National Honors

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RESEARCH SOLUTIONS

Heated concrete shows promise as sustainable addition to winter maintenance toolbox

When installed at trouble spots like icy bridge decks, electrically heated concrete could one day help keep pavement clear of snow and ice without the need for repeated salting—a boon to the environment. While heated concrete systems have been in development for decades, a recent innovation has made them more energy-efficient by adding electrically conductive carbon fibers embedded within the concrete. Building on the successes of previous small-scale tests, researchers created a full-scale field demonstration to test and compare different configurations of this new system under real-world conditions.

THE NEED

Iowa's state and local transportation agencies spend significant time and money each year to remove snow and ice from roadways. While snowplows and deicing chemicals work well in most locations, some areas require extra attention, like highway bridges that freeze before the rest of the roadway or exit ramps where vehicles need to decelerate quickly.

To keep these areas clear, agencies across the country have experimented with heated concrete systems that warm the surrounding pavement and melt the snow from the ground up. However, earlier heating technologies have been vulnerable to problems (such as leakage from hydronic heating systems or damage to embedded heating cables) that can affect heating efficiency and pavement structural performance. Identifying and fixing these problems can be costly and destructive to the concrete.

Researchers are now exploring an innovative new approach: an electrically conductive concrete system that incorporates conductive carbon fibers within the concrete mix. Powered by electrodes embedded in the concrete, the system uses the inherent elec-

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> **"Electrically conductive concrete shows promise. Future research will help us determine where and when it could be an effective alternative to traditional snow and ice removal methods."**
>
> — MIKE HARVEY,
> Director, Iowa DOT Support Services Bureau

trical resistance of the concrete to keep the pavement surface above freezing.

After years of investigation, researchers with Iowa State University installed the world's first full-scale test of an electrically conductive concrete system at Des Moines International Airport in 2016. To build on the success of that project and determine the most cost-effective and energy-efficient electrode configurations for other potential applications, Iowa DOT commissioned many of the same researchers for this effort: the largest-to-date field study of an electrically conductive concrete heated pavement system, with test sections of a variety of electrode configurations arranged within a 75-ft.-by-24-ft. area.

RESEARCH APPROACH

First, the researchers performed a variety of laboratory tests on electrodes of different sizes and geometries to determine candidates for further in-field study. A parking lot at Iowa DOT's headquarters in Ames was chosen as the installation site, with researchers replacing 10 concrete slabs that were already in need of rehabilitation.

Once the old slabs were removed, researchers created 10 test sections within the empty area. They installed stainless steel electrodes of various sizes and shapes in several configurations, as well as sensors to track and report surface temperature and other data. Wireless sensors were added to allow the electricity to be turned on and off remotely.

For the pavement's surface layer—placed on top of the electrodes and sensors—researchers selected a standard concrete mix designed for heavy traffic loads, adding carbon fibers to the mix for increased conductivity. After the concrete hardened, the researchers conducted stress tests to assess the strength and structure of the pavement with the embedded electrical system in place. Finally, the research team operated and monitored the heated pavement for three winter seasons.

WHAT IOWA LEARNED

Throughout the evaluation period, all of the electrode configurations successfully melted snow and ice on the pavement surface. Data showed that electrode size impacted cost-effectiveness; larger electrodes tended to be more cost-efficient than smaller ones. Tests also showed that the carbon fibers in the concrete mix not only improved conductivity but also served to make the pavement stronger.

The researchers suggested several best practices to optimize the performance of the system, such as turning on the electricity in the pavement ahead of winter storms to melt snow as it falls and adding heating elements along the melted water's drainage route so ice doesn't re-form along that path.

PUTTING IT TO WORK

Electrically conductive concrete systems show promise as a sustainable winter maintenance alternative that could help agencies reduce their use of deicing chemicals. Although more research is needed prior to roadway installations, Iowa DOT is considering how the technology could be used at rest areas, and a follow-up IHRB study is implementing this technology at new bus stops and bus loading areas in Iowa City.

ABOUT THIS PROJECT

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PROJECT CHAMPION:
Mike Harvey, P.E.
Director, Iowa DOT Support Services Bureau
mike.harvey@iowadot.us
515-239-1327

TECHNICAL ADVISORY COMMITTEE:
Ahmad Abu-Hawash, Brandon Billings, Chris Brakke, Todd Hanson, Brian Keierleber, Steve McMenamin, Kevin Merryman, Brian Moore, Greg Mulder, Wes Musgrove, Scott Schram, Danny Waid, Wade Weiss, Bob Younie.

PROJECT MANAGER:
Vanessa Goetz, P.E.
State Research Program Manager
Iowa Highway Research Board
Iowa DOT
vanessa.goetz@iowadot.us
515-239-1382

PRINCIPAL INVESTIGATOR:
Halil Ceylan, Ph.D., P.E.
Iowa State University
hceylan@iastate.edu
515-294-8051

IOWA DOT RESEARCH:
iowadot.gov/research
ideas.iowadot.gov

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