Durability or bust

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MANHATTAN, Kan. -- A Kansas State University-led research project is helping high-speed rail systems handle the stress of freezing and thawing weather conditions.

The university's Kyle Riding, assistant professor of civil engineering, is leading a three-year study that looks at the freeze-thaw durability of concrete railroad ties. The research is essential to developing safe and durable high-speed rail systems.

Riding is collaborating with Mohammed Albahttiti, civil engineering doctoral candidate from the United Arab Emirates; the university's Institute of Environmental Research; as well as a colleague at the University of Illinois at Urbana-Champaign, and commercial partners Canadian National Railroad and CXT Concrete Ties Inc. The Federal Railroad Association recently awarded Riding more than $1.2 million to study the materials and fabrication process, and to develop quality control tests that ensure safe freeze-thaw durable concrete railroad ties.

"Freeze-thaw is a stressor that happens in pretty much all concrete when it is exposed to water and then freezing and thawing temperatures," Riding said.

When water freezes it grows in size by roughly 9 percent, Riding said. These increases, coupled with the decreases when the ice melts, cause stress on the container the ice forms in. When too much stress occurs the container can break -- similar to what happens when a full soda bottle is left in the freezer.

In concrete rail ties water collects and freezes in the pores of the concrete. As the liquid freezes it creates stress in the railroad tie, which can crack the ties. High-speed rail systems are more sensitive to these problems because of the high speed at which the trains travel on the tracks.

As high-speed rail systems become more widely adopted around the world, it becomes essential to keep passengers safe and maintain the rail system infrastructure against freezing and thawing conditions, Riding said.

To study the freeze-thaw conditions in concrete rail ties, researchers will add surfactants to the concrete as it is being mixed in the laboratory. These compounds produce millions of microscopic bubbles in the concrete that act as pressure release valves to help protect the concrete against damage.

One of the challenges will be to ensure that the bubbles are evenly dispersed through the concrete rail ties and small enough to protect the concrete from damage.

Researchers will evaluate the vibration conditions and air voids created by the bubbles in rail ties produced from various other materials, including surrogate clear

materials, cement paste and mortars before scaling up to concrete. The ties will also be studied to determine if they get wet enough on the tracks to cause damage.

Additionally, the team is developing evaluation methods that will help railroad tie manufacturers determine the freeze-thaw resistance of concrete rail ties once they are produced.

"This is a good way to take fundamental science and apply it to a real-world application that will affect our transportation infrastructure and our communities," Riding said. "Plus, who doesn't like trains?"

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