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UTC Spotlight

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Seeing the Unknown for Safer Bridges

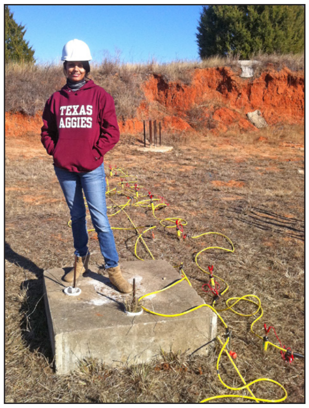
Like an iceberg, a lot of what gives a bridge its strength is hidden. The question is, how much of a bridge's foundation is exposed, and how much is still hidden? In Texas there are approximately 10,000 bridges with unknown foundations. That's one out of five bridges—many of which are old with lost documentation, or the depth of the foundation was not documented to begin with. The depth of the bridge foundation is very important in determining whether the bridge needs to be repaired or replaced.

Texas A&M Transportation Institute

Bridge failure due to scour.

Sponsored by the Southwest Region University Transportation Center, researchers at Texas A&M University's Department of Civil Engineering have developed a technology that uses induced polarization and electrical resistivity to "see" underground and determine if a bridge has maintained its designed margin of safety with regard to foundation depth. Stefan Hurlebaus, Jean-Louis Briaud, and Stacey Tucker tested a unique method of examining the bridge-weakening effects of scour on unknown bridge foundations. Scour is the void left behind when the sediment (soil, sand, and rock) washes away from the bottom of a river and from around the bridge piers and abutments that support the bridge. Heavy scour around bridge foundations can be a sign of instability—depending on how deep the foundation goes. This is why finding and knowing that depth is so important to bridge engineers.

The new test method requires a 90-foot line of electrodes spaced approximately 3 feet apart. "We see the bridge pier. It's in the center of our electrode line. But we want to know what's underneath," Hurlebaus said. Current is applied to each electrode in the line one at a time while the other 27 measure the amount of current flowing into the ground. When there is a difference in the resistivity of the soil caused by either soil-to-concrete or soil-to-steel contact, it is detected and recorded. Software takes this information and builds an image of the resistivity of the ground. Where there are changes indicated by color, the foundation can be located.



Stacey Tucker

Civil Engineering graduate student researcher, Negin Yousefpour, assists with initial technique testing at the Texas A&M Transportation Institute Proving Grounds Research Facility.

The type of soil surrounding the bridge can be an issue. "This method is quite reliable, depending on the soil type. It's better in clay versus sand. We see much better resistivity contrast in clay," noted Hurlebaus. In either soil, steel reflects better than concrete.

Before any actual bridges were tested, researchers took advantage of an old National Geotechnical Experimentation Site at the Texas A&M Transportation Institute's Riverside Proving Grounds Research Facility. Constructed in the mid-90s, this test site has numerous types of concrete and steel piles in both sandy and clay soils. Briaud told civil engineering students assisting with the project that he knew the answer but would not tell them until they had gone to the site and used the method to measure how deep the piles were. "It was a great test bed for the technique," he said.

After the initial testing at Riverside, researchers moved to actual bridge structures. "It was a blind test. We were given access to a number of bridges. After testing, we requested the files on those bridges," Hurlebaus said.

Stacey Tucker

Electrode line array under Navasota River Relief Bridge at Brazos/Madison County Line, Texas.

The results show promise. "We blind tested a number of foundations and got within 2 or 3 feet of the known depth. But, in general, that's not a big issue. What we really want to know is the minimum depth for the bridge to be safe. If we find out that only 10 feet of depth is required for the structure to be safe, and we see at least 10 feet in our data, the bridge will be fine. It doesn't matter if the foundation is actually 20 feet," Hurlebaus explained.

The technique is also useful in locating buried gas lines. If the lines are located near the surface, excavators can avoid damaging a line while digging. "If the line is 100 feet in the ground, this method won't detect it. Excavations are usually much closer to the surface than that. It's a great method to see if there is something underneath or not," said Hurlebaus.

Researchers are hoping an implementation project will be the next step in developing this technology. Hurlebaus said, "We really want to show departments of transportation how this technology can be used. We want them to gain experience with the equipment and the technique."

"It's another tool in the box for scour engineers," Briaud added.

Stacey Tucker

Electrode line array under Gum Creek Bridge in Grimes County, Texas.

About This Project

The coprincipal investigators for this project were Stefan Hurlebaus, Ph.D., and Jean-Louis Briaud, Ph.D., of the Zachry Department of Civil Engineering at Texas A&M University. Dr. Hurlebaus' research interests include structural health monitoring, nondestructive testing, smart structures, and wave propagation in elastic solids. Dr. Briaud's interests include soil mechanics, scour around bridges, field testing, and geoenvironmental engineering. Graduate research assistant Stacey Tucker, now an Assistant Professor at Kansas State University, also assisted in this research effort. This study was sponsored by the Region 6 Southwest Region University Transportation Center under the direction of Melissa Tooley, Ph.D.