

Bureau of Materials and Physical Research

Illinois Modified ASTM C 672-12

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**Standard Method of Test
for
Scaling Resistance of Concrete Surfaces
Exposed to Deicing Chemicals**

1. Scope

- 1.1 This test method covers the determination of the resistance of concrete specimens to surface deterioration by repeated cycles of freezing, ice removal with sodium chloride, and thawing. The test method is used for evaluation of concrete sealers and concrete mix designs.

2. Referenced Documents

2.1 AASHTO Standard Method of Tests

T 119*	Slump of Hydraulic Cement Concrete
R 39*	Making and Curing Concrete Test Specimens in the Laboratory
T 152*	Air Content of Freshly Mixed Concrete by the Pressure Method
T 22*	Compressive Strength of Cylindrical Concrete Specimens

2.2 AASHTO Standard Specifications

M 85	Standard Specification for Portland Cement
M 143	Standard Specification for Sodium Chloride
M 201*	Moist Cabinets, Moist Rooms, and Water Storage Tanks Used in the Testing of Hydraulic Cements and Concretes

* Illinois Modified

3. Significance and Use

3.1 This test method is for three different applications:

- Verification of a concrete mix design as discussed in the current "Portland Cement Concrete Level III Technician Course – Manual of Instructions for Design of Concrete Mixtures."
- To assure a concrete sealer conforms to the requirements of the Standard Specifications for Road and Bridge Construction, Section 1026 (January 1, 2007).
- For evaluation of experimental materials and their mix design.

4. Apparatus

4.1 Freezing Equipment

A chest or room of sufficient size to hold the specimens and capable of lowering the temperature of the specimens to $5^{\circ} \pm 2^{\circ}\text{F}$ ($-15^{\circ} \pm 1.1^{\circ}\text{C}$) within 15.0 hours and maintaining this temperature with a full load of specimens. The required temperature range is optimal for sodium chloride.

4.2 Molds

The molds for the scaling specimens shall be made of steel, cast iron, magnesium, or other nonabsorbent material; nonreactive with concrete containing Portland or other hydraulic cements. The molds shall be watertight during use. A suitable sealant, such as heavy grease, modeling clay, or microcrystalline wax shall be used where necessary to prevent leakage through the joints. The molds shall be rectangular in shape and of the dimensions required to produce a specimen having a minimum 7 in. x 12 in. (178 mm x 305 mm) upper surface and a minimum depth of 3 in. (76 mm). A method shall be provided for the construction of watertight dikes upon the upper surface of the specimen. The width of the dikes shall not exceed 0.75 in. (19 mm), and the height should not exceed 0.75 in. (19 mm).

4.3 Tamping Rod

The rod shall meet the requirements of Illinois Modified AASHTO T 119.

4.4 Small Tools

Wood strike-off board, wood float, square end trowel, and scoop.

For constructing a mortar dike, a mold angle, a 6 in. x 11 in. (52 mm x 279 mm) insert mold, and a semi-circular trowel are required.

4.5 Slump Cone

The cone shall meet the requirements of Illinois Modified AASHTO T 119

4.6 Air Meter

The meter shall meet the requirements of Illinois Modified AASHTO T 152.

4.7 Scales

The scales shall meet the requirements of Illinois Modified AASHTO R 39.

4.8 Concrete Mixer

The mixer shall meet the requirements of Illinois Modified AASHTO R 39.

4.9 Thawing Racks

Racks for storing specimens during the thawing period shall be provided. The shelves of the racks should be inclined approximately 70° from the vertical to facilitate runoff of both thawing ice and rinse water.

5. **Materials, Proportioning, Mixing and Testing**

5.1 Materials

5.1.1 Materials are as specified by the mix designer as outlined in 3.1a and 3.1c.

5.1.2 The following materials are used to produce concrete for evaluation of a concrete sealer as outlined in 3.1b (the test specimens and control specimens shall be from the same concrete batch):

Coarse Aggregate- The coarse aggregate shall be Class A quality [Article 1004.01 (b)], superstructure quality [Article 1004.01 (b) Note 10], meet the Department's freeze-thaw rating [Article 1004.02 (f)], and meet an Illinois gradation CA 7 [Article 1004.01 (c)], as indicated in the Standard Specifications for Road and Bridge Construction (January 1, 2007).

Fine Aggregate- The fine aggregate shall be Class A quality [Article 1003.01 (b)] and meet an Illinois gradation FA 1 [Article 1003.01 (c)], as indicated in the Standard Specifications for Road and Bridge Construction (January 1, 2007).

Cement- Type I, Portland cement according to Article 1001.01 of the Standard Specifications for Road and Bridge Construction (January 1, 2007).

