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# 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 C 1645/C 1645M; 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 covers the resistance to freezing and thawing of solid interlocking concrete paving units conforming to the dimensional requirements of Specification C936. Units are tested in a test solution that is either 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 the standard.\*~~

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 C 936/C 936M. 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 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 This standard does not purport to address all of the safety concerns, in 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 limitation prior to use.*

## 2. Referenced Documents

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

C936 936/C 936M 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 C 936/C 936M while immersed in a test solution. Other types of segmental concrete paving units that do not conform to the dimensional requirements of Specification C 936/C 936M 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 C 936/C 936M.

## 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 an air temperature of  $-5 \pm 3^{\circ}\text{C}$  ( $23 \pm 5^{\circ}\text{F}$ ) within 1 h of introduction of specimens. The thawing chamber shall maintain a controlled air temperature. This temperature shall never be greater than  $+30^{\circ}\text{C}$  ( $86^{\circ}\text{F}$ ).~~—~~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 Oven~~—~~The oven shall be vented and capable of being maintained at  $60 \pm 2^{\circ}\text{C}$  ( $140 \pm 4^{\circ}\text{F}$ ).~~

4.3 Drying Oven— The drying oven shall be vented and capable of being maintained at 100 to 115°C [212 to 239°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

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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.

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

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 C 936/C 936M.

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

## 6. Preparation of Test Specimens

6.1 *Curing and Conditioning*—Test specimens shall consist of full size units, a minimum of 28 days old. After sampling, all test specimens shall be cured for 14 days in a moist chamber (cabinet or room) at an air temperature of  $23 \pm 2^\circ\text{C}$  ( $73 \pm 4^\circ\text{F}$ ) and a relative humidity of at least 90%. Moist curing shall be followed by air curing for a minimum of 14 days at  $23 \pm 5^\circ\text{C}$  ( $73 \pm 9^\circ\text{F}$ ) at a minimum 40% relative humidity.

6.1.1 After air curing, specimens then shall be oven conditioned for  $48 \text{ h} \pm 2 \text{ h}$  at  $60^\circ \pm 2^\circ\text{C}$  ( $140 \pm 4^\circ\text{F}$ ).

6.1.2 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.—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  $190 \text{ cm}^2$  [ $29.5 \text{ in.}^2$ ]. Test specimens shall be a minimum of 28 days old before freeze-thaw cycling begins. After sampling, all test specimens shall be cured for 14 days in a moist chamber (cabinet or room) at an air temperature of  $23 \pm 2^\circ\text{C}$  [ $73 \pm 4^\circ\text{F}$ ] and a relative humidity of at least 90 % or submerged in a saturated lime solution maintained at  $23 \pm 2^\circ\text{C}$  [ $73 \pm 4^\circ\text{F}$ ]. Moist curing shall be followed by air curing for a minimum of 14 days at  $24 \pm 8^\circ\text{C}$  [ $75 \pm 15^\circ\text{F}$ ] at a maximum 80 % relative humidity. The curing and conditioning of the test specimens shall be waived at the option of the manufacturer of the pavers. When curing is waived, allow the specimens to air cure for a minimum of 48 h at  $24 \pm 8^\circ\text{C}$  [ $75 \pm 15^\circ\text{F}$ ] at a maximum 80 % relative humidity.

6.1.1 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  $16 \pm 1$  h of freezing followed by  $8 \pm 1$  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  $-5 \pm 3^\circ\text{C}$  ( $23$  [ $23 \pm 5^\circ\text{F}$ ] $5^\circ\text{F}$ ) for the last 7 to 12 h of the freezing cycle and a minimum of  $+5^\circ\text{C}$  ( $40^\circ\text{F}$ ) [ $40^\circ\text{F}$ ] 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 oven conditioning, each warm 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, or plastic) spacers approximately 5 mm ( $0.2 \text{ in.}$ ) [ $0.2 \text{ in.}$ ] high to ensure exposure of the entire at least 95 % of the bottom surface to the test solution. A minimum of 5 mm ( $0.2 \text{ in.}$ ) [ $0.2 \text{ in.}$ ] clearance shall be provided between the specimen and the container in all directions.

7.3 *Test Solution*—If the test solution is saline, containers shall be filled with  $3 \pm 0.1\%$  NaCl solution. The test solution (tap water or saline) shall have a minimum temperature of  $15^\circ\text{C}$  ( $60^\circ\text{F}$ ). The level of the test solution shall be  $5 \pm 1 \text{ mm}$  ( $0.2 \pm 0.04 \text{ in.}$ ) above the surface of the specimens. Excess test solution volume shall be avoided in order to ensure rapid freezing of the specimens. After filling the containers they shall be immediately closed to minimize evaporation and the closed containers left at a minimum temperature of  $15^\circ\text{C}$  ( $60^\circ\text{F}$ ) for  $24 \text{ h} \pm 1 \text{ h}$ .

7.4—*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  $3 \pm 0.1\%$  (by weight) NaCl solution. The test solution (tap water or saline) shall have a temperature of  $24 \pm 8^\circ\text{C}$  [ $75 \pm 15^\circ\text{F}$ ]. The level of the test solution shall be  $5 \pm 1 \text{ mm}$  [ $0.2 \pm 0.04 \text{ in.}$ ] 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  $24 \pm 8^\circ\text{C}$  [ $75 \pm 15^\circ\text{F}$ ] for  $24 \pm 1 \text{ h}$ . 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  $5 \pm 1 \text{ mm}$  [ $0.2 \pm 0.04 \text{ in.}$ ] 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-hour/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, recorded min and reported recorded. If for any reason, except for residue collection, continuous 24-hour/24-h cycles cannot be maintained, then this shall be noted in the report.

7.5 *Collection of Residue*—After 10, 25, and (if necessary) 50 cycles, the specimens shall be washed with de-ionized water to remove all loose particles. These particles and spalled material collected at the bottom of the containers shall be washed, filtered