**Progress Report #3**
**February 2005**

**FHWA POOLED-FUND PROJECT NUMBER:** ***TPF5-(075)***

**TITLE:** Extending the Season for Concrete Construction and Repair – Phase II, Defining Engineering Parameters

**PRINCIPAL INVESTIGATOR:**
Charles Korhonen
US Army Cold Regions Research and Engineering Laboratory
72 Lyme Road
Hanover, NH 03755
603/646-4438 phone
603/646-4640 fax
E-mail: Charles.J.Korhonen@erdc.usace.army.mil

**OBJECTIVE:** To define the effect of the antifreeze admixtures developed in Phase I on the freeze-thaw durability of portland cement concrete. We expect this study to lead to guidance for enhanced service life of concrete in northern climates.

**REPORTING PERIOD:** 01 December 2004 through 01 February 2005

**ITEMS IN THIS ISSUE:**

- Funding
- Progress since last report
- ASTM
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- Looking ahead

***Funding*:** Funding for the second year seems to be in order. All participating states have either sent funds to FHWA or will have done so within the next month. Thank you all for supporting both Phase I and Phase II of our cold weather concreting research. This work is making a difference as evidenced by the new ASTM specification that is being developed and by the numerous enquiries we receive every winter.

***Progress since last report:*** At last report, numerous beams, cast from six different concrete mixtures representing a range of w/c ratios and cement factors, were cured at room temperature and subjected to freeze-thaw cycling. This freeze-thaw testing is nearing completion and preliminary analysis of the data suggests that the freeze-thaw durability of all six concrete mixtures increases with admixture dosage, except at the higher doses where durability begins to decline again. One possible explanation for this decline is that the concrete may become loaded with more solids (dehydrated admixture) than can be accommodated by its combined capillary and gel pore volumes, thus rendering the concrete weaker and more susceptible to frost action. We are actively looking into this, as this has interesting implications as to the ultimate freezing point depression possible in concrete and, thus, the lowest temperature that antifreeze concrete can resist. It also suggests that admixtures should enhance the service life of concrete in cold regions and that there might be an optimum admixture dosage to achieve this effect. We are cautiously optimistic with these findings thus far.

Because the conventional freeze-thaw tests (ASTM C 666) take so long to perform (usually more than 1 month) we devised lab equipment to measure the length change of concrete beams cycled from room

temperature to -60C and back again in less than 1 day. The thinking is that concrete that is susceptible to frost action will expand when internal pore water freezes and remain permanently dilated upon thawing while concrete that is immune to frost action may dilate somewhat during freezing but it should return to its original length when thawed. Sudden changes in the slope of the length change curve should also reveal how the freezing process differs when admixtures are present in pore water. This part of testing began last week. So far, the ability of the test equipment to faithfully measure the length change of an aluminum beam demonstrated the equipment's accuracy and repeatability. The few control (no admixture) beams that we have tested thus far show that the concrete contracts initially upon cooling and rapidly dilates at approximately -5C and again at approximately -40C. The controls do not return to their original length at the end of the test, as expected. Testing on the beams made with admixtures will commence within the next week. Beside building our understanding on the freezing process in concrete, we hope that the dilation test may also provide a rapid way to determine freeze-thaw susceptibility of concrete.

***ASTM:*** As Chair of ASTM Section C09.23.06, Cold Weather Admixture Systems, I am working with members from Sika, Euclid, Axim, Master Builders, Grace, NIST, Concurrent Technologies Corp., and other independent consultants to develop a standard specification for antifreeze admixtures (now known as cold weather admixture systems, CWAS). The second draft of the spec was balloted and reviewed at our ASTM committee meeting in December, 2004. Out of 45 ballots sent out, 34 were returned with slightly over 90% affirmative. Two negative ballots along with comments on four other ballots were received. The balloting effort met ASTM voting requirements so the spec was redrafted and re-submitted for ballot in January 2005. As mentioned in the last report, this ASTM work will pave the way for admixture companies to begin to market antifreeze admixtures that are tech-supported. Again, I'd like to thank all of you for being a part of this developing success.

***Users of Phase I Technology:*** The last report mentioned two non-DoT users of Phase I results. A report will be published on the results from the Grand Forks Air Force Base, ND, later this spring. Look for it on our website.

***Looking ahead:***
We continue to be asked for cold-weather concrete guidance from contractors and others as they become aware of our website and the possibilities it offers for extending the concrete construction season. Here's a reply we just received from a contractor in Connecticut:

"*Just wanted to thank you and Lynette Barna for your input on my decision to pour a foundation wall here in CT last week. It was supposed to be a 28 degree high, but I'm not sure it hit that high. We backfilled today and the wall looks outstanding. Many thanks for sharing your time and experience, helping us keep our customer happy, and for the winter employment my crew and myself will enjoy the next 6-8 weeks.*"

The most common advice we hand out, or try to hand out, is how to tailor the admixture dosages, provided in our Phase I report that you all have, to the existing conditions at a given jobsite. As we say in that report, we only have a one-size-fits-all recommendation; i.e., either you use it or you don't. For the Connecticut contractor, we helped him realize that he only needed to use some of our recommendations. Quite obviously, he was pleased with our modified guidance.

A guide for tailoring admixture dosages to a given situation, which includes mix design, weather conditions, and pour geometry, is needed. Though we try to provide dosage guidance case-by-case, we really need to look at past studies we have conducted as well as conduct additional lab studies to come up with a reliable first-generation guide to help everyone determine a safe admixture dosage to use without having to use too much. After all, the admixtures cost money, even if at their current recommended dosages they are less expensive than heat.

We envision developing a series of tables that allows one to select the correct admixture dosage based on the Weather Service predicted max/min temperatures for the time around the pour and on the concrete mixture design. These tables could be incorporated into the March 2004 Guide we produced for you. Comments received from the field on that Guide suggest that adding such guidance would make the Guide even more useful, and probably more likely to be used. Let us know if you'd like us to pursue this next year.