Air-Entraining Admixture-Air-entrainment shall be a neutralized Vinsol resin according to Article 1021.02 of the Standard Specifications for Road and Bridge Construction (January 1, 2007).

5.1.3 Sodium Chloride (Rock Salt)- The sodium chloride shall meet the requirements of AASHTO M 143, Type I, Grade 1.

5.1.4 Preparation- Prepare materials according to Illinois Modified AASHTO R 39.

5.2 Proportioning

5.2.1 For evaluation according to 3.1b, the concrete that will have a concrete sealer applied to it shall be proportioned as follows:

- For the control and tests specimens, a cement factor of 565 lb/ yd³ (335 kg/m³) and a mortar factor of 0.80 shall be used.
- The air content of the freshly mixed concrete shall be 5.0 to 8.0 percent.
- The slump of the freshly mixed concrete shall be 3.0 in. to 4.0 in. (75.0 mm to 100.0 mm).

5.2.2 For evaluation according to 3.1a and 3.1c, the concrete proportions shall be specified by the mix designer.

5.3 Mixing

Mix the concrete according to Illinois Modified AASHTO R 39.

5.4 Testing

5.4.1 Slump- Immediately after mixing, measure the slump of each batch of concrete according to Illinois Modified AASHTO T 119.

5.4.2 Air Content- Immediately after mixing, measure the air content of each batch of concrete according to Illinois Modified AASHTO T 152. Discard the concrete used for air content determination.

6. **Specimens**

6.1 Scaling Specimens

The area of the scaling surface shall be a minimum of 50.0 in.² (32,258 mm²) with retaining dikes in place.

A minimum of three specimens shall be made for each test condition.

6.2 Fabrication of Scaling Specimens

6.2.1 Coat the inside surface of the mold with a light coat of mineral oil or a suitable nonreactive release material just prior to fabrication of the specimens.

6.2.2 Fill the mold in one layer. Do not rod the concrete, tap the mold, or vibrate the concrete to consolidate. Spade around the periphery with a square end trowel. Level the surface, parallel to the long or short dimension of the form, with several passes of a wood strike-off board.

6.2.3 After the concrete has stopped bleeding, finish the surface with a minimum number of passes using a wood float. The finish operation shall be performed with a sawing-motion, which shall be parallel to the long dimension of the form. The finished surface shall be level with the edge of the mold and moderately smooth. All specimens within a batch should be finished with the same number of passes, and should have a similar surface texture.

Dike

6.2.3.1 Wood Dike- The first day after the specimen has finished the air storage period, a wood dike may be constructed. The height of the wood dike should be approximately 0.50 in. (13 mm) and the width shall not exceed 0.75 in. (19 mm). NOTE: Wood having these dimensions is commonly known as door stop. A caulk which has sealing and bonding properties shall be used to attach the wood dike to the concrete specimen. The caulk shall not extend more than 0.25 in. (6 mm) beyond the inner edge of the wood dike. After the caulk has cured, pour water on the specimen to ensure the wood dike is water-tight. If the wood dike leaks, apply additional caulk.

6.2.3.2 Mortar Dike- After the concrete has initially set, but still slightly plastic, attach the mortar dike mold angle to the specimen mold. Mix 1-part Portland cement and 2-parts fine sand by weight, a small amount of air-entraining admixture, and sufficient water to produce a mortar with stiff consistency. For a mortar dike to be watertight, etch a very small line onto the surface of the concrete in the specimen mold, approximately 0.25 in. (6 mm) inside the outer perimeter of the surface. The mortar dike is then constructed with the tools discussed in 4.4, filling the line which was etched in the surface. The width of the mortar dike shall not exceed 0.75 in. (19 mm). The first day after the specimen has finished the air storage period, pour water on the specimen to ensure the mortar dike is water tight. If the mortar dike leaks, apply caulk to seal the leak. The caulk shall not extend more than 0.25 in. (6 mm) beyond the inner edge of the mortar dike.

6.2.3.3 Other Dikes- A dike may be made of any material that will adhere to the specimen and serve to maintain the sodium chloride solution on top of the specimen throughout the period of the test.

6.3 Fabrication of Compressive Strength Specimens

Mold and cure three 4 in. (102 mm) diameter by 8 in. (203 mm) height cylinder specimens according to Illinois Modified AASHTO R 39. Cure the three cylinders until the sealer or mix design specimens are removed from moist storage. The compressive strength test is performed at that time according to Illinois Modified AASHTO T 22. Cylinder results are for informational purposes.

