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# Tell Me Where It Hurts, Mr. Highway

By: Michael Haederle | February 10, 2010 | 15:40 PM (PDT) | Print

In El Paso, our Michael Haederle reviews innovative ideas suggested for arresting the wear and tear on roads, bridges and other infrastructure.

Roads, bridges, drainage projects — the things we all use and take for granted — are the engineer's stock-in-trade, but they suffer from incessant wear and tear. How do we know when they're wearing out? What's the best way to rehabilitate these structures to avoid a costly replacement?

What about infrastructure as a whole? How do we minimize the vulnerability of interconnected systems like transportation, power, communication and other systems?

Those are the themes being explored today at the *Building Partnerships and Pathways to Address Engineering Grand Challenges Conference* at the University of Texas at El Paso.

Ominously, from a transportation infrastructure standpoint, scheduled keynote speaker Victor Mendez, administrator of the Federal Highway Administration, has been stranded in Washington, D.C., by yet another blizzard. Filling in for Mendez is Nenad Gucunski, chair of civil and environmental engineering at Rutgers University, who graciously prepared a last-minute presentation.

He is a specialist in infrastructure condition monitoring, particularly nondestructive evaluation techniques for studying bridge safety.

It's an urgent problem, Gucunski notes. There are about 590,000 bridges in the United States, with an average age of 45 years. He estimates that we spend about $5 billion each year to repair or replace portions of 2.8 billion square feet of bridge decks.

Gucunski shows photos of bridge decks whose concrete surfaces are delaminating and spalling due to weather and heavy use — evidence of what happens when evaluation and rehabilitation are postponed past the point of no return.

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"We need to expand our nondestructive evaluation to nondestructive rehabilitation," Gucunski says. "We would like to find effective ways to fuse the data from different technologies.

He is leading development of ANDERS (the Automated Non-Destructive Evaluation and Rehabilitation System), which he notes means "different" in both German and Dutch. "That is what we would like to do," Gucunski says, "to develop something that is very different from what we do today."

The ANDERS system starts with a van equipped with scanning devices like ground-penetrating radar, a chemical sensor and high-resolution cameras. That information is processed to determine when repairs need to be made, which then guides the work of a robotic vehicle equipped with a precision drill that targets the damaged areas.

"There is no question that the issues related to transportation infrastructure present a major challenge," Gucunski says. "There should be a lot of communication between different programs, and those programs should be complementing each other."

Next comes the Assessment and Management of Decaying Urban Infrastructure Session, a systems engineering doctoral student from the University of California, Berkeley, Michael Darter, director of the Pavement Research Institute at the University of Minnesota; Amir Mirmiran, dean of the College of Engineering and Computing at Florida International University, and (via phone link) Monica Starnes, a senior program officer for the Transportation Research Board.

Starnes talks about the importance of locating buried utilities in highway construction and rehabilitation projects, noting that many companies maintain inconsistent or outdated databases about what is buried where.

Some available technologies include electromagnetic locators, ground-penetrating radar and various acoustical approaches, she says.

"While there are steps on the way to standardize record-keeping … much of the existing information about buried utilities must be considered suspect until proven correct," she says.

Starnes is followed by Mirmiran, who talks about infrastructure in its broadest terms as the intersection of physical infrastructure, natural systems and human services.

"It is not possible to address one without the other one," he reminds us. "It is not possible to address the vulnerabilities that these systems have without knowing how they correlate with each other."

He points to the 2003 blackout that affected much of the Northeast, which impacted railroads, highways and air transportation, along with communications and other systems. After Hurricane Katrina in 2005, a main north-south oil pipeline was shut down for more than 20 days, affecting communities in the upper Midwest that had been spared the storm's fury, he says.

Planners and engineers need to account for "steady stressors," such as aging, fatigue and deterioration (which affect capacity) and population growth, which affects demand, Miriman says.

Then there are "transient stressors," which may be natural hazards like hurricanes, floods and earthquakes that "show the vulnerability of our infrastructure," he says. And, we also must account for man-made hazards, like terrorist attacks.

In search of solutions, there are general approaches, like performance-based design and consequence-based risk management, as well as specific methods, which include capacity building, hardening and structural monitoring.

"Unless you come up with integrated solutions, you would never be able to meet the demand and build as much capacity," Miriman says.

In the Bay Area, Dan Work and his collaborators have been looking at ways to deal with traffic congestion, which wastes about 2.9 billion gallons of fuel each year. They're interested in "Cyber Physical Systems," which couple physical components with a computational system via the Internet. The problem is, you need sensors to generate data.

"As far as I know, cell phones are the world's largest sensor network," Work says.

"There's more than 3 billion devices worldwide." And while they may not be the most elegant approach to designing traffic sensors, modern smart phones are equipped with on-board sensors like GPS and accelerometers. Best of all, they are connected to the Internet.

With the Mobile Millennium project, Berkeley scientists got 5,000 Bay Area motorists to download an application that downloads real-time updates from a traffic-monitoring network while uploading positional data that tells it where traffic is heaviest.

The proof-of-concept came in a test on Feb. 8, 2008, when 175 graduate students spent eight hours driving rented cars while traffic patterns were closely monitored with high-definition cameras. "We learned the going rate for a graduate student is about $200 a day and they were happy to drive around for eight hours over the same 10-mile loop," Work says. The audience cracks up.

Work also shows a multi-modal smart-phone app from BayTripper.org that can tell whether buses and trains are on time. "Once you start providing this inform online, the kinds of services you can provide to people are really quite rich," Work says.

If Work and company are using cyber-engineering, Mike Darter is an old-fashioned concrete-and-asphalt kind of guy. But he dreams big: "This is an intellectual challenge. How do we design infrastructure that will last a long time, that will have low maintenance?"

He shows the audience a photo of a cross-section of concrete pavement poured in Bellefontaine, Ohio, in 1891. An early example of concrete paving, it is still in use after 119 years.

"It seems like we got it right the first time around, and we've been going downhill ever since," he cracks.

But Darter thinks road surfaces can achieve much longer life spans by combining smart design, quality materials, first-rate construction and repair of wear-and-tear before it causes structural damage.

He notes that highways in Minnesota have been designed for 75-year span, with about 8 percent in additional up-front construction costs being offset by substantial savings in repair and replacement costs down the road.

Even more ambitious is the idea of designing a road that will last a century. “That’s an attention getter,” Darter says. “Even politicians can understand that concept.”

These approaches save lives (2,000 people die each year in work zone accidents), reduce engine pollution from construction-caused traffic congestion and minimize the economic impact on surrounding neighborhoods and businesses, Darter says.

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