MCA Tech Bulletin

Preventing Scaling of Concrete Surfaces in Michigan

Scaling, as defined by the American Concrete Institute (ACI) Committee 116, is the "local flaking or peeling away of the near-surface portion of hardened concrete or mortar." Sometimes called mortar flaking when it occurs just over the aggregates near the surface, it is primarily a physical action created by hydraulic pressures from repeated freeze-thaw cycles within the concrete. The expansive forces caused by the formation of ice are exacerbated with deicing chemicals, which increase both the saturation of the concrete and the number of freeze-thaw cycles. The distress mechanisms of scaling are complex on both a microscopic and macroscopic level.

Michigan is in a severe exposure climate where exterior concrete is subjected to continuous moisture, cycles of freezing and thawing, and use of deicing chemicals. Therefore, exterior concrete must be proportioned with durable ingredients designed for the climate with an entrained air-void system using proper placement, finishing, curing and protection to resist hydraulic pressures (stresses) that can promote scaling.

Severity of Scaling

ACI 116R classifies scaling as:

- Light (loss of surface mortar without exposure of coarse aggregate)
- Medium (loss of surface 0.2 to 0.4 in. in depth and exposure of coarse aggregate)
- Severe (loss of surface 0.2 to 0.4 in. in depth with some loss of mortar surrounding aggregate particles 0.4 to 0.8 in. in depth)
- Very Severe (loss of coarse aggregate particles as well as surface mortar, generally to a depth greater than 0.8 in.)

Causes

The most common causes of scaling are related to one or a combination of the following factors:

- **Lack of, or inadequate, curing** and protection. Do not let the concrete surface dry out after placement. Cement reacts with the water in the mix. Once the water is gone, the chemical reaction stops and the concrete stops gaining strength. A surface that dries out before it reaches strength will be weak. Curing compounds and/or secured plastic sheeting can be used to keep the surface from drying during the first few days, allowing it to gain full strength. Curing is always critical, but it is more critical on comfortable feeling low humidity days than on hot humid days.
- **Improper finishing** operations that work or trap water at the surface, resulting in a high water-cementitious ratio and low strength, creating a low-durability surface layer. Delayed or extended finishing will also allow early drying of the exposed concrete surface, prior to curing application, which can result in a weak surface.
- The use of **non-air-entrained concrete** or too little entrained air, resulting in a non-durable concrete mix. A poor air-void system may also be created at the surface via over-manipulation of the plastic concrete during finishing operations.
- Using concrete with **low strength or excessively high water-cementitious ratio** will allow for deeper penetration of water and deicing chemicals.

Examples of scaling (left, medium severity; and right, light severity, sometimes called mortar flaking)

- **Exposure of new concrete to freeze-thaw cycles** before it has been adequately cured, and not allowed to air dry. Intentional application or indirect exposure (from vehicle traffic) to deicing chemicals at this early age greatly increases the likelihood of scaling.
- Exposure to **aggressive/corrosive salts** and fertilizers. Never use calcium or magnesium-based deicers on concrete. Sodium chloride (table salt, rock salt, or safe salt) may be used in moderation to melt the ice.
- **Misunderstanding the use of supplemental cementitious materials** (SCMs) may lead to scaling. Properly designed, finished, and cured mixes containing SCMs have the same resistance to scaling as 100% portland mixes. SCMs generally improve strength, durability, and water tightness. However, they also extend the concrete set time. Understanding set time and when to perform the varying finishing operations is crucial to the overall durability of a mix containing SCMs.

Preventing / Minimizing Scaling

1. Use a *"severe exposure" concrete mix* including:

- Durable and well-graded aggregates. Ensure that stockpiles are kept moistened at or above the saturated surface dry (SSD) condition at the time of batching.
- Low water-cementitious ratio – 0.45 or less.
- For residential and commercial flatwork mixes:
  - Minimum 4,000 psi compressive strength (consistent with the requirements of ACI 332, Code for Residential Concrete).
  - When slag cement is utilized, the mix should contain a minimum cementitious content of 564 lb/yd^3.
- 5 to 8% entrained air for 3/4 to 1-inch top size aggregates.