7. **Curing**

7.1 Cover the specimens first with wet burlap and then a polyethylene sheet immediately after finishing. The burlap and sheet shall not contact the concrete surface.

7.2 Remove the specimens from the molds at an age of 20 to 24 hours after addition of water to the mix, and continue moist storage according to Illinois Modified AASHTO M 201.

7.3 For evaluation according to 3.1a and 3.1c, remove the specimens from moist storage at the age of 14 days and store in air for 14 days at $73^{\circ} \pm 3^{\circ} \text{ F}$ ($23^{\circ} \pm 1.7^{\circ} \text{ C}$).

7.4 For a concrete sealer evaluation according to 3.1b, remove the specimens from the moist storage at the manufacturer recommended concrete age before application of sealer. Store the specimens in air at $23^{\circ} \pm 1.7^{\circ} \text{ C}$ ($73^{\circ} \pm 3^{\circ} \text{ F}$) until the following day, but no longer than three days. After the curing and drying times are completed the concrete sealer is applied and allowed to dry according to the manufacturer's instructions. The quantity of concrete sealer and application method shall be according to the manufacturer's instructions. The dikes are then applied, allowed to dry, and checked for water tightness before starting the test.

8. Procedure for Freeze-Thaw Cycle

8.1 The freeze-thaw cycle shall be started by introducing sufficient water to provide a surface depth of 1/8 to 1/4 in. (3 to 6 mm) on the impounded surface. The specimens are then placed in a freezing environment for 15.75 to 16.00 hours. At the end of this time the surface area of each specimen is evenly covered with sodium chloride, at a minimum rate of 0.67 gram per square inch (0.001 gm/mm²), and returned to the freezing environment for 4.75 to 5.00 hours. The specimens are then removed from the freezing environment and placed on the thawing racks, rinsed with clear water, and allowed to thaw in a minimum air temperature of 70.0° F (21.1° C) for 3.00 to 3.50 hours; at this time another cycle begins.

8.2 Either keep specimens frozen during any interruption in the daily cycling or maintain them in a damp condition after removal of the sodium chloride.

8.3 A complete test is 60 cycles.

9. Report and Evaluation

9.1 Report

- 9.1.1 The type of materials, the proportions of materials, the slump, and the air content of the mix.
- 9.1.2 Curing and drying period, if other than standard.
- 9.1.3 Type of concrete sealer, time, method, and rate of application.

9.2 Evaluation

9.2.1 A rating, based on a visual evaluation of the specimens, shall be made at 0, 5, 20, 40, and 60 cycles of freezing, ice removal with sodium chloride and thawing. A minimum 3 in. x 5 in. (76 mm x 127 mm) photograph of the control and test specimens will be required at 0, 5, 20, 40, and 60 cycles of testing.

9.2.2 The visual rating of the specimens shall be determined as follows:

The scaling specimens are rated and photographed when the surface is wet. The specimens shall be rated after the thawing portion of the cycle.

When rating the condition of the surface there are five different conditions to rate individually. Rate each different condition as a percent and record to the nearest 0.1.

Examine the condition of the specimen surface and evaluate the five different conditions as follows:

- What percentage of the surface shows “dusting off of surface” and worse?
NOTE: As an example, anything worse would consist of “light scale or sand pitting, light scale with coarse aggregate showing, medium scale with coarse aggregate protruding, and heavy scale.”
- What percentage of the surface shows “light scale or sand pitting” and worse?
- What percentage of the surface shows “light scale with coarse aggregate showing” and worse?
- What percentage of the surface shows “medium scale with coarse aggregate protruding” and worse?
- What percentage of the surface shows “heavy scale?”

After rating each condition, sum the values to obtain the total rating. If the test specimen has damage prior to testing, determine the percentage and record to the nearest 0.1. This value is deducted from the total rating.

If the total rating is 0, this means 100% of the original surface is present.

Example of a rating after five cycles.

Number of Cycles→	0	5	20	40	60
Condition of surface	Rating				
Dusting off of surface.		0.8			
Light scale or sand pitting.		0.5			
Light scale with coarse aggregate showing.		0.2			
Medium scale with coarse aggregate protruding.					
Heavy scaling.					
(Range 0-5) Total Rating→		1.5			

The final rating is determined from the average of three specimens and rounded to the nearest 0.1.

- 9.2.3 For tests involving evaluation of a concrete sealer, a value of “0.1” will be assigned to the control test specimens when a rating of “0” is determined after 60 cycles. The average visual rating of the test specimens treated with sealer, divided by, the average visual rating of the untreated test specimens shall not exceed 0.80 after 60 cycles. If the control specimens should have a rating greater than 3.0, the test series may be repeated.