Finishing the Sidewalk Scaling Situation

An investigation of widespread damage caused by extreme weather

by Henry B. Prenger

It was a year of extreme winter weather in Maryland—a year with so many ice storms that salt reserves in the area were nearly depleted. It was 1994, a year that became known within the Maryland State Highway Administration as the year that all the sidewalks scaled. The widespread damage prompted what has turned into my lifelong study of the problem. I previously investigated some major concrete issues as a concrete engineer for the state of Maryland, but none of those issues stirred such visceral feelings in the community as occurred when the sidewalks began to scale in the spring of 1994.

After investigating and identifying the issues that caused the scaling, meetings were held with contractors, concrete material suppliers, ready mixed concrete producers, and inspectors to address the issues. Things were better in the following years, and the issue was forgotten—until about 10 years later, when another round of bad weather hit the area and showed that the root cause was never addressed. Scaling was a problem once again, and this time, the problem wasn't limited to Maryland.

A Second Wave

When the second wave of scaling began, I was working as a technical service representative in the cement and concrete industry. My territory comprised the Northeast United States, and I soon found that most of the states in the region had the same problem. Under the leadership of the Federal Highway Administration (FHWA), I was enlisted to work with a team reviewing the materials in the concrete mixtures, project specifications, and construction practices in the affected states and municipalities. Among the most pertinent findings of the study were:

- Many states had progressed to using pre-snow deicing brines containing magnesium chloride (MgCl). While MgCl was an effective material for deicing, it has been linked to concrete deterioration that is more severe than that caused by traditional deicers[1];
- Most states and municipalities were not meeting maximum water-cementitious materials ratio (*w*/*cm*) and minimum strength requirements in industry standards;
- Inspection and testing of concrete was inadequate or nonexistent;
- Most inspectors were not familiar with industry-recommended finishing practices;
- Many concrete mixtures were difficult to finish; and
- Extended setting times in colder weather, coupled with reduced bleeding in some mixtures, were resulting in poor timing of finishing operations.

We also learned that poor concrete finishing practices were common, including:

- Addition of water to the concrete to increase flowability, without regard to slump or *w*/*cm* requirements;
- "Blessing" (sprinkling water on the surface) the concrete at every point of the finishing process;
- Performing final finishing operations before initial setting and while bleed water was still coming to the surface;
- Using steel trowels during finishing operations;
- Over-finishing;
- Brooming water into the surface; and
- Poor to nonexistent curing practices.

A demonstration evaluation was also commissioned. A sidewalk, with various materials and conditions, was placed for the Montgomery County Department of Transportation in Maryland to study the effects of slag cement and fly ash on scaling of concrete flatwork. The field study included concrete mixtures that met minimum industry standards, and the concrete was tested, placed, finished, and cured properly. The sidewalk, which was placed in November of 2015, included concrete mixtures with straight portland cement; 15% and 25% cement replacement with Class F fly ash; and 25%, 35%, and 50% portland cement replacement with slag cement. These six mixtures had a total of 615 lb/yd^3 (365 kg/m^3) cementitious material and a design *w*/*cm* of 0.45. An additional mixture, containing 580 lb/yd^3 (344 kg/m^3) of cement with a design *w*/*cm* of 0.50, was also used.

The sidewalk went through a freezing-and-thawing cycle within 48 hours of placement. Two months after placement,

Curing

Proof of record snow in Maryland the first year in service

Testing for set

Concrete placement in Montgomery County, MD, trial of various SCM mixtures

the sidewalk was covered with nearly 30 in. (762 mm) of snow in a record-breaking blizzard. The sidewalk lines a road that is a feeder to Interstate 270, a major thoroughfare leading into Washington, DC, and as such, is heavily treated with deicing chemicals during snow and ice events. While there are no signs of scaling or deterioration on the demonstration sidewalk after 3 years of service, the sidewalk sections that were placed on either side of the demonstration section have scaled.

Certified Progress

Based on these findings, the Delaware Department of Transportation (DelDOT), with assistance from the FHWA, developed a program for training contractors and inspectors on proper finishing techniques. By June 2018, all contractors performing certain flatwork concrete placement work were required by specification to have a finisher on each project certified through one of two programs: the ACI Concrete Flatwork Finisher program or the National Ready Mixed Concrete Association (NRMCA) Best Practices for Exterior Flatwork Finishing program. Both require a performance assessment of finishing practices.

To date, over 200 finishers and inspectors have been certified to perform on DelDOT projects. Feedback has been largely positive, and finishers have generally proven to be very good and knowledgeable. Most already understand and can identify the proper and improper procedures for finishing concrete.

Productivity Pitfalls

The contractors that I've talked to, however, share a common concern. Proper finishing takes time and requires enough qualified personnel. Bidding pressures are forcing contractors to use smaller crews and to push for more production. To meet those demands, crews are forced to start final finishing operations before the concrete sets up. They also tend to use excessive water (either in the mixture or on the surface) and steel trowels to work concrete that is getting away from them.

If the state or municipality establishes appropriate specifications and prequalification requirements for contractors, and uniformly enforces proper finishing practices, it establishes an even playing field that will result in appropriate bids. This, in turn, should result in better concrete

flatwork at a minimal price increase to the owner.

DelDOT, for example, has worked with the contracting industry in Delaware to ensure consistent enforcement of its specification requirements. This agency has made a laudable effort to try to shift the scaling paradigm, and it is committed to following through. It's a critical effort, as other transportation and infrastructure authorities in the region are monitoring DelDOT's progress—they will likely develop their programs using the DelDOT program as the framework.

Slag cement sidewalks after a winter in service. Dark marks are temporary due to melting snow and ice

Typical scaling problems that were happening in the Northeast United States due to harsh winters

Study Summary

Mixtures should be specified and developed to ensure success when placing concrete in extreme temperatures. Many of the problems I have witnessed are the result of premature finishing of extremely slow-setting concrete in cold temperatures or using water as a finishing aid in hot temperatures. Optimizing concrete mixtures for cold and hot weather construction by judicious use of appropriate cement content, admixtures, and quantities of supplementary cementitious materials (SCMs) to achieve predictable setting times is essential for success.

On the part of the contractor, understanding the basic finishing procedures and ensuring proper curing will go a long way to alleviate our current cycle of troubleshooting scaling problems every spring in cold climate regions. There is not much we can do with the choice of deicing chemicals, but good quality concrete and proper finishing and curing practices, as evidenced in our demonstration project, can deliver required service life of sidewalks and associated concrete flatwork.

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Reference

1. Sutter, L.L.; Van Dam, T.J.; Peterson, K.R.; and Johnston, D., "Long Term Effects of Magnesium Chloride and Other Concentrated Salt Solutions on Pavement and Structural Portland Cement Concrete – Phase I Results," *Journal of the Transportation Research Board*, Transportation Research Board, V. 1979, 2006, pp. 54-59.

Selected for reader interest by the editors.

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