Progress Report
November 2001

FHWA POOLED-FUND PROJECT NUMBER: ***TPF5-(003)***

TITLE: Extending the Season for Concrete Construction and Repair

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OBJECTIVE: To develop an antifreeze admixture conforming to existing industry standards. This work will adapt recently developed knowledge about off-the-shelf admixtures to the specific conditions of highway construction. The admixture will protect concrete to 23°F (-5°C) or lower and allow concrete to gain appreciable strength while at that temperature.

REPORTING PERIOD: 01 June 2001 through 01 November 2001

ITEMS IN THIS ISSUE:

- Newest members
- Funding
- Web page
- Results from the lab
- Looking ahead

Welcome! We wish to extend a warm welcome to our newest DOT project partners: Idaho, Utah and Vermont. It is not too late to join the project. Your input is what will make this project a success. Today's concrete operations require new capabilities to meet the challenges.

***Funding*:** Seven states contributed SPR funds to this project in FY 2001. This year (FY2002), ten states are aboard and assuming that last year's difficulties don't repeat, your funds should automatically find their way to FHWA. If anyone experiences problems in obligating funds let us know, as these problems tend to slow things down. In addition, we could use the support of one or two more states, so if you can talk this project up or can share potential names from other states, we'll gladly contact them about this project.

Web page: Last fall we announced our new Cold Weather Concrete web page <www.crrel.usace.army.mil/concrete> as the vehicle to use for information on cold weather construction. Some of the buttons will be activated soon as we now have several reports in the required .pdf format. The direct link for updates and information on the pooled-fund project is: <http://www.crrel.usace.army.mil/concrete/Antifreeze_Admixtures.htm>.

We bring your attention this time to our 'Other Initiatives' section found under 'Extending the season for concrete construction and repair'. Please visit this to learn about collaborative efforts with the Civil Engineering Research Foundation (CERF) and Current Technologies Corporation (CTC). *Why are these*

important? Because they are timely in showing the interest in developing this technology on a commercial level and in bringing the technology of using antifreeze admixtures to the marketplace.

Briefly, CRREL is working with the CERF to develop acceptance standards for antifreeze admixtures. Such standards are necessary to facilitate the production and widespread use of this new technology. With CTC, CRREL is introducing an expedient cold-weather concrete to the Department of Defense. The need here is to develop a concrete that cures in below freezing weather but that doesn't have to last more than five years. Both of these efforts tie in nicely with our pooled-fund project.

Lab Results: Our goal this time was to develop laboratory mixing, curing and testing protocol to mimic field performance. Our last progress report stated that we had achieved our first goal of confidently designing a -5°C concrete from commercial admixtures. We also learned last time that mixing 1½ ft^3 mixes in the lab at room temperature provided a good indicator of how the concrete would or would not retain its workability (slump) in a truck in cold weather. This was an important find as it allowed us to evaluate in the lab slump loss over time without having to wait for colder weather to do it at full-scale. This time it was important to come up with the right combination of admixtures in the optimum dosages and added into the mix in the proper sequence so that the resulting concrete would be useable to the construction worker in the field. At this point, rapid slump loss was the hurdle to cross.

The admixtures were chosen for both economy and for simplicity. In general, we used the least number of admixtures to simplify dosing sequences in the field and no more than the manufacturer's recommended maximum dose of any single admixture to achieve the desired freeze protection level. The mix design we chose to study consisted of 658 lbs Type I/II portland cement, 1820 lbs coarse aggregate (3/4" NMSA), 1350 lbs sand, 287 lbs water along with a mid-range plasticizer and an air entraining admixture. To this we added several admixtures to achieve a desired performance.

Because this project is limited to studying off-the-shelf admixtures, many of the applicable products contain chemicals that accelerate the hydration rate of cement. This dictated that all admixtures could not be added at the ready-mix plant—some had to be withheld and added later (at the construction site). Because all admixtures we studied contained more than 50% water, it was necessary to withhold water at the ready-mix plant so that the rest of the water could be added at the construction site in the form of an admixture. This created a low W/C at the ready-mix plant and, thus, a need for plasticizers.

The best batching sequence for the laboratory mixes studied this past summer is as follows:

- Place all coarse aggregate and sand into a pre-buttered mixer.

(The butter consisted of 20lb sand, 4 2/3 lbs cement, and water. Mixing sand had the air-entraining agent sprinkled on its surface before the sand was added into the mixer.)

- Mix aggregates dry for 1 minute. Add half of mixing water (while mixer is still rotating) and continue to mix for 45 seconds.
- After 45 seconds add all of the cement, while mixer is still rotating.
- Next 15 seconds add the remaining mixing water (still rotating).

(The end of this two-minute period constitutes the time water hits the cement. Mixing continues throughout 2-minute period.)

- Next 3 minutes with mixer turning add plasticizers (mid- and high-range) followed by other admixtures, dosing each separately into concrete. (All admixtures that are added in small amounts [less than a quart] are in pre-wetted beakers and rinsed with 1 lb of mixing water set aside for this purpose.)
- Stop mixer and allow resting for 3 minutes. Scrape down any dry ingredients from mixer sides.
- Start mixer and finish mixing for 2 minutes. (This constitutes the plant mix.)
- Make first measurements of slump and air content. Return waste from all slump tests to mixer.

- Over the next 45 minutes turn drum for 45 seconds every 5 minutes (simulates 3 ½ rpm of truck drum, also simulates transit time to construction site)
- After 45 minutes, add the final "site dose" admixtures separately into rotating drum. Mix for 2 minutes. (Sometimes extra air entrainers are added by applying them to a small amount of sand, which is then added into the mixer.)

Slump, air content, unit weight, and mix temperature are measured every 15-20 minutes.

By following the above laboratory procedure, we were able to develop 4 four mixtures that maintained some mobility in the mixing drum for 45-50 minutes (i.e., before admixtures are added at the construction site). Once the final site doses were added, the slump and air contents of the mixes returned to acceptably high levels. Because the slump loss was very rapid thereafter, it was envisioned that the concrete would have to be unloaded within 20 to 40 minutes, depending which of the four mixes was being used. At this point, we were ready to conduct a field test to determine how well the mixes perform under actual conditions.

Looking ahead: We have two sites to test our concrete. As reported last time, WisDOT has selected a pavement repair project. It's located at the intersection of highways 8 and 17 in Rhinelander. The plan is to repair four approximately 12x20ft sections of road in March 2002. Two sections will be cast and covered with plastic, while the other two will get an additional layer of insulation. Peter Kemp is the POC in Wisconsin.

The other site is in Littleton, NH. A tractor-trailer recently damaged about 40 feet of curbing on the I-93 bridge crossing the Ammonoosuc River, creating a very practical and timely application for our technology. The plan is to use one of our antifreeze mixes to make the bridge repairs sometime after Thanksgiving. Chuck Corliss is the POC in New Hampshire.