

# A Scientific Approach to Engineering Problem-Solving

Wiss, Janney, Elstner Associates' structural evaluations and forensic investigations make significant contributions to the construction industry

by Monica Schultes

From its humble beginnings as a one-man firm in 1956, Wiss, Janney, Elstner Associates (WJE) has become synonymous with problem-solving and investigative work. The company's engineers, architects, and materials scientists are involved in an ever-widening array of services aimed at solving problems in the built world. "Effective use of field and laboratory testing is in our DNA," says Gary Klein, executive vice president and senior principal with WJE.

Jack Janney, WJE's founder, coined the expression "ask the structure," which harkens back to his research background with the Portland Cement Association. "Our investigators rely on testing, experimentation, and instrumentation to better understand the problem—the most important step in solving it," says Klein. "The firm's success is founded on delivering better solutions, starting with asking the structure."

For example, when the Chicago Department of Transportation asked WJE to confirm that the planned replacement of the Wacker Drive Viaduct would last 100 years, the WJE team followed Janney's directive. Based on findings of an earlier WJE investigation, the team concluded that the badly deteriorated main thoroughfare needed to be rebuilt using high-performance concrete. In addition to developing and testing concrete mixture proportions for improved durability, a full-size prototype of a portion of the structure was developed to test its structural response. WJE was subsequently hired to develop long-term health monitoring for the viaduct.

**"Our investigators rely on testing, experimentation, and instrumentation to better understand the problem ... The firm's success is founded on delivering better solutions, starting with asking the structure."**

## Attracting Outstanding Talent

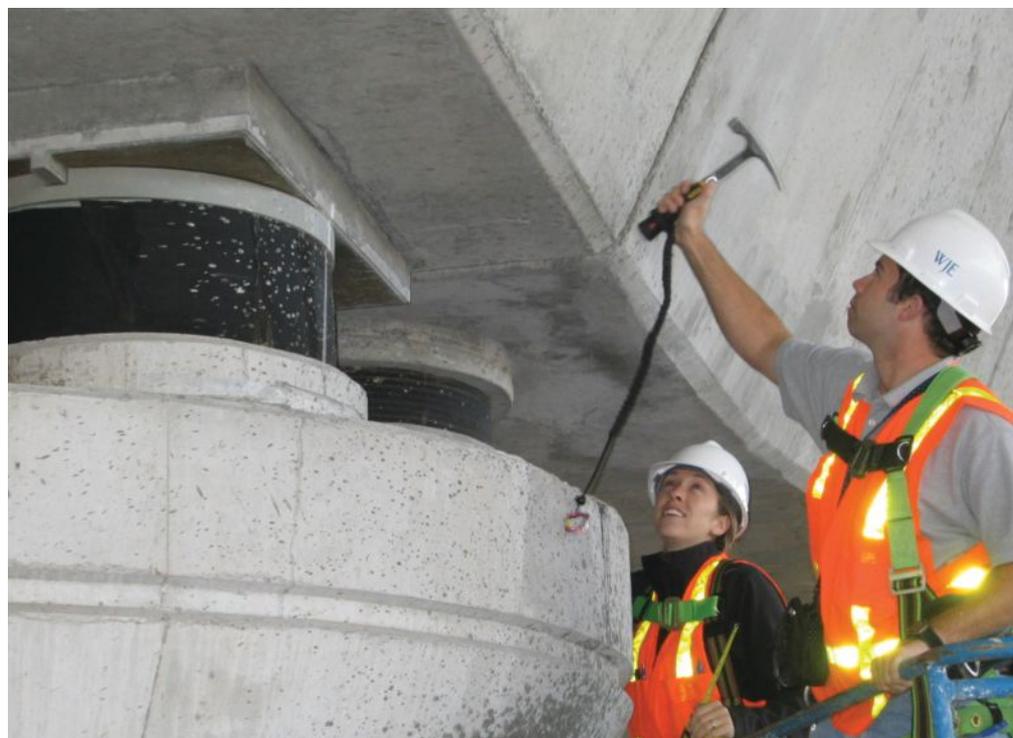
Challenging work and complex problem solving appeal to the talented

