



Designation: C1781/C1781M – 21

Standard Test Method for Surface Infiltration Rate of Permeable Unit Pavement Systems¹

This standard is issued under the fixed designation C1781/C1781M; 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 the determination of the field surface infiltration rate of in place permeable unit pavement systems surfaced with solid interlocking concrete paving units, concrete grid paving units, or clay paving brick.

NOTE 1—For in-place pervious concrete, Test Method C1701/C1701M should be used. Test Method C1701/C1701M is functionally identical to this standard, but does not include the added provisions for positioning and securing the test ring to a discontinuous surface, which are detailed in this standard. Both tests methods give comparable results

1.2 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.

1.3 The text of this test method references notes that provide explanatory material. These notes shall not be considered as requirements of the test method.

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

1.5 *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.*

¹ This test method is under the jurisdiction of ASTM Committee C15 on Manufactured Masonry Units and is the direct responsibility of Subcommittee C15.04 on Research.

Current edition approved Dec. 1, 2021. Published December 2021. Originally approved in 2013. Last previous edition approved in 2018 as C1781/C1781M – 18¹. DOI: 10.1520/C1781_C1781M-21.

2. Referenced Documents

2.1 *ASTM Standards:*²

C902 Specification for Pedestrian and Light Traffic Paving Brick

C920 Specification for Elastomeric Joint Sealants

C936/C936M Specification for Solid Concrete Interlocking Paving Units

C1232 Terminology for Masonry

C1272 Specification for Heavy Vehicular Paving Brick

C1319 Specification for Concrete Grid Paving Units

C1701/C1701M Test Method for Infiltration Rate of In Place Pervious Concrete

2.2 *Other Standards:*³

Federal Specification A-A-3110 (TT-P-1536A) Plumbing Fixture Setting Compound

3. Terminology

3.1 The terms used in this test method are defined in Terminology C1232.

3.2 *Definitions:*

3.2.1 *permeable unit pavement system, n*—pavement with wearing surface made from clay or concrete units that allows infiltration of water through open-graded aggregate in the joints, cores, or other openings, to a bed, base, and subbase, or combinations thereof.

3.2.1.1 *Discussion*—Permeable pavement systems are utilized to reduce stormwater runoff. Permeable pavements have wearing surfaces with high initial water infiltration through open spaces filled with aggregates to drain water into open-graded bedding and base materials. The open spaces in the

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 Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098, http://dodssp.daps.dla.mil.

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

wearing surface are designed to enable sufficient infiltration rates to handle runoff from designated storm types (for example, 1 year, 24-hour event). With unit pavers the open spaces can be achieved with exposed coring, a specially-shaped perimeter configuration, or wider joints, or combinations thereof. Permeable pavement systems can also be made with standard units and a laying pattern that permits sufficient water entry.

4. Summary of Test Method

4.1 An infiltration ring is temporarily sealed to the surface of a permeable unit pavement system. These pavements typically consist of solid concrete paving units conforming to Specification C936/C936M, concrete grid paving units conforming to Specification C1319, or clay paving brick conforming to Specification C902 or C1272. These pavements allow drainage through joints between the units or through voids formed by the intersection of two or more units or intentionally manufactured into the units. The results of this test method for unit pavement systems can be compared to that using Test Method C1701/C1701M for pervious concrete. After pre-wetting the test location, a given mass of water is introduced into the ring and the time for the water to infiltrate the pavement is recorded. The infiltration rate is calculated in accordance with 9.1.

5. Significance and Use

5.1 This test method can be used for acceptance of surface infiltration of new permeable unit pavement systems.

5.2 Tests performed at the same location across a span of years may be used to detect a reduction of infiltration rate of the permeable surface, thereby identifying the need for any remedial maintenance intended to increase the infiltration rates to predefined levels.

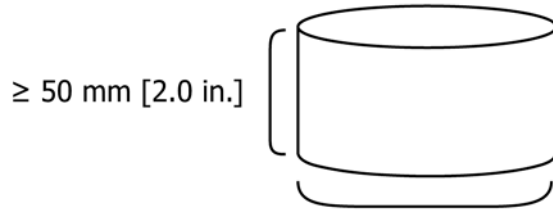
5.3 The infiltration rate obtained by this method is valid only for the localized area of the pavement where the test is conducted. To determine the surface infiltration rate of the entire permeable pavement, multiple locations must be tested and the results averaged.

