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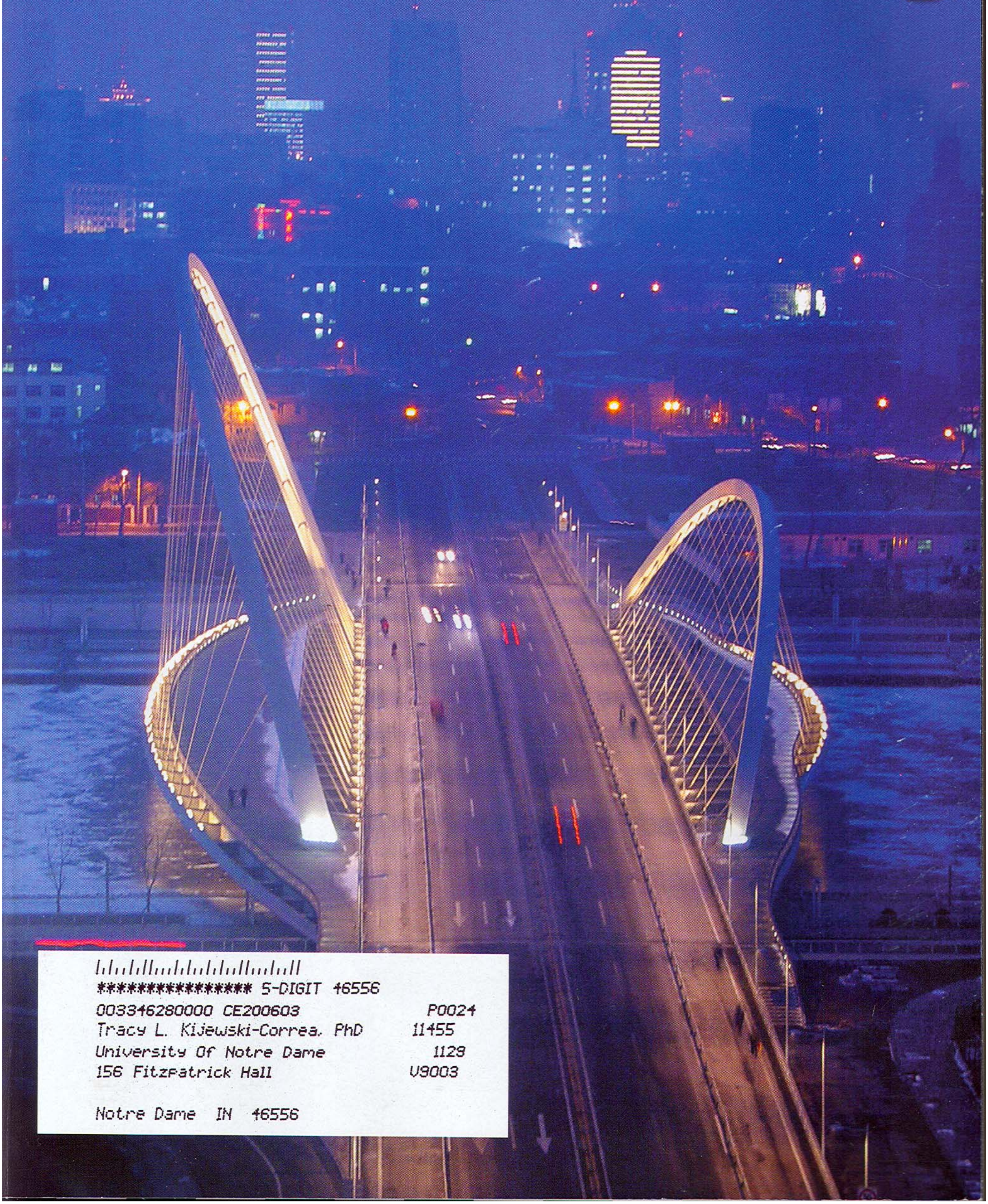

was covered with other dredged materials to prevent contamination leakage.

Tuchman does not anticipate any significant recontamination of the lagoon because tests show that the Detroit River, while far from pristine, is less polluted than in the past. Industrialization has declined in the area, and permitting regulations are now in place. "We're pretty sure that the sediments are clean now," says Tuchman, who adds that the EPA will continue to monitor the site every few years.

