite edge resting on a piece of felt ⅛ in. (3.2 mm) thick (see Fig. 2). Adjust the back of the assembly to rest against the upright part of the fixture. Fasten the assembly to the fixture by means of two clamps and place the fixture with the specimen assembly in the compression testing machine. Place the appropriate key on the edge of the tile specimen, with a ⅛-in. (3.2-mm) thick felt strip between the key and the tile edge as shown in Fig. 2. Use that key which most nearly covers the full length of the tile edge to be loaded without touching adjacent tile. The key shall cover not less than 70 % of the tile edge and be centered on it. Load one specimen at a time at the rate of 200 ± 20 psi/min (1.4 ± 0.1 MPa/min) in a shear until the bond is broken.

10. Calculation

10.1 Calculate the strength of the bond, *B*, in pounds-force per square inch (or pascals), as follows:

$$B = P/A \tag{1}$$

where:
B = bond strength, psi (or Pa),
P = maximum load, lbf (or N), and
A = bonded area of the tile, $in.^2$ (or m^2).

11. Report

11.1 Report the following information:

11.1.1 Identification of the material being tested,

11.1.2 Type of design on the back of the tile and its orientation with respect to the direction of the load,

11.1.3 Bond strength in pounds-force per square inch (or pascals) for each tile,

11.1.4 Location of failure for each tile; that is in the tile itself, between tile and bond coat, between bond coat and mortar setting bed, in the setting bed itself, and

11.1.5 Average bond strength in pounds-force per square inch (or pascals) for the sample.

12. Precision and Bias

12.1 Measurements of shear bond strength between ceramic tile and portland cement mortar are not precise. The range among five or more strength determinations in a set is frequently as large as 80 % of the lower recorded strength. Accuracy is ±10 to 20 % of the average bond strength.