5.4 The minimum acceptable infiltration rate is typically established by the design engineer of record or the municipality and can be a function of the design precipitation event.

5.5 This test method can also be used to demonstrate the infiltration rate of a particular permeable unit pavement system if the drainage joints are filled with the aggregate that is specified for use in that system.

6. Apparatus

6.1 *Infiltration Ring*—A cylindrical ring, open at both ends (See Fig. 1). The ring shall be watertight, sufficiently rigid to retain its form when filled with water, and shall have a diameter of 300 ± 10 mm [12.0 ± 0.5 in.] with a minimum height of 50 mm [2.0 in.]. The bottom edge of the ring shall be even. The inner surface of the ring shall be marked or scored with two lines at a distance of 10 and 15 mm [0.40 and 0.60 in.] from the bottom of the ring. Measure and record the inner diameter of the ring to the nearest 1 mm [0.05 in.].



300 mm +/- 10 mm [12.0 in. +/- 0.5 in.]

FIG. 1 Dimensions of Infiltration Ring

NOTE 2—Ring materials that have been found to be suitable include steel, aluminum, rigid plastic, and PVC.

6.2 *Balance*—A balance or scale accurate to 0.05 kg [0.1 lb].

6.3 *Container*—A cylindrical container typically made of plastic having a volume of at least 20 L [5 gal], and from which water may be easily poured at a controlled rate into the infiltration ring.

6.4 *Stop Watch*—Accurate to 0.1 s.

6.5 *Plumbers Putty (Non-Hardening)*—Meeting Specification C920 or Federal Specification A-A-3110.

6.6 *Water*—Potable water.

7. Test Locations

7.1 Perform tests at multiple locations at a site as requested by the purchaser of testing services. Unless otherwise specified, use the following to determine the number of tests to perform:

7.1.1 Three test locations for areas up to 2500 m² [25 000 ft²].

7.1.2 Add one test location for each additional 1000 m² [10 000 ft²] or fraction thereof.

7.2 Provide at least 1 m [3 ft] clear distance between test locations, unless at least 24 h have elapsed between tests.

8. Procedure

8.1 Clean the pavement surface by only sweeping off trash, debris, and other non-seated material.

8.2 If the test is being conducted to demonstrate the infiltration rate of a particular permeable unit pavement system, fill the drainage joints with the aggregate specified for use in that system (see Note 3).

NOTE 3—The performance of any permeable unit pavement system is related to the interaction of the paving units with the aggregate that is used to fill the drainage joints. When conducting tests to document the performance of a particular permeable unit pavement system, tests should not be conducted with empty or partially filled drainage joints as this will yield unrealistically high drainage rates that are not representative of the complete system.

8.3 Take a photograph of the immediate area to be tested to document the pavement pattern and layout. Move the ring over the surface of the pavement until the pattern, drainage joints and drainage voids framed within the infiltration ring are representative of the entire paving pattern, drainage joints and drainage voids across the pavement surface. Set the ring on the pavement surface and mark its location by circumscribing it

with chalk or other temporary marking. Take a photograph of the circumscribed chalk or temporary marking to document the placement of the ring relative to the pavement pattern and layout (see [Note 4](#)).

NOTE 4—The procedure in [8.3](#) for selecting and documenting the placement of the infiltration ring on a representative area of the pavement is sufficient in most cases for determining the infiltration rate of the pavement. The drainage area within the infiltration ring is typically within $\pm 20\%$ of the average drainage area of the pavement as a whole. This accuracy is adequate for most situations. If a more accurate quantification of the infiltration rate is needed, the procedure detailed in [Appendix XI](#) can be used to normalize the drainage area within the infiltration ring to the average drainage area of the pavement as a whole.

8.4 For solid interlocking concrete paving units and clay brick paving, remove aggregate to a depth of no greater than 10 mm [0.5 in.] in any joint or drainage void that will be directly below the test ring and fill these areas with plumbers putty so that a positive seal can be made to the test ring once it is placed on the surface. Take care not to extend the plumbers putty more than 10 mm [0.5 in.] inside the perimeter of the chalk line or other temporary marking. For concrete grid paving units, center as much of the ring as possible on the webs. For ring locations over openings, remove any vegetation, if present, directly below the test ring to a depth of no greater than 10 mm [0.5 in.] and apply plumbers putty to the surface of the soil, or to the aggregate, if present, so that a positive seal can be made to the test ring once it is placed on the surface. Take care not to extend the plumbers putty more than 10 mm [0.5 in.] inside the perimeter of the chalk line or other temporary marking.

