



Designation: C1645 – 22a

# Standard Test Method for Freeze-thaw and De-icing Salt Durability of Solid Concrete Interlocking Paving Units<sup>1</sup>

This standard is issued under the fixed designation C1645; 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 evaluates the resistance to freezing and thawing of solid interlocking concrete paving units conforming to the dimensional requirements of Specification C936/C936M. Units are tested in a test solution that is either tap water or 3 % saline solution, depending on the intended use of the units in actual service.

1.2 The values stated in SI units are to be regarded as standard. The values given in parentheses after SI units are provided for information only and are not considered standard.

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

1.4 *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>

C936/C936M Specification for Solid Concrete Interlocking Paving Units

## 3. Significance and Use

3.1 This test method is intended to determine the effects of freezing and thawing on units conforming to the dimensional requirements of Specification C936/C936M while immersed in a test solution. Other types of segmental concrete paving units

<sup>1</sup> This test method is under the jurisdiction of ASTM Committee C15 on Manufactured Masonry Units and is the direct responsibility of Subcommittee C15.03 on Concrete Masonry Units and Related Units.

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<sup>2</sup> 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.

that do not conform to the dimensional requirements of Specification C936/C936M may be tested using this test method.

3.2 The results from this test method are not intended to provide a quantitative measure of the length of service from concrete paving units conforming to the dimensional requirements of Specification C936/C936M.

## 4. Apparatus

4.1 *Freezing-and-Thawing Apparatus*—The freezing apparatus shall consist of suitable cabinet or cold room with controls to reach and maintain within 1 h of introduction of specimens an air temperature of  $-5 \pm 3^\circ\text{C}$  ( $23 \pm 5^\circ\text{F}$ ) at all locations within the chamber regardless of the number of specimens in the chamber. The thawing chamber shall maintain a controlled air temperature. This temperature shall never be greater than  $+30^\circ\text{C}$  ( $86^\circ\text{F}$ ).

4.2 *Balance*—A balance capable of weighing 500 g with an accuracy of  $\pm 0.1$  g shall be used for measuring the mass of the fine spalled material.

4.3 *Drying Oven*—A ventilated oven of appropriate size capable of maintaining a uniform temperature of  $110 \pm 5^\circ\text{C}$  ( $230 \pm 9^\circ\text{F}$ ).

4.4 *Specimen Container*—The specimen container shall be made of non-corroding flexible material and have dimensions that allow complete submersion of the specimen in the test solution. The size of the container shall be less than or equal to three times the volume of the unit that is being tested. The container shall prevent evaporation of the test solution.

## 5. Sampling

5.1 *Selection of Test Specimens*—Select whole units representative of the lot from which they are selected. The units shall be free from visible cracks, chipped edges, and structural defects.

5.2 *Number of Test Specimens*—Sample according to the requirements of Specification C936/C936M.

5.3 *Identification*—Mark each test specimen so that it is identifiable at any time.

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

## 6. Preparation of Test Specimens

6.1 *Sampling*—When possible, specimens shall be full-sized units. When the units cannot be tested full-size due to specimen configuration or lack of suitable specimen containers, obtain a specimen by saw-cutting a full-height coupon with a surface area of at least 190 cm<sup>2</sup>. Test specimens shall be a minimum of 28 days old before freeze-thaw cycling begins.

6.2 *Curing*—All samples shall be moist cured as specified in 6.2.2 for 14 ± 1 days then air cured as specified in 6.2.3 for a minimum of 14 days prior to testing.

6.2.1 The manufacturer of the pavers shall have the option to waive curing of the test specimens as specified in 6.2. In that case, specimens shall be air cured for a minimum of 48 h as specified in 6.2.3 prior to testing.

6.2.2 *Moist Curing*—Moist curing shall be carried out in a moist chamber (cabinet or room), which shall maintain a controlled air temperature of 23 ± 2°C (73 ± 4°F) and a relative humidity of at least 90 %. Alternatively, the units shall be stored by submerging them in a saturated lime solution maintained at 23 ± 2°C (73 ± 4°F).

