



Designation: C1823/C1823M – 20

## Standard Test Method for Shear Bond Strength of Adhered Dimension Stone<sup>1</sup>

This standard is issued under the fixed designation C1823/C1823M; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

### 1. Scope

1.1 This test method is used for determining the shear bond strength of dimension stone wall or floor assembly adhered to a substrate.

1.2 This test method was developed for adhered stone applications and may be used in a laboratory or in the field.

1.3 Testing is performed on cured stone assemblies on a vertical or horizontal plane in an interior or exterior application. Load is applied to one edge of the stone. The load is applied at a specified rate until the stone assembly fails.

1.4 The values stated in either inch-pound units or SI units are to be regarded separately as standard. The values stated in each system are not necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be used independently of the other, and values from the two systems shall not be combined.

1.5 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

### 2. Referenced Documents

2.1 *ASTM Standards:*<sup>2</sup>

[C119 Terminology Relating to Dimension Stone](#)

[D4580 Practice for Measuring Delaminations in Concrete Bridge Decks by Sounding](#)

<sup>1</sup> This test method is under the jurisdiction of ASTM Committee C18 on Dimension Stone and is the direct responsibility of Subcommittee C18.01 on Test Methods.

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

### 3. Terminology

3.1 *Definitions:* All definitions are in accordance with Terminology C119.

3.1.1 *adhesive, n*—a material used to bond the stone to its substrate.

3.1.2 *adhesive contact or coverage, n*—the percentage of net adhesive contact to bondable surface area.

3.1.3 *adhesive failure, n*—the failure that occurs at the interface between any two component materials of the stone assembly as a result of the specimen being subjected to a load applied by the test apparatus.

3.1.4 *bondable surface area, n*—the area of the back of a stone unit that is intended to be bonded to its substrate.

3.1.5 *cohesive failure, n*—the failure that occurs within any of the component materials of the stone assembly.

3.1.6 *gross shear bond strength, n*—the ultimate test load divided by the gross area of the test specimen.

3.1.7 *hollow sound, n*—when acoustically testing a stone surface with a hard-dense object, hearing a hollow sound might indicate that portion of the tile is not bonded or has a void beneath it.

3.1.7.1 *Discussion*—The hollow sound should have a discernibly different sound than a solid sound, but might be indicative of the underlying assembly and not relate to the tile attachment.

3.1.8 *net adhesive contact area, n*—the bondable surface area less the areas of voids in the adhesive.

3.1.9 *net shear bond strength, n*—the ultimate test load divided by the net adhesive contact areas.

3.1.10 *solid sound, n*—when acoustically testing a stone surface with a hard-dense object, hearing a solid sound might indicate that portion of the tile is bonded in those spots.

3.1.10.1 *Discussion*—The solid sound should have a discernibly different sound than a hollow sound, but might be indicative of the underlying assembly and not relate to the tile attachment.

3.1.11 *stone unit, n*—an individual tile or panel adhered to a substrate.

3.1.12 *specimen, n*—an individual stone unit, or a piece of stone that is cut from a stone unit, to be used for testing.

#### 4. Significance and Use

4.1 This test method provides a quantitative means of determining the shear bond strength between an installed adhered stone and its substrate. This test can be used as a means of determining the shear bond strength of pre-existing or recently installed stone assemblies.

4.2 The maximum stone specimen size is 6 by 6 in. [150 by 150 mm]. The size limitation is provided to establish a practical specimen size, limit maximum breaking load, and prevent out-of-plane stress.

#### 5. Apparatus

5.1 Shear Testing Apparatus (Fig. 1 and Fig. 2) shall be capable of applying a uniformly distributed load to the stone specimen, producing a steadily increasing shear stress in the tested assembly at a rate of  $100 \pm 20$  psi/min [ $0.7 \pm 0.14$  MPa/min]. Load shall be measured in lbf/min [N/min] using a calibrated indicator with an accuracy of  $\pm 1.0$  % of total load.

5.2 The application plate of the test apparatus shall be capable of uniformly loading the full width and thickness of the test specimen such that the force is applied parallel to the surface plane of the test specimen.

