Bridge-Monitoring Poster Wins Grand Prize At 2006 Research Expo

March 1, 2006

Rex Graham

Hong Guan opens a wire mesh door to a computer server in a UCSD engineering laboratory at 2 p.m., Feb. 23 and watches lines form across the monitor, including a few that jiggle up and down. The lines register the output of sensors attached to a highway bridge about 170 miles east of campus. "Some trucks cross that bridge at 90 miles an hour and if you're standing under it when that happens it sounds like you're inside a giant percussion instrument," said Guan, a Ph.D. candidate in structural engineering.

A few hours earlier, amid a cacophony of 250 simultaneous poster presentations by graduate students at the Jacobs School's Research Expo, Guan's presentation on bridge-performance monitoring was judged the best poster by a structural engineering graduate student.

More than 600 guests attended Research Expo 2006, an event held the morning of Feb. 23 to foster interaction among Jacobs School faculty, students, alumni, and industry partners. In addition to the graduate student poster exhibit, the day's activities included technical breakout sessions led by Jacobs School faculty and a luncheon featuring remarks by Ralph J. Cicerone, the president of the National Academy of Sciences.

Hong Guan's faculty advisor, Vistasp Karbhari, a professor of structural engineering, helped him analyze monitoring data collected from an innovative composite bridge called the Kings Stormwater Channel Bridge. The bridge was built in 2000 near the Salton Sea on California State Route 86 in rural Riverside County. Sensor measurments are transmitted from the bridge to UCSD and the California Department of Transportation via the National Science Foundation-funded High Performance Wireless Research and Education Network (HPWREN).

After Cicerone's luncheon speech, the top poster winners from each of the Jacobs School's five departments, including Guan, were announced and invited onstage to accept their awards. Carrie Munce, vice president of research for Hitachi Global Storage Technology, then announced that Guan, was the grand prize winner. Frieder Seible, dean of the Jacobs School, clipped a blue ribbon to the surprised student's lapel.

"I felt honored," Guan said later in his laboratory. "There were so many excellent posters from the Department of Structural Engineering alone, and I still have a lot more work to do on this project."

Guan was born in Zhengzhou, China. He received a bachelor's degree from Tongji University in Shanghai and a master's degree from Hong Kong University of Science and Technology. He enrolled at UCSD to study in its Department of Structural Engineering, a world leader in the design and testing of fiber-reinforced composite structures, earthquake resistant buildings, bridges, and other structures. "Hong is an exceptional student working on a problem of utmost importance to the designers of new bridges and the owners of tens of thousands of aging bridges across the country," said Vistasp Karbhari, a professor of structural engineering and Guan's faculty advisor.

Karbhari is collaborating with the California Department of Transportation (Caltrans) on a variety of research projects, including one that involves the design, construction, and monitoring of an innovative new bridge called the Kings Stormwater Channel Bridge. The structure, built in 2000, is located near the Salton Sea on a rural stretch of California State Route 86, a north-south highway in Riverside County dubbed "The NAFTA Highway" for its high volume of truck traffic to and from Mexico. (NAFTA stands for the North America Free Trade Agreement.) A first-of-its-kind composite bridge, the Kings Stormwater Channel Bridge was designed by a team of engineers from UCSD, Caltrans, and industry. The team, led by UCSD professors Karbhari, Gilbert Hegemier, and Frieder Seible, is interested in bridges that are faster to construct and lighter than conventional reinforced-concrete while also being more durable. Costly steel rebar was essentially eliminated and replaced with non-corroding composites, which are expected to give the bridge a longer life expectancy than a conventional steel-reinforced concrete design.

Under Karbhari's supervision, Guan has studied the two-lane 66-foot-long bridge as part of his Ph.D. project. The bridge is supported by six carbon-fiber-reinforced epoxy tubes about 1 foot in diameter that were positioned on site and filled with concrete. The bridge's deck is made of a high-performance glass-fiber-reinforced polymer. The UCSD team tested full-scale models of the bridge in the laboratory before Caltrans authorized construction. Guan uses 63 accelerometers to measure vertical and horizontal accelerations, which can be as high as 1 G when fully loaded trucks zoom over the bridge at high speeds. In addition, 20 strain gages, a temperature sensor, and other instruments provide data needed to monitor the bridge's structural health. "There is no significant degradation," Guan said. "We are seeing some changes, but the bridge is holding up well."

All the sensor measurements are transmitted from the bridge to UCSD and Caltrans laboratories wirelessly via the National Science Foundation-funded High Performance Wireless Research and Education Network (HPWREN). The sensors can provide information about the response of the bridge as well as the flow of traffic on it. The technology is so versatile that it may one day be used to monitor bridges' health, provide real-time data on traffic flows, and function as non-stop weight station, recording the weight of trucks as they roll past.

The monitoring system also could reduce the need for expensive, time-consuming visual inspections. A collection of appropriate sensors could give highway officials advance warning of any structural weakness or deterioration, reducing the possibility of unexpected failures. If weaknesses did develop, the system comprising the sensors and damage detection algorithms would pinpoint the precise locations of the problems, saving repair crews' time.

"This research has demonstrated that bridge sensors and wireless technologies could be enormously valuable components of a 'smart' transportation infrastructure of the future," said Karbhari. "We are making excellent progress toward a continuous autonomous monitoring, which amounts to a new paradigm of efficient assessment of the condition of our transportation infrastructure."

Media Contact: Rex Graham, Jacobs School of Engineering -- 858-822-3075.