US Army Corps of Engineers®
Engineer Research and Development Center

Cold Weather Concreting

Description

Chemical admixtures that can extend the temperature range at which concrete can be placed, thus expanding the construction season, have been developed at the Cold Regions Research and Engineering Laboratory in Hanover, New Hampshire. CRREL offers preliminary guidance to enable military and civil engineers to design, from readily available chemicals, cold-weather concrete admixtures that are suited to their particular structural and environmental requirements.

Antifreeze concrete is

- Structurally comparable to conventional concrete
- Resistant to freezing and thawing
- Predictable to formulate and test for quality
- Cost-competitive with conventional concrete
- Capable of preventing frost damage during cure.

Concrete is the backbone of modern construction. CRREL provides guidance on chemical admixtures that allow concrete to be placed, finished, and set up at temperatures as low as -14ºF (–10ºC) without the need for heated enclosures, insulation blankets, or other forms of thermal protection, which are expensive in terms of both labor and money and are especially difficult and expensive for pavements.

Chemical admixtures allow this concrete to cure to design strength without heat or insulation.

Capabilities

On the battlefield or in an emergency, when concrete must be placed regardless of the temperature, military engineers may not have access to insulation, let alone heated enclosures. CRREL has developed preliminary guidance to enable military engineers to design expedient (i.e., with a service life up to 5 years) cold-weather concrete admixtures for field use from chemicals that are readily available but not marketed expressly as concrete admixtures. The Army has evaluated more than 50 expedient chemicals for use down to 14ºF (–10ºC) and even lower in emergency situations.

For civilian purposes, CRREL is working with several state departments of transportation to develop chemical admixtures that depress the freezing point of mix water, promote concrete strength at low temperatures, and conform to existing industry standards. Recently developed knowledge about off-the-shelf admixtures is being adapted to the specific conditions of highway construction. The admixture will protect concrete to 5ºC (41ºF) or lower and allow it to gain appreciable strength at that temperature. Designated as Federal Highway Administration pooled-fund study TPF-5(003), this three-year project with state DOTs will run through the spring of 2004. Participants will receive the guidance and tools necessary to design and test antifreeze concrete. Sufficient funding has been secured to start the project, but additional sponsors are being sought for the outlying years. Parties interested in acquiring the technology should contact the CRREL project POC. Ten states (Idaho, Michigan, Montana, New York, New Hampshire, Pennsylvania, Wisconsin, Wyoming, Vermont, and Utah) have committed to participating in the project, using their SP&R funding through FHWA. Several other states have indicated an interest in joining.

Supporting Technology

CRREL offers guidance, research, and on-site consultation on the development of appropriate admixtures based on the specific requirements of each project, including temperature ranges, structural design criteria, and the concrete mix design.

More information can be found in the following reports:

- Technical Report: C.J. Korhonen (2002) Off-the-Shelf Antifreeze Admixtures, ERDC/CRREL TR 02-7.

- Special Report: C.J. Korhonen (1999) Expedient Low-Temperature Concrete Admixtures for the Army, CRREL Special Report 99-17.

- Special Report: C.J. Korhonen, E.R. Cortez, T.A. Durning, and A.A. Jeknavorian (1997) Antifreeze Admixtures for Concrete, CRREL Special Report 97-26.

Benefits

The energy cost for concrete thermal protection is estimated to be $800 million per year. With the successful development of a robust antifreeze concrete technology, as proposed for this study, there is a potential market for more than 14 million cubic yards of concrete to support winter highway and street construction projects in the U.S. alone.

Antifreeze concrete can

- Be placed at a mix temperature below 0°C (32°F) and cured without insulation in freezing temperatures and still develop strength at acceptable rates without frost damage.

- Recover full strength, even when exposed to temperatures below those for which it is designed.

- Be safely placed on frozen substrates.

With antifreeze concrete

- The construction season can be extended by 60 to 120 days.

- The impact of construction on the public is reduced because traffic volumes are at peak during the summer.

- Fewer accidents will occur in work zones because construction can be extended to low-traffic periods.

- There are direct energy savings because added heat is unnecessary.

- Construction equipment and labor will be in more continuous use.

- Seasonal unemployment will be reduced, providing a more continuous construction team in whom employers can invest training, knowing they can obtain a return in increased productivity.

Success Stories

The Cold Regions Research and Engineering Laboratory has developed several formulations of antifreeze concrete that allow appreciable strength to be gained while the internal temperature of the concrete is below freezing. To date, the use of antifreeze admixtures has been limited to case-by-case studies, but CRREL proposes extending this technology to common practice.

One such case won CRREL the Vice President's Hammer Award. The Tennessee Valley Authority discovered structural problems in ice-storage rooms in a nuclear plant. They asked CRREL whether its development of concretes that can be poured in subfreezing temperatures could be applied to solve their problem and avoid a $1M/day loss of revenues from shutting down the plant. Working with TVA and others, CRREL developed a concrete mixture that allowed the structural repairs while the plant continued operations.

CRREL has worked with private industry to develop prototype admixtures that protect concrete down to –5ºC (23ºF), temperatures at which normal concrete suffers irreparable damage. The work was conducted under the authority of the U.S. Army Corps of Engineers Construction Productivity Advancement Research (CPAR) program, which is a cost-shared program between the Corps and the U.S. construction industry. Currently, two prototype admixtures—one from Master Builders, Cleveland, Ohio, and the other from W.R. Grace, Cambridge, Mass.—have been brought to the threshold of commercialization. One was used at a Corps project in northern Michigan. Ordinary admixtures worked at –8ºC (18ºF) for the TVA.

ERDC POC(s)

Contact Charles Korhonen at (603) 646-4438, or by email at:
Charles.J.Korhonen@erdc.usace.army.mil

Enclosures have been needed to promote concrete strength when temperatures fall below 5°C