5.3 Loading force shall be generated by reacting against adjacent intact restraining surface (for example, adjacent stone or added bearing plate) unit.

5.4 Use load indicator that measures and records the maximum load.

5.5 Load application plate shall be of adequate thickness to minimize test apparatus deformations.

5.6 The top lip of the loading plate shall be aligned with the bottom of the test specimen. Additional plates may be necessary for proper alignment.

#### 6. Sampling, Test Specimens, and Test Units

6.1 One full stone unit shall be used for sizes up to 6 by 6 in. [150 by 150 mm]. For stone sizes that are greater than 6 by 6 in. [150 by 150 mm], the test area shall be field cut to a region



**FIG. 1 Suitable Apparatus for Shear Bond Test of Adhered Stone**

not larger than 6 by 6 in. [150 by 150 mm]. The stone shall be cut through its entire thickness. When cutting the stone, avoid cutting into the substrate.

6.2 Stone test unit locations shall be selected to provide a representative sampling of the stone under consideration. Test specimen locations shall be selected to provide a representative sampling across the full width and length of the stone unit being tested.

6.3 A minimum of five stone units shall be tested for each assembly or substrate type. Include a range of hollow to solid sounding conditions based on an acoustical survey.

6.4 The joint into which the loading apparatus is inserted must be wide enough to accommodate the apparatus loading and reaction plates. Each stone test specimen must be completely separated from the adjacent stones to the extent that you can verify the depth of the cut.

6.5 The testing apparatus loading frame shall sit flush against the stone face. Stones with faces that are not flat shall be ground flat prior to testing.

#### 7. Preparation

7.1 Adjust the loading plate, so that the loading lip's depth reaches the bottom of the stone specimen's edge within  $\frac{3}{32}$  in. [2.4 mm] of the bottom of the stone, but is not greater than the thickness of the stone specimen.

7.2 If necessary, an independent reaction plate attached to the substrate can be used to act as a bearing surface to react against when applying the shear load to the specimen.

#### 8. Conditioning

8.1 Conduct test after the setting materials have cured according to manufacturers' directions.

8.2 Before testing in cold or wet weather, extended cure time should be allowed in accordance with setting material manufacturer's instructions.

#### 9. Procedure

9.1 Select test units and assign unique numbers to each test specimen.

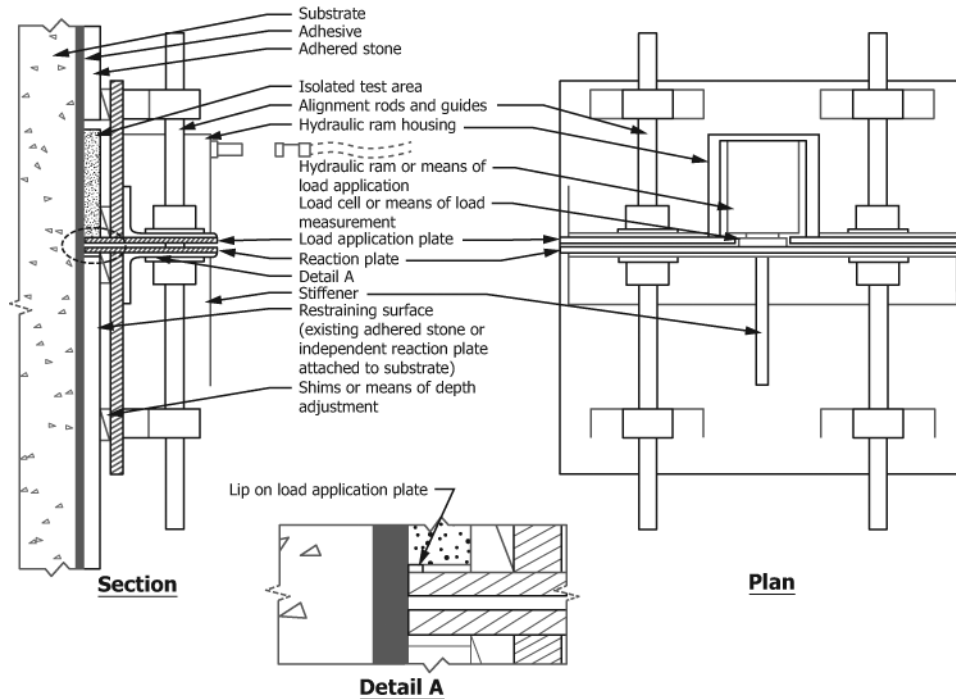
9.2 Acoustically survey the stone surface following sounding procedures described in Practice D4580 to identify solid-sounding areas versus hollow-sounding areas that can be relevant and indicate areas that may not be bonded.

