Pervious Concrete Pavement Surface Durability in a Freeze-thaw Environment where Rain, Snow and Ice Storms are Common Occurrences

By: The Ohio Ready Mixed Concrete Association
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HANDOUT

Following is a summary of replies we received from various entities when we asked them "In your ongoing research/experience with pervious concrete, have you noted/recorded any observations of the material's freeze-thaw durability at your installation sites or in your laboratory?"

Replies from those identified in our presentation

Cleveland State University - Norbert Delatte n.delatte@csuohio.edu ,
We have not noted any freeze-thaw deterioration on the one installation we have in our campus parking lot. There has been some clogging along the edge.

Degussa Construction Chemicals - Mark Bury mark.bury@degussa.com
In-house research on pervious concrete for resistance to deterioration due to freezing and thawing cycles is being performed on beams using the ASTM C 666 test method. The work is ongoing with no conclusions drawn at this time.

Iowa State University - John Kevern kevernj@iastate.edu ,
The final report for the phase I mix design study can be found online at:
http://www.ctre.iastate.edu/reports/mix_design_pervious.pdf .

MN Road Research Facility - Kevin MacDonald kmacdonald@cemstone.com
We have noted that the freeze thaw performance is dependent on the paste to aggregate bond, and on the presence of frost susceptible particles in the coarse aggregate.
The laboratory results were predictive of the field performance.

Northern Kentucky Sanitation District - George Robinson grobinson@sd1.org
Our office parking lot, having pervious concrete and pervious asphalt, is well maintained and closely monitored. Debris collected by suction of the mechanical sweeper is saved and analyzed. Our snow plow's steel blade has not marred the pervious concrete surface. We have not had any cracking issues, nor any freeze-thaw damage.

Clarkson University - Narayanan Neithalath nneithal@clarkson.edu
I have had quite a few pervious concrete freeze-thaw tests in the laboratory. Some of my comments, which have been published elsewhere are the following:

1. ASTM C 666 is a harsh test for conventional Pervious concrete. From my experience on tests conducted on mixtures with various aggregate sizes (and therefore pore sizes) and blends of aggregate sizes, it was found that maintaining a more than 60% relative modulus for more than 40-50 cycles (the pass criterial as per 666) is difficult. Air entrainment (again, it is difficult to quantify the air in the paste by any of the conventional methods) was found to make the material more durable

2. In a slow freezing and thawing process, where the mixtures are subjected to only one FT cycle a day (instead of the 6-7 as per C 666), the resistance was much better with pervious concrete samples performing better.

Please see the following link for our complete report on pervious concrete. Freeze-thaw is covered in Chapter 9
http://ntl.bts.gov/lib/24000/24600/24636/SQDH2003-5_Final_Report.pdf .

3. The mechanisms of failure in a C666 test is rather easy to explain. The specimen is completely saturated, and the repeated freezing and thawing stresses need to be taken by the cement paste alone, which in normal pervious concrete has no air. Also, the paste thickness that surrounds the aggregate is very low, causing a rapid deterioration of the specimens. In fact, the damage is quite dramatic where the mixture is reduced to a heap of aggregates (if they are sound!!!). With air entrainment, there is some outlet for the stresses, but I presume that if the air content is not sufficient (which will reduce the already low strength dramatically), it will not be all that useful. Strengthening the matrix phase with latex or other polymeric materials might be an option to get better FT resistance.

4. In field, this might not be as big an issue as observed in the lab, if the pervious concrete system is capable of draining efficiently thus never being saturated completely (this has a lot to do with clogging and the associated influence of pore structure), and because of the fact that 6-7 cycles of FT never happens in a day. But in the absence of a standard testing method, it will be difficult for establish what is a FT resistant pervious concrete and what is not. I have been trying to get the pervious concrete community think about a different test method for FT, which can address some of these concerns.

5. And finally, the point that I have always been raising in all possible pervious concrete conclaves - though not necessarily associated with FT. We need to have test methods to establish the properties and performance of the material. There is no disagreement that strength is not one which all of us should be gung-ho about, and a visual inspection of the pore structure alone will do more harm than good when the material is more widely used. We badly need test methods that can tell if the material as placed meets the requirements, predict if it will continue doing so, and at what stages do we need to go in and maintain. The paper I am presenting at Nashville is our first step in trying to come up with something that is rational and quantifiable so that all in the industry benefits.

Replies from others (some are scheduled as presenters at the Forum)
Tennessee Concrete Association - Alan Sparkman asparkman@trmca.org
I have not observed any freeze-thaw damage in any of our installations here in Tennessee. Our oldest project is about 10 years old and still in good shape. I have only observed two small areas in that lot (about 2 square feet) that show any kind of damage after 10 years.