This spring the City of Trenton will restore the shoreline around the lagoon and eventually may build a marina adjacent to a park on the south side of the lagoon. The site occupied by the steel plant is to be converted into condominiums and commercial and industrial facilities.

Environmental Quality Management, Inc., of Cincinnati, served as the contractor on the project.

—*Karen Trimbath*

STRUCTURAL ENGINEERING

Researchers Test Skyscraper Responses in Chicago

For many years, the design of high-rise buildings has been based on computer analyses and scale models tested in wind tunnels. But these designs have not been verified using data from actual structures. In a new study, three Chicago skyscrapers have been equipped with accelerometers and Global Positioning System (GPS) receivers to collect the data under wind loads. Researchers from the University of Notre Dame—in collaboration with personnel from the Chicago office of Skidmore, Owings, and Merrill (SOM) and the University of Western Ontario's Boundary Layer Wind Tunnel Laboratory (BLWTL)—are comparing the data with predictions derived from computer models and wind tunnel tests. "Our goal is to validate the tools used to design high-rise buildings—something that has not been done in the United States using full-scale data," says Ahsan Kareem, Ph.D., M.ASCE, a professor of civil engineering at Notre Dame and one of the project's two principal investigators. The other is Tracy Kijewski-Correa, Ph.D., A.M.ASCE, an associate professor at Notre Dame.

Although the names of the three buildings in Chicago are being kept confidential at the owners' request, it is known that the researchers chose them on the basis of their varied structural systems. The first building is a steel tube that comprises exterior columns, spandrel beams, and other steel members designed to stiffen the perimeter frame. The second building's structural system comprises reinforced-concrete shear walls located near the building's core that provide lateral load resistance. Reinforced-concrete outrigger walls tie the core to the perimeter columns. The third building features wide, closely spaced columns connected by deep spandrel beams. According to Kareem, this building functions like "a vertical cantilever fixed at the base to resist wind loads."

The engineers have collected estimates of such dynamic properties as damping and periods of vibration and such building responses as acceleration and displacement, which have been measured by accelerometers and the GPS receivers. They have compared the data thus far obtained from these devices with the predictions made on the basis of finite-element models and wind tunnel tests at the time of design.

The investigators have determined that the first building performs as predicted with respect to dynamic properties and the response to lateral loads. The second building exhibits a lower period of vibration and higher damping than had been predicted. (Damping is measured as a percentage of the building's critical damping—or the amount of energy dissipation necessary for the building to immediately come to a stop if it has been moved from its original position.) The investigators attribute the second building's discrepancies to the fact that it is constructed of concrete. According to Kareem, concrete structures are difficult to model accurately because they form cracks that render them more flexible and because their exact modulus of elasticity is unknown until the concrete is mixed.

The third building exhibits a higher period of vibration than predicted in the finite-element analysis used in its design. The researchers believe this discrepancy derives from a number of factors, including the use of deep spandrel beams and large columns. "The joints connecting these large elements can deform somewhat under wind," Kareem says. He also says that simple computer models do not necessarily capture this type of behavior, resulting in "buildings that look stiffer than they are in practice." The investigators are now considering ways of improving the accuracy of finite-element models so that they will better accord with full-scale results. They are also looking at methods to more accurately extract the dynamic features of buildings.

The ages of the buildings—between 10 and 30 years—have posed several challenges for the researchers because wind tunnel testing technology has advanced since the buildings' original design and current technologies produce more precise and detailed loading information. Also, changes in the Chicago cityscape have altered the buildings' exposure to the wind. As a result, the buildings were retested using current wind tunnel technology and updated models of their surroundings.

Kareem says that all of the buildings being monitored in Chicago are structurally sound and are performing as expected based on data collected

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over the past three years. To develop a more comprehensive validation, the researchers will continue to monitor the structures for as long as possible. They are also seeking funding for additional studies on other buildings. The current project was supported by a grant from the National Science Foundation, Notre Dame, and the Chicago Committee on High-Rise Buildings. In-kind support has been provided by SOM and the BLWTL. Details of the project are available at http://windycity.ce.nd.edu.

—Brett Hansen