2. Utilize *proper placement and finishing practices*. The best practice for exterior concrete consists of placing and consolidating the concrete in the forms, then striking off the surface to final grade, and smoothing/flattening with a float to fill in any holes in the surface. As the concrete surface starts to stiffen or

set up, a final texture is achieved with a burlap drag, light broom, or a patterned stamp. The water in fresh concrete gives the surface a glossy sheen. During the finishing process this sheen dissipates as the surface water evaporates. A curing membrane is applied as soon as the surface sheen starts to disappear. During the finishing process it is acceptable to lightly mist the surface (if needed) to replace water that has evaporated, but it is not acceptable for the finishers to mix water into the surface with their finishing tools – this practice leads to a weak concrete surface with a high chance of scaling.

3. *Cure the concrete slab* immediately after finishing for seven (7) days, when ambient conditions are near 70°F. Conditions may at times require less or more curing time. Curing is the maintenance of moisture and temperature directly following finishing so that properties such as strength and durability develop, especially at the surface. Curing requirements include protection from either excessive hot or cold temperatures.

4. Apply a commercially available, 100% silane or siloxane, penetrating concrete sealer per the manufacturer's recommendations. The concrete should be reasonably dry prior to the sealer application, to properly absorb the sealer.

5. Minimize application of or exposure to deicers until after one year. Concrete placed late in the season, such as in October or November, may not have sufficient drying time (30 days) before deicer application. Instead, consider using sand for traction over snow and ice.

6. It is important to note that all concrete surfaces will wear and scale to some extent over their lifetime. Prevention and taking measures to ensure the potential for scaling is minimized while concrete is placed and protected while "new" are critical to achieving a quality concrete project that will stand the test of time.

Repair or Treatment

Although scaling is not desired, it is generally a cosmetic issue not affecting the structural integrity of the slab and therefore may not require repair. For larger areas exhibiting pronounced surface loss, grinding will typically remove the scaled surface. However, the difference in appearance of ground vs. non-ground surfaces will be noticeable due to aggregate exposure in the ground areas.

Example of a diamond-ground street

A common treatment for lightly to moderately scaled exterior concrete surfaces is the application of a sealer to help create a moisture barrier, thus preventing water from penetrating into the concrete. This can be accomplished with a light power washing of the surface to remove all loose material and debris. After a short drying period, treat the surface with a high-quality penetrating product such as a silane sealer. These products are designed to penetrate into the pores of concrete, and once there, react with the alkaline materials and moisture to form a barrier that limits water and deicer penetration. Application rates will vary based on the specific product.

Application of a penetrating sealer to concrete

References

- American Concrete Institute, ACI 201.2R Guide to Durable Concrete, (www.concrete.org)
- American Concrete Institute, ACI 305R (Hot Weather)
- American Concrete Institute, ACI 306R (Cold Weather)
- American Concrete Institute, ACI 308R Guide to Curing Concrete
- American Concrete Institute, ACI 332 Residential Code Requirements for Structural Concrete
- National Ready Mixed Concrete Association, Concrete in Practice (CIP) 2, Scaling Concrete Surfaces, (www.nrmca.org)
- International Code Council, 2012 International Building Code
- Federal Highway Administration, FHWA SD2002-01-X, TPF-5(042)-X and SD2002-01-G, TPF-5(042)-G
- Ohio Concrete, Technical Tip—A Case for Sealing Concrete Surfaces, 2006
- 2013 Ohio Concrete, Industry Recommendation for Exterior Concrete Flatwork
- Portland Cement Association, 2007 Engineering Bulletin 221—Specifiers Guide to Durable Concrete, Rachel J. Detwiler and Peter C. Taylor
- Portland Cement Association, 2005 Design and Control of Concrete Mixtures 16th Edition, 2016

Published January 2019