Designation: C1791 − 16

Standard Guide for Reduction of Efflorescence Potential in New Unit Pavement Systems[1]

This standard is issued under the fixed designation C1791; 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 guide covers methods for reducing efflorescence potential in new unit pavement systems.

1.2 The values stated in inch-pound units are to be regarded as the standard. The SI units given in parentheses are for information only.

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

2. Referenced Documents

2.1 *ASTM Standards:*

C67 Test Methods for Sampling and Testing Brick and Structural Clay Tile
C270 Specification for Mortar for Unit Masonry
C1180 Terminology of Mortar and Grout for Unit Masonry
C1232 Terminology of Masonry

3. Terminology

3.1 *Definitions:*

3.1.1 Terminology defined in Terminologies C1180 and C1232 shall apply in this guide.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *cryptoflorescence, n*—a crystalline deposit of water-soluble compounds in the pores of unit pavement system materials.

3.2.2 *efflorescence, n*—a crystalline deposit, usually white, of water-soluble compounds on the surface of a unit pavement system.

3.2.2.1 *Discussion*—While not considered to be efflorescence, stains produced by acid-soluble vanadium compounds in clay masonry are usually yellow or green; and stains produced by acid-soluble manganese compounds are usually brown or gray.

3.2.3 *jointing material, n*—mortar, aggregate, sealant, or other materials used between paver units.

3.2.4 *unit pavement system, n*—a system consisting of edge restraint, wearing course of discrete clay or concrete pavers, setting bed, jointing material, base or sub-base, or combination thereof, and appropriate drainage elements.

3.2.4.1 *Discussion*—Flexible pavement is a unit pavement system whose wearing course consists of discrete clay or concrete pavers on an aggregate base, an aggregate base stabilized with asphalt or cement, or asphalt pavement.

3.2.4.2 *Discussion*—Rigid pavement is a unit pavement system whose surface wearing course consists of discrete clay or concrete units on a rigid base such as concrete.

4. Significance and Use

4.1 This guide provides information that, if implemented, will reduce efflorescence potential in new unit pavement systems. However, its implementation will not always completely prevent efflorescence.

4.2 This guide may be augmented by related information contained in the appendixes of Specification C270, the additional material listed in Appendix X1 in this standard, and other publications.

5. Principles of Efflorescence

5.1 Efflorescence is directly related to the quantity of water-soluble compounds within, or exposed to, a unit pavement system; and to the quantity of water exposed to these compounds. Water-soluble compounds or water causing efflorescence may be from adjacent surfaces or beneath the pavement system: for example, fertilizer in runoff from adjacent flower beds or lawns; ground water evaporating through the wearing course; water-soluble compounds leaching out of crushed recycled concrete used in pavement bases; and water from sprinkler systems and roofs. Since neither water nor water-soluble compounds can be completely eliminated from unit pavement systems, the potential for efflorescence is reduced by reducing water-soluble compounds and water retained within the unit pavement system.

[1] This test method is under the jurisdiction of ASTM Committee C15 on Manufactured Masonry Units and is the direct responsibility of Subcommittee C15.05 on Masonry Assemblies.

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

5.2 Water can penetrate through joints in the surface of unit pavement systems. It can penetrate voids in the mortar joints or the interface between the paver unit and jointing material.

5.3 If a significant amount of water penetrates a unit pavement system, the water will dissolve water-soluble compounds that may exist in the paver units, mortar components, grout, setting bed, concrete slab, admixtures or other secondary sources, and may deposit them on the exterior surface of the unit pavement system when it migrates to the surface and through evaporation. The presence of a concrete slab below sand setting beds in unit pavement system allows water to remain on top of the slab where it can more readily dissolve water-soluble compounds in the concrete.

5.4 The most common efflorescence deposits contain two or more of the following: potassium, sodium, calcium, sulfates, carbonates, bicarbonates, chlorides, and hydroxides.

5.5 Some water-soluble compounds deposited on the surface of unit pavement systems can chemically react to form compounds that are not water-soluble. Calcium carbonate ($CaCO_3$) deposits on unit pavement system are a fairly common example. They are a result of reaction between the efflorescence compound calcium hydroxide and carbon dioxide after the calcium hydroxide is deposited on the surface of the pavement and is exposed to the air.

5.6 Under some circumstances, particularly when exterior coatings are present, efflorescence compounds can be deposited below the surface of the paver units. This condition is called cryptoflorescence. When cryptoflorescence occurs, the forces resulting from its confinement can cause disintegration of pavement surfaces.

6. Reduction of Efflorescence Potential in New Pavements

6.1 Efflorescence on new unit pavement systems is reduced when water penetration of the pavement is minimized; when water that penetrates pavement is quickly drained from the pavement; when contact between dissimilar paver units is minimized; when potential efflorescence compounds in the pavement system materials are minimized; and when exposure of the pavement to potential efflorescence causing compounds is minimized.

6.2 The amount of water from precipitation and other sources that is able to penetrate a unit pavement system is minimized by:

6.2.1 A minimum surface slope to drain of ¼ in./ft (20 mm/m).

6.2.2 Good bond and full contact between paver units and mortar in masonry pavements. This condition is achieved by using mortar that is compatible with the paver units; completely filled mortar joints; compacted concave, V, or grapevine mortar joints; cold weather construction practices that prevent masonry materials from freezing.