9.3 Adjust the reaction plate so that the force is applied equally along the length and full depth of the stone test specimen's edge. Adjust as necessary to ensure that it extends within  $\frac{3}{32}$  in. [2.4 mm] of the full depth of the stone unit, but does not extend beyond the back face of the stone.

9.4 To apply the shear force to the stone being tested, there must be a stable reaction surface for the testing apparatus to bear against (for example, adjacent stone or added bearing plate).

9.5 Apply a load at a rate that produces a shear stress in the test specimen of  $100 \pm 20$  psi/min [ $0.7 \pm 0.14$  MPa/min]. Apply the load uniformly along the entire edge and parallel to

**Schematic Shear Bond Test Apparatus**



**FIG. 2 Diagram of an Example Apparatus for Shear Bond Test of Adhered Stone**

the face of the stone test specimen to avoid any out of plane force to the specimen.

9.6 Continue to apply the load until failure occurs.

9.7 Observe and record the failure load applied to each specimen.

9.8 Observe and record the area of adhesive coverage between the untested portion of stone and substrate, which will require the removal of the stone. Record the percentage of adhesive that remains bonded to both the specimen and substrate, if any. See Fig. 3 for an example of a method for recording the percentage of adhesive bond for a 6 by 6 in. [150 by 150 mm] area. Other methods can be utilized.

9.9 Record the thickness range of the adhesive material within 1/32 in. [2.4 mm], which may require its partial removal.

9.10 Remove entire stone unit.

9.11 Record the location and type of failure for each specimen (and each respective area of failure type as a percentage of the total area if multiple failure types occurred). See Fig. 4.

9.12 Record environmental conditions and surface temperature of specimen.

**10. Calculation**

10.1 Calculate gross shear bond strength in pounds-force per square inch [or MPa] for each test specimen as follows:

$$B_g = P/A_g \quad (1)$$

where:

- $B_g$  = gross shear bond strength, psi [MPa],
- $P$  = ultimate test load, lbf [N], and
- $A_g$  = gross area of test specimen, in.<sup>2</sup> [mm<sup>2</sup>].

10.2 Use the recorded area of adhesive coverage from 9.8 to determine net adhesive contact area. Net adhesive contact area is the difference between the surface area of the tested specimen minus the surface areas of the voids.

10.3 Calculate net shear bond strength in psi [MPa] for each test specimen as follows:

$$B_n = P/A_n \quad (2)$$

where:

- $B_n$  = net shear bond strength, psi [MPa],
- $P$  = ultimate test load, lbf [N], and
- $A_n$  = net adhesive contact area, in.<sup>2</sup> [mm<sup>2</sup>].

10.4 Calculate the net adhesive contact area as a percentage of the surface area of each stone specimen tested. Net adhesive contact area is the difference between the surface area of the tested specimen minus the surface areas of the voids