6.2.3 *Air Curing*—Air curing shall be carried out in lab conditions at 24 ± 8°C (75 ± 15°F) and a relative humidity of no less than 40 % nor greater than 80 %.

6.3 Before testing begins, the specimens shall be brushed clean with a stiff bristled brush and all loose burrs and edge shards shall be removed with a carborundum stone.

## 7. Procedure

7.1 *Freezing and Thawing Cycles*—One freeze-thaw cycle shall be completed every 24 h. The cycle shall consist of 16 ± 1 h of freezing followed by 8 ± 1 h of thawing. The specimens shall be subjected to continuous cycles. If for reasons beyond the operator's control, a freezing period cannot commence at the specified time, the specimens shall remain in a thawed condition until conditions are suitable for resumption of the test but not longer than 96 h. The specimen temperature shall conform to -5 ± 3°C (23 ± 5°F) for the last 7 to 12 h of the freezing cycle and a minimum of +5°C (40°F) for the last 1 h of the thawing cycle. The temperature shall be recorded at least every 15 min in the smallest and largest specimen (by weight) within the apparatus with a temperature probe that is insulated from cabinet air and rests against, below, or inside a specimen.

7.2 *Specimen Containment*—Immediately following completion of the conditioning, each specimen shall be centered with the wearing surface facing upwards in individual containers. The supported bottom surface of the specimens shall rest on solid, noncorrosive, nonabsorptive (for example, glass, stainless steel, ceramic, plastic, etc.) spacers approximately 5 mm high to ensure exposure of at least 95 % of the bottom surface to the test solution. A minimum of 5 mm clearance shall be provided between the specimen and the container in all directions.

7.3 *Test Solution*—The test solution shall be tap water or saline as requested by the client. If the test solution is saline, containers shall be filled with 3 ± 0.1 % (by weight) NaCl solution. The test solution (tap water or saline) shall have a temperature of 24 ± 8°C. The level of the test solution shall be

5 ± 1 mm above the top surface of the specimens (Note 1). After filling the containers, they shall be immediately closed to minimize evaporation and the closed containers left at a temperature of 24 ± 8°C for 24 ± 1 h. After the 24 h soak period, check the level of the test solution and add additional test solution as needed to maintain the required level of 5 ± 1 mm above the surface of the specimens.

NOTE 1—Excess test solution volume should be avoided in order to ensure rapid freezing of the specimens. Likewise, choose a container with a plan area similar to the test specimen to minimize excess test solution.

7.4 *Temperature Monitoring*—Following the 24-h saturation period, the specimens shall be subjected to continuous freeze-thaw cycles. The ambient temperature in the freeze-thaw apparatus, as well as those of the specimen, shall be continuously measured at least every 15 min and recorded. If for any reason, except for residue collection, continuous 24-h cycles cannot be maintained, then this shall be noted in the report.

7.5 *Collection of Residue*—After 7, 28, and (if necessary) 49 cycles, the specimens shall be washed with test solution (tap water or saline, as appropriate) to remove all loose particles. These particles and spalled material collected at the bottom of the containers shall be filtered using a sieve or filter paver with a maximum opening of 80 μm and washed with tap water to remove any soluble salts (Note 2). Dry all the filter paper and residue (spall) collected from each specimen in the drying oven for not less than 4 h and until two successive weighings at intervals of 2 h ± 15 min show an increment of loss not greater than 0.2 % of the last previously determined weight. Place the filter paper and residue in a draft-free location within the laboratory for a period of 2 h ± 15 min to allow the filter paper and residue to come to equilibrium temperature with the laboratory environment. Weigh the filter paper and residue to the nearest 0.2 g and record as  $W_{f+r}$ . Calculate the residue weight,  $W_r$ , as follows:

$$W_r = W_{f+r} - W_f \quad (1)$$

where:

$W_r$  = weight of residue (spall), g,

$W_{f+r}$  = weight of the dried residue and filter paper, g, and

$W_f$  = initial weight of the filter paper, g.

NOTE 2—A 75-μm (No. 200) sieve is acceptable for residue collection.