6.2.3 Construction practices that protect uncompleted unit pavement systems from rain or snow during construction.

6.2.4 Properly sized and located movement joints in the pavement and in rigid bases such as concrete.

6.2.5 Gutters, overhangs, and canopies to protect the pavement from rain.

6.2.6 For concrete paving units, utilization of integral efflorescence controlling compounds in the units or compatible applied water repellent sealer on the surface of unit pavement, or both.

6.2.7 Utilization of compatible integral water repellent admixtures and mortar modifiers.

6.3 Water that penetrates a unit pavement system is quickly drained out of the system by:

6.3.1 The use of a drainage system that conveys water to low points and allows water to be conveyed out of the pavement system.

6.3.2 Drainage holes through the slab base at the low points in systems that are installed over slab bases to drain water off the slab base.

6.4 Contact between dissimilar paver units is minimized by:

6.4.1 The use of a separator between changes in paver materials in unit pavement systems.

6.5 Potential efflorescence compounds in the pavement system materials can be minimized by:

6.5.1 Preconstruction testing of all unit pavement system materials, water, cleaning agents, deicing chemicals, and admixtures to be used to evaluate their potential to contribute to efflorescence. The results of these tests should be evaluated together with the influence of construction practices and design in predicting efflorescence potential in pavements. Available preconstruction tests include: Test Method C67 efflorescence test for brick; chemical analysis of cements to determine water soluble alkali (Na_2O K_2O) content; chemical analysis of hydrated lime to determine calcium sulfate content; and chemical analysis of sand, water, admixtures and cleaning agents to determine alkali, chloride, and sulfate content. Presently, there is no ASTM efflorescence test for concrete paver units or mortar. The potential for efflorescence increases with increasing amounts of water-soluble alkali, chlorides, and sulfates in segmental and masonry pavement materials.

6.5.2 Storage and protection of all unit pavement system materials prior to use to prevent contact with dissimilar materials and to protect materials from moisture.

6.5.3 Protection of all unit pavement system materials during transportation when there is a probability of contamination from road salts, fertilizers, and airborne contaminants.

6.5.4 Utilization of proper cleaning materials and procedures on new unit pavement systems.

6.5.5 Not using crushed recycled concrete in pavement bases where drainage is poor or high ground water conditions exist.

6.6 Exposure of unit pavement systems to potential efflorescence causing compounds is minimized by:

6.6.1 Minimizing the use of deicing chemicals.

6.6.2 Minimizing water runoff from adjacent flower beds or lawns on the pavement.

7. Keywords

7.1 drainage; efflorescence; mortar; paving units; percolate; preconstruction testing; water penetration

APPENDIX

(Nonmandatory Information)

X1. ADDITIONAL MATERIAL

X1.1 Application Guide for Interlocking Concrete Pavers, Tech Spec Number 10, Interlocking Concrete Pavement Institute, Herndon, VA.

X1.2 Bedding Sand Selection for Interlocking Concrete Pavements in Vehicular Applications, Tech Spec Number 17, Interlocking Concrete Pavement Institute, Herndon, VA.

X1.3 Brick in Landscape Architecture-Pedestrian Applications, Technical Notes 29, Brick Institute of America, Reston, VA, July, 1994.

X1.4 Chin, I. R., and Petry, L., "Design and Testing to Reduce Efflorescence Potential in New Brick Masonry Walls," Masonry: Design and Construction, Problems and Repair, ASTM STP 1180, J. M. Melander and L. R. Lauersdorf, Eds., American Society for Testing and Materials, Philadelphia, 1993, pp. 3–17.

X1.5 "Control and Removal of Efflorescence," NCMA-TEK 8-3A, National Concrete Masonry Association, Herndon, VA, 2003.

X1.6 "Stains—Identification and Prevention," Technical Notes 23, Brick Industry Association, Reston, VA, June, 2006.

X1.7 "Efflorescence—Causes and Prevention," Technical Notes 23A, Brick Industry Association, Reston, VA, June, 2006.

X1.8 Guide Specification for the Construction of Interlocking Concrete Pavement, Tech Spec Number 9, Interlocking Concrete Pavement Institute, Herndon, VA.

X1.9 Paving Systems Using Clay Pavers, Technical Notes 14, Brick Industry Association, Reston, VA, March 2007.

X1.10 Paving Systems Using Clay Pavers on a Sand Setting Bed, Technical Notes 14A, Brick Industry Association, Reston, VA, October, 2007.

X1.11 Paving Systems Using Clay Pavers on a Bituminous Setting Bed, Technical Notes 14B, Brick Industry Association, Reston, VA, June, 2010.

X1.12 Paving Systems Using Clay Pavers on a Mortar Setting Bed, Technical Notes 14C, Brick Industry Association, Reston, VA, July, 2011.

X1.13 Permeable Clay Brick Pavements, Technical Notes 14D, Brick Industry Association, Reston, VA, February, 2012.

X1.14 Structural Design of Interlocking Concrete Pavements for Roads and Parking Lots, Tech Spec Number 4, Interlocking Concrete Pavement Institute, Herndon, VA.

X1.15 "Trowel Tips: Efflorescence," 1S239, Portland Cement Association, Skokie, IL, 1991.

SUMMARY OF CHANGES

Committee C15 has identified the location of selected changes to this standard since the last issue (C1791 – 15) that may impact the use of this standard. (August 1, 2016)

(1) Revised 5.1 and 6.2.6.

(2) Added 6.5.5.

Committee C15 has identified the location of selected changes to this standard since the last issue (C1791 – 14a) that may impact the use of this standard. (July 1, 2015)

(1) Added 6.3.2.