8.5 Infiltration Ring Installation—Apply plumbers putty around the bottom edge of the ring and place the ring onto the surface being tested. Press the putty into the surface and around the bottom edge of the ring to create a watertight seal making sure that the putty does not extend more than 10 mm [0.5 in.] inside the perimeter of the ring. Place additional putty as needed to ensure a watertight seal.

NOTE 5—In a hot environment or when the surface temperature is over 38°C [100°F] plumbers putty may not adhere to the surface of the pavement easily. Therefore it is advisable to perform this test during a cooler temperature.

8.6 Prewetting—Pour water into the ring at a rate sufficient to maintain a head between the two marked lines. Take care to pour the water such that it falls directly on the surface of a paving unit and not onto the joints. This minimizes displacement of jointing aggregate and any accumulated sediment in the joints during the test (see [Note 6](#)). Use a total of 3.60 ± 0.05 kg [8.0 \pm 0.1 lb] of water. Begin timing as soon as the water impacts the permeable pavement surface. Stop timing when free water is no longer present on the surface. Record the amount of elapsed time to the nearest 0.1 second.

NOTE 6—It is recommended that the pour height be limited to a maximum of 150 mm [6.0 in.] above the surface of the paving units to minimize disruption.

8.7 Test—The test shall be started within 2 min after the completion of the prewetting. If the elapsed time in the prewetting stage is less than 30 s, then use a total of 18.00 ± 0.25 kg [40.00 \pm 0.5 lb] of water. If the elapsed time in the prewetting stage is greater than or equal to 30 s, then use a total

of 3.60 ± 0.05 kg [8.0 \pm 0.1 lb] of water. Record the weight of water to the nearest 0.05 kg [0.1 lb]. Pour the water onto the ring at a rate sufficient to maintain a head between the two marked lines and until the measured amount of water has been used. Take care to pour the water such that it falls directly on the surface of a paving unit and not onto the joints. This minimizes displacement of jointing aggregate and any accumulated sediment in the joints during the test (see [Note 7](#)). Begin timing as soon as the water impacts the permeable pavement surface. Stop timing when free water is no longer present on the surface. Record the testing duration (*t*) to the nearest 0.1 second.

NOTE 7—If a sloped pavement is being measured, maintain head between the two marked lines at the lowest point of the slope.

8.8 If a test is repeated at the same location, the repeat test does not require pre-wetting if conducted within 5 min after completion of the first test. If two tests are conducted at a location on a given day, the infiltration rate at that location on that day shall be calculated as the average of the two tests. No more than two tests shall be conducted at the same location on the same day.

8.9 When completed with testing, remove plumbers putty from the joints and surface, reinstate the removed aggregate jointing materials, and sweep test area clean.

9. Calculation

9.1 Calculate the infiltration rate (*I*) using consistent units as follows:

$$I = KM/(D^2 * t) \quad (1)$$

where:

I = Infiltration rate, mm/h [in./h],

M = Mass of infiltrated water, kg [lb],

D = Inside diameter of infiltration ring, mm [in.],

t = time required for measured amount of water to infiltrate the surface, s, and

K = 4 583 666 000 in SI units or 126 870 in [inch-pound] units.

NOTE 8—The factor *K* has units of (mm³s)/(kgh) [(in.³s)/(lbh)] and is needed to convert the recorded data (*W*, *D*, and *t*) to the infiltration rate *I* in mm/h [in./h].

10. Report

10.1 Report the following information:

10.1.1 Identification number,

10.1.2 Location,

10.1.3 Date of test,

10.1.4 Illustration of test site including approximate size and test ring locations,

10.1.5 Age, type and thickness of paving units (label Unknown if not known),

10.1.6 Description of aggregate used in drainage joints and condition of joints (see [Note 9](#)).

10.1.7 Include a photograph of the immediate area that was tested to document the pavement pattern and layout and a photograph of the circumscribed chalk or temporary marking to document the placement of the ring relative to the pavement pattern and layout,

- 10.1.8 Time elapsed during prewetting, s,
- 10.1.9 Amount of rain during last event, if known, mm [in.],
- 10.1.10 Weight of infiltrated water, kg [lb],
- 10.1.11 Inside diameter of infiltration ring, mm [in.],
- 10.1.12 Time elapsed during infiltration test, s,
- 10.1.13 Infiltration rate, mm/h [in./h], and
- 10.1.14 Number of tests performed at each location, if applicable.

