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UTC Spotlight

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Robotic Nondestructive Evaluation Tool Helps Bridge Engineers Validate Bridge Deck Condition Assessments

In the 1950s President Eisenhower initiated the creation of an interstate highway system that would connect every part of the country via nearly 50,000 miles of roadway. Considered the greatest public works project in history, it resulted in one of the Nation's most productive eras of economic growth.

Within that vast network are around 600,000 bridges—some built at the same time as the interstates—that play a crucial role in the Nation's commerce, mobility, and security.

Keeping these assets in a state of good repair requires regular monitoring and maintenance. To gauge bridge condition, transportation agencies have traditionally used methods—such as the chain drag and hammer sounding—that rely largely on the finely tuned senses of experienced inspectors. But recent advancements in nondestructive evaluation (NDE) technologies help make assessments more quickly, improve safety, catch potential problems earlier, and lessen traffic disruptions. NDE also provides bridge owners and managers with quantitative data that lets them "dig deeper" into bridge deck issues without actually digging into the structure.

Rutgers' Center for Advanced Infrastructure and Transportation (CAIT) took NDE to the next level with the Robotics Assisted Bridge Inspection Tool (RABIT™), an automated NDE platform that simultaneously deploys multiple NDE tools, gathering a range of condition data that can be fused into a comprehensive picture of a bridge's health.

The RABIT™ bridge deck assessment tool uses sophisticated technologies to gather location-tagged surface and subsurface condition data. When combined, these data can quickly characterize, evaluate, and pinpoint areas needing repair, saving time and money and limiting traffic delays.

The tool measures electrical resistivity, which characterizes the corrosive environment of the concrete. It deploys ultrasonic surface waves to evaluate concrete quality and impact echo to detect and characterize delamination. It uses two high-definition cameras to capture images of the deck surface and 360-degree images of the surrounding area and a global positioning system (GPS) to tag data with exact location. Its ground penetrating radar (GPR) uses electromagnetic waves to "map" rebars and other objects below the surface and provides qualitative assessment of concrete deck deterioration.

The team deploys the RABIT™ bridge deck assessment tool.

According to development team leader Nenad Gucunski: "In the past, we didn't have a way to compile information on delamination (horizontal cracking), degradation, corrosion, precise location, photographic, or load stress data all at once. Not only does the RABIT™ bridge deck assessment tool help us validate data collected from individual machines, but it forms a meaningful picture of what's happening inside the bridge deck in real-time to help us arrest deterioration."

For inspectors, researchers, and motorists, the RABIT™ bridge deck assessment tool reduces exposure to the dangers inherent in any roadway work zone. The area to be scanned is preprogrammed with a highly accurate GPS unit, eliminating the previously necessary extra step of manually premarking a test grid. It can be controlled remotely by a smartphone or iPad, so the operator doesn't have to be in traffic. In addition, its internal laser scanning system prevents collision with barriers, curbs, vehicles, and people.

The RABIT™ bridge deck assessment tool is environmentally conscious as well. The same van that transports the robot to testing sites doubles as a mobile command center, adding to its speed and efficiency. Condition data is wirelessly transmitted in real time to computers in a van where it is compiled and rendered on monitors that display NDE data and imaging, data analysis, deck condition data, and crack mapping. This allows engineers and inspectors to analyze and share photographic, NDE, and location data at once.

Drew Noel

The team reviews data collected by the RABIT™ bridge deck assessment tool.

"With our platform, we're able to tell bridge managers exactly where they need to apply repairs—this reduces bridge closure time, which improves safety and doesn't hinder traffic or businesses," Gucunski said. "It also can reduce unnecessary expenditures of time and money."

The RABIT™ bridge deck assessment tool team debuted the platform in November 2012 for FHWA Administrator Victor Mendez on a Virginia bridge that is part of the LTBP study. Mendez called the RABIT™ "amazing" and deemed it to be "at the forefront of a new industry." In the following months, FHWA tasked the team with validating previously collected data on several other LTBP bridges along the East Coast, including the iconic Arlington Bridge between Washington, D.C., and Virginia.

The team is currently testing the RABIT™ bridge deck assessment tool on a number of bridges in the mid-Atlantic states to validate and perfect the operation of each of the tool's many components.

Since its debut, the NDE robot is becoming a celebrity in the engineering community, drawing crowds of transportation experts at several major events—including the Transportation Research Board annual meeting, LTBP state coordinators' meeting, the ASCE Innovative Technology subcommittee meeting, and a congressional staffers' meeting—and media attention.

"We have transportation agencies from around the country asking us to use the RABIT™ bridge deck assessment tool to test their structures," Gucunski said.

The RABIT™ bridge deck assessment tool provides engineers with a way to advance structural health and state of good repair—*and* it promotes prudent infrastructure spending.

"This platform is a powerful asset to bridge engineers who meticulously collect and analyze condition data," Gucunski said." The RABIT™ bridge deck assessment tool improves the quality and quantity of data available so that we can make more judicious, effective bridge management decisions."

About This Project

The RABIT™ bridge deck assessment tool sprung from the Federal Highway Administration (FHWA) Long-Term Bridge Performance (LTBP) program and was championed by the infrastructure management team of FHWA's Turner Fairbank Highway Research Center under the leadership of Hamid Ghasemi, Ph.D., Firas Ibrahim, Ph.D., Michael Trentacoste, and Jorge Pagan and CAIT researchers Nenad Gucunski Ph.D., and Ali Maher Ph.D.