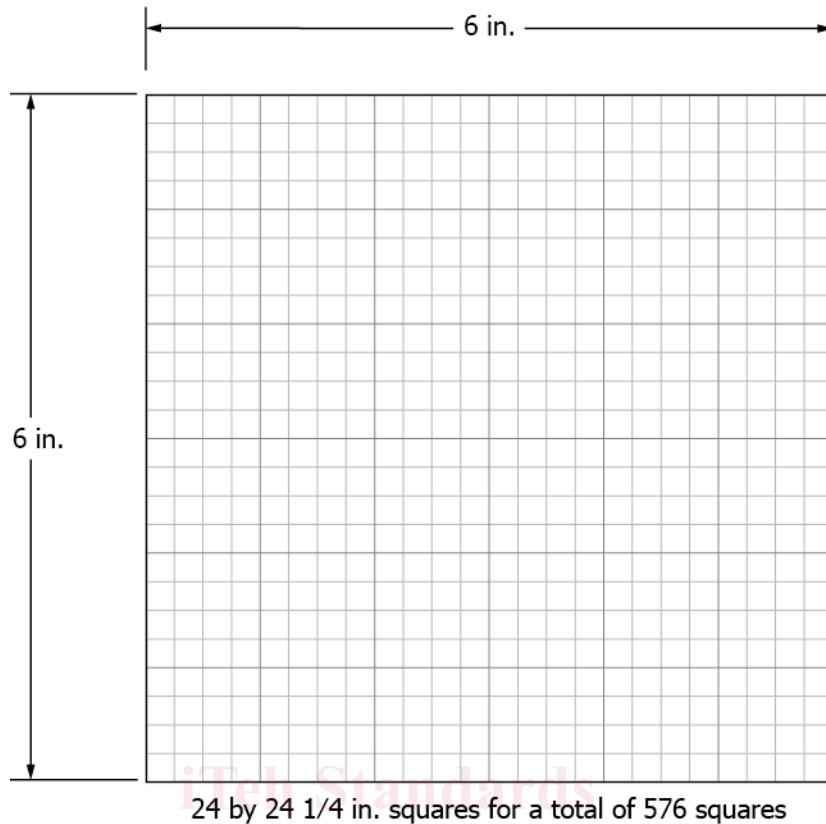
**11. Report**

11.1 Report the following information:

11.1.1 Testing agency and personnel responsible for the test results.

11.1.2 Location of test (for example, building name and address).

11.1.3 Identification of the stone material being tested. Include geological classification or material type, if known.



Darken the squares where adhesive bond was achieved. Estimated bond area percentage is the total number of darkened squares divided by 576 total squares multiplied by 100.

**FIG. 3 Failure Coverage Area Chart**

11.1.4 List the size of stone unit being tested; width, length, and thickness.

11.1.5 Identify adhesive material and all other installation materials used in the assembly, by type, or name if known.

11.1.6 Identify substrate and supporting elements by type and thickness.

11.1.7 Specific location of test unit(s) on building.

11.1.8 Date and time of test.

11.1.9 Age of installation or length of cure time of adhesive material at time of test.

11.1.10 Environmental conditions at time of test (that is, temperature, precipitation, humidity, etc.).

11.2 Report the following information for each tested stone unit:

11.2.1 List the unique identifying stone unit numbers.

11.2.2 List the number of test specimens tested per unit.

11.2.3 Report acoustical survey results of solid sounding areas versus hollow sounding areas and indicate if there is any correlation to the shear bond test results or adhesive coverage of the tested specimen.

11.3 Report the following information for each specimen tested:

11.3.1 Unique identifying test specimen number.

11.3.2 Location of test specimen relative to overall stone unit dimensions. Provide sketch of location if needed.

11.3.3 Thickness of adhesive material at test specimen.

11.3.4 Observed estimated percent adhesive contact area of entire stone based on all exposed areas examined, including tested and untested areas of the tested specimen.

11.3.5 Condition of test specimen and assembly components (for example, moisture conditions).

11.3.6 Gross area of test specimen (width by length).

11.3.7 Void area of adhesive for test specimen (non-adhesive contact between stone and its substrate).

11.3.8 Net adhesive contact area for test specimen (gross area of test specimen minus void area of adhesive for test specimen).

11.3.9 Percent area of adhesive contact to back of test specimen (net adhesive contact area for test specimen divided by gross area of test specimen).

11.3.10 Ultimate test load (failure load) in pounds-force (lbf) or newtons [N].

11.3.11 Calculated gross shear bond strength in pounds-force per square inch [megapascal - MPa] (ultimate test load divided by gross area of test specimen) for each individual test and average of all tests for each respective unit and application.

11.3.12 Calculated net shear bond strength in pounds-force per square inch [megapascal - MPa] (ultimate test load divided by net adhesive contact area for test specimen) for each individual test and average of all tests for each respective unit and application.