NOTE 9—Describe the size and shape of aggregate, if possible, and the condition of the joints such as how full they are, if they are visibly clogged with sediment, etc.

11. Precision and Bias^{4,5}

11.1 The following precision statements are based on duplicate measurements done at 74 locations on 37 different

⁴ Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:C15-1000. Contact ASTM Customer Service at service@astm.org.

⁵ Further discussion on developing the Precision and Bias Statements can be found in: Walloch, Craig, Brown, Heather J., and Smith, David R., "Development of a New Test Method for Determining the Surface Infiltration Rate of Permeable Unit Pavement Systems," *Symposium on Masonry 2014*, ASTM STP 1577, ASTM, 2014.

permeable unit pavement systems with average infiltration rates ranging from 30 to 1600 in./h by two separate operators:

11.1.1 The 95 % Confidence Limit (CL) for single-operator repeatability (r) averages 7.7 % with a median value of 5.9 %.

11.1.2 The 95 % CL for the multiple-operator reproducibility (R) averages 19.8% with a median value of 10.0%.

11.2 Based on the average results of four measurements at each of two locations on 37 different permeable unit pavement systems with average infiltration rates ranging from 30 to 1600 in./h, the difference between average results at the two locations averages 19.1 % with a median value of 12.2 %.

11.3 This test method has no bias because the infiltration rate of permeable unit pavement systems is defined only in terms of this test method.

12. Keywords

12.1 clay paving units; concrete grid paving units; concrete paving units; infiltration; permeable; unit pavement systems; water

APPENDIX

(Nonmandatory Information)

X1. PROCEDURE FOR NORMALIZATION OF DRAINAGE AREA WITHIN THE INFILTRATION RING TO THE AVERAGE DRAINAGE AREA OF THE PAVEMENT AS A WHOLE

X1.1 Scope

X1.1.1 The procedure in 8.3 for selecting and documenting the placement of the infiltration ring on a representative area of the pavement is sufficient in most cases for determining the infiltration rate of the pavement. The drainage area within the infiltration ring is typically within ± 20 % of the average drainage area of the pavement as a whole. This accuracy is adequate for most situations. If a more accurate quantification of the infiltration rate is needed use the procedure detailed in this appendix to normalize the drainage area within the infiltration ring to the average drainage area of the pavement as a whole.

X1.1.2 The provisions in this appendix cover two basic drainage methods: the first in which the system is designed to drain through the joints between units and the second in which the system is designed to drain through voids that are formed at the intersection of two or more units or that are intentionally manufactured into the units.

X1.1.3 For systems designed to drain through joints between the units, for the sake of simplicity, the drainage area is estimated by measuring the total linear drainage joint length. This assumes that the joint width is designed to be consistent across the field of the pavement. This removes the necessity of measuring the width of each individual joint.

X1.1.4 For systems designed to drain through voids that are formed at the intersection of two or more units or that are

intentionally manufactured into the units, for the sake of simplicity, the drainage area is estimated by the counting the number of voids in a given area. This assumes that the voids are designed to be consistent in size across the field of the pavement. This removes the necessity of determining the area of each individual void.

X1.1.5 For systems designed to drain through a combination of joints and voids or in which the joints or voids are of different widths or sizes, the drainage area can be determined by calculating the area of each joint and void within a given area and summing the areas together. These areas could then be used in calculations analogous to the ones shown in this appendix to normalize the drainage area within the infiltration ring to the average drainage area of the pavement as a whole.

X1.2 Procedure

X1.2.1 Determine the amount of drainage area per surface area of pavement as follow:

X1.2.1.1 For systems designed to drain through joints between the units, mark off with chalk or other temporary marking an area of pavement that has minimum dimensions of 1.5 by 1.5 m [5 by 5 ft] (see Note X1.1). The edges of the marked area shall not coincide with a continuous drainage joint. Measure and record as L_a in cm [in.] the length of the marked off region. Measure and record as W_a in cm [in.] the width of the marked off region. Measure and record as L_d in cm