7.5.1 Provide a new test solution following each determination of loss of mass. The 24-h presoaking period shall be waived following 7 and 28 cycles provided that the specimens are maintained in a saturated condition during mass determination.

7.5.2 Every time a container is replaced into a multi-level freezing test chamber, the container shall be placed on the level immediately above the level on which it was previously located. If the container was previously located on the top level of a multi-level freezing chamber, replace it onto the bottom level. Also rotate containers from front-to-back and left-to-right when moving to a new shelf.

7.5.3 The test shall continue until 28 freeze-thaw cycles have been completed or if the average mass loss for all specimens tested is greater than 225 g/m<sup>2</sup>. If the average mass loss exceeds 225 g/m<sup>2</sup>, the test shall continue until 49 freeze-thaw cycles have been completed. If at any time the average

mass loss for all specimens tested is greater than 500 g/m<sup>2</sup> or disintegration of the specimens necessitates the premature termination of testing, the mass loss shall be determined and added to the previously lost mass.

## 8. Calculation and Report

8.1 The weight of all collected residue shall be measured and recorded as  $W_r$  to the nearest 0.2 g.

8.2 The total surface of the paver shall be calculated by one of the following methods:

8.2.1 Sum the calculated area of all surfaces from the specified shape and dimensions shown in the manufacturer's mold drawings.

8.2.2 Sum the calculated areas of all surfaces as determined from the measured dimensions of the test specimens taken before the beginning of testing.

8.2.3 For rectangular-shaped specimens, calculate the total surface area prior to testing using the length, width and thickness measurements in millimetres as determined in accordance with Test Method C140, Annex A4 with the following formula:

$$\begin{aligned} \text{Surface area}(A_s) &= (L_s \times W_s + L_s \times T_s + W_s \times T_s) \quad (2) \\ &= 2 \times (L_s \times W_s + T_s \times (L_s + W_s)) \end{aligned}$$

where:

$L_s$  = length of the specimen, mm,  
 $W_s$  = width of the specimen, mm, and  
 $T_s$  = thickness of the specimen, mm.

8.3 Calculate the mass loss to the nearest 1 g/m<sup>2</sup> using the following equation:

$$\text{Mass loss (ML), g/m}^2 = (W_r \times 1,000,000)/A_s \quad (3)$$

where:

$W_r$  = weight of collected residue (g) and  
 $A_s$  = calculated surface area (mm<sup>2</sup>).

8.4 *The report shall include the following:*

8.4.1 Name of client and manufacturer;

8.4.2 The date of manufacture and sampling;

8.4.3 Plant or field sampling;

8.4.4 The batch number;

8.4.5 Identification of specimens and color;

8.4.6 Dimensions and total surface area of the specimens and whether the dimensions were determined from the manufacturer's mold drawings or by measurement;

8.4.7 Cumulative mass lost by each specimen and the average results after 7, 28, and 49 (if necessary) cycles or at the time of termination of the test;

8.4.8 Dates of the beginning and end of the test;

8.4.9 The number of cycles at termination;

8.4.10 A description of the damage suffered by the specimens, with photographs where possible; and

8.4.11 Any deviations from this testing procedure.

## 9. Precision and Bias

9.1 Precision and bias data for this test method is not yet available.

## 10. Keywords

10.1 freeze-thaw durability; interlocking concrete pavers

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## SUMMARY OF CHANGES

Committee C15 has identified the location of selected changes to this standard since the last issue (C1645 – 22) that may impact the use of this standard. (December 1, 2022)

(1) Revised 6.2 and added 6.2.1 to clarify the curing requirements including when the curing is waived by the manufacturer.

Committee C15 has identified the location of selected changes to this standard since the last issue (C1645 – 21) that may impact the use of this standard. (July 1, 2022)

(1) Revised 6.2 to remove reference to 'conditioning'.

Committee C15 has identified the location of selected changes to this standard since the last issue (C1645/C1645M – 19) that may impact the use of this standard. (June 1, 2021)

(1) Revised Section 6 to harmonize moist and air curing requirements for paving slabs between other standards.