Our other installations go back about five years and I visit them periodically, but not regularly. I have not observed freeze-thaw damage in any of these installations to date.

We will be doing a much more formal evaluation of existing pervious projects over the summer using an intern from MTSU. He will be visiting as many sites as we can locate to do a condition survey and also do infiltration testing to see what kind of clogging the sites are experiencing once in service. We will have a report done by the end of August or so.

Middle Tennessee State University - Zhifu Yang zyang@mtsu.edu
Based on my study, it seems that the freeze-thaw damage mechanisms of pervious concrete are similar to those of conventional concrete. However, pervious concrete has an open inter-particle void system and a thin layer of paste, the pores and air voids on the paste can be saturated in a much shorter period of time when it is kept in a wet environment. As a result, pervious concrete is not as durable as conventional concrete in a wet environment. On the other hand, pervious concrete is more resistant to fatigue damage caused by repeated freeze-thaw cycles because the pressure generated in the paste can be easily released. In a dry environment, pervious concrete is durable to freeze-thaw cycles.

We are doing more studies on freeze-thaw durability of pervious concrete at MTSU, including the influence of freezing rate, fiber reinforcement, wet/dry cycles on durability. We are also planning to do some field studies. If you are interested in these areas or other specific topics, we may do some joint research.

National Ready Mixed Concrete Association - Dan Huffman dhuffman@nrmca.org
Early documentation of pervious concrete's freeze-thaw durability is available on the NRMCA's website, www.nrmca.org , as a downloadable report entitled,
Freeze Thaw Resistance of Pervious Concrete.pdf .

Indiana Ready Mixed Concrete Association - Pat Kiel pkiel@irmca.com
The IRMCA has been working intensively with pervious concrete throughout the state of Indiana over the past three plus years. We are aware of several projects that are over 5 years old in the state, and have a total of over 25 projects that we are aware of in Indiana, (some of which were placed on less than ideal sub-bases), we have no knowledge of any freeze – thaw damage to any of these projects.

Axim Italcementi Group - Richard Blackburn Richard.Blackburn@essroc.com
Axim Italcementi is in agreement with the Iowa DOT Study from Feb. 2006, in regards to compaction of material aiding in greater freeze thaw durability. Lower water cement ratios in the mixes provide a reduced permeability in the paste aiding in increased resilience to freeze thaw mechanisms. Axim is currently expanding out our research to include ASTM 666 in our PCPC tests to determine the durability of the mix design.

California Nevada Cement Promotion Council - Andy Youngs andy.youngs@cncpc.org
I began to investigate pervious concrete in March of 2000. Due to the potential for it to become an environmental godsend for Lake Tahoe, freeze/thaw durability was of particular concern to me. I did an ad hoc survey of industry colleagues and found that the pervious concrete sites (some in New Mexico and Pennsylvania were said to be over 10 years old) which proved to be

durable in these climates had two things in common – use of air-entraining admixtures and placement on at least six inches of drain rock.

In the west, we have several installations which have been through two, three or four winters. All were placed with air-entrainment and on at least eight inches of ¾" crushed rock. All have exhibited no freeze/thaw or snowplow damage. Those in the Tahoe Basin can experience over 100 freeze/thaw cycles annually.

In freeze/thaw environments I typically recommend the use of a ½" X 3/8" crushed rock placed with either a weighted Bunyan Screed with cross-rolling; or with a Texas Screed followed by compaction with a vibratory plate compactor.

Gallup Sand & Gravel Co. - Frank Kozeliski fakoz@cia-g.com
As of this date the pervious concrete has not fallen apart due to freeze thaw. The parking lot which is about 15 years old has some mud and dirt on the surface but water still seeks its way through the pervious. Some of the other pervious on a little hill is still intact and there is no break up due to freeze thaw. It just works with no problem. All this work was done by my brother and myself with the kids helping. None of use are certified. I guess I need to get certified.

We are using a 1/2" maximum size aggregate for drainage under astro grass. This is fake grass for out west where it does not rain and the grass stays green all year long. The water drains through the pervious.

Kentucky Ready Mixed Concrete Association - John McChord jmcchord@krmca.org
Kentucky has no formalized lab study on freeze-thaw resistence of pervious concrete. No in-place project has shown signs of this type of distress. The oldest project of any consequence has gone through 3 winters.

Stoney Creek Materials NW - Scott Erickson Scott@stoneycreekmaterials.com
We have a project installed in the Columbia Gorge near Stevenson Washington that is exposed to very extreme weather including ice storms and freeze thaw cycles. It has been installed since 2003 and as of a few months ago looked to be in perfect condition.

Carolinas Ready Mixed Concrete Association - William Arent arent@crmca.com
We have installations that have been in place for over tens years in areas that have experienced multiple freeze-thaw cycles with no apparent damage.