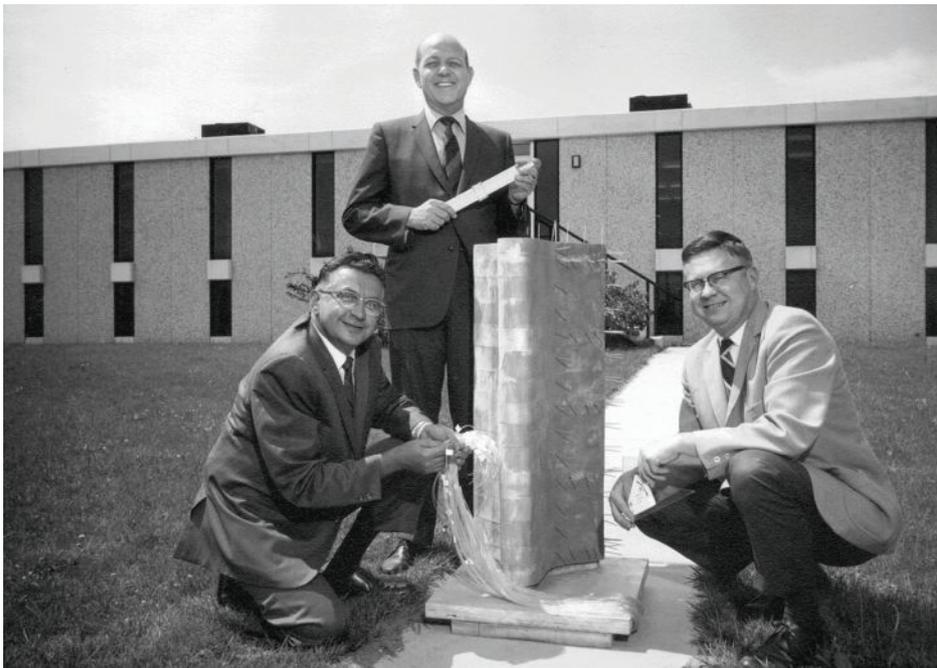
Wiss, Janney, Elstner Associates conducted field investigations of the Central Artery Tunnel (Big Dig) project in Boston, Mass. This involved visual inspections and nondestructive testing that included sounding the bearing area near epoxy-injected cracks on the Zakim Bridge.

Photo: Metropolitan Highway System.

engineers, architects, and materials scientists (most with advanced degrees) who join WJE. Their sharp minds want to be a part of solving built-world mysteries.

Michael Lee, principal with WJE, recalls that he was attracted to the firm for two reasons: the in-house materials sciences resources (such as petrography and chemistry) and the firm's Janney Technical Center (JTC) laboratory in Northbrook, Ill. Those assets give WJE the ability to supplement engineering theory and numerical modeling. "All firms can use software to run the numbers, but to really understand the structure, having the complete package of technical resources often makes the difference. Those professionals who want





Left to right, founding partners and pioneers Jack Wiss, Jack Janney, and Dick Elstner. The firm that bears their names has become synonymous with forensic investigations, testing, and cutting-edge research. Photo: Wiss, Janney, Elstner Associates.

to dig a little deeper into the nuances of structural and materials behavior find a home at WJE," explains Lee.

WJE nurtures a cross-disciplinary exchange of ideas. Technical resource groups meet routinely, and discussion forums are in place to query experts throughout the company. Information from investigations is shared across teams through webinars, white papers, and workshops.

Wiss, Janney, Elstner Associates has its own in-house testing facilities and laboratories. The firm's main research facility is the state-of-the-art, 70,000 ft<sup>2</sup> Janney Technical Center, where chemistry, petrography, metallurgy, concrete, corrosion, and large-scale structural testing is conducted. Photo: Craig Dugan Photography.

"Collectively, our employees and the knowledge that we have learned over 65-plus years is our largest and most valuable asset," says Andrew Osborn, senior principal at WJE. "Most of our work product is written reports, which are found in a searchable database," he adds. "We help our associates develop and grow professionally through mentoring, but we place a high degree of responsibility on individual initiative. It is a two-way

street, not just top-down instruction," he says.

## Extensive In-House Facilities

In 1967, WJE's founders built a structural laboratory at the Northbrook, Ill., headquarters. In 1985, WJE added concrete chemistry and petrographic expertise with the acquisition of Erlin Hime Associates. The company consolidated its laboratories in a new building on the Northbrook campus five years ago.

JTC is a state-of-the-art, 70,000 ft<sup>2</sup> testing and applied research facility that includes a full array of chemistry, petrography, metallurgy, concrete and mortar, corrosion, and structural testing laboratories, as well as environmental exposure chambers, for hands-on problem solving. JTC also includes space for large-scale structural testing of everything from wall samples to bridge retrofits. Other laboratories in Austin, Tex., and Cleveland, Ohio, supplement the main facility.

In addition to its broad array of structural engineering, architecture, and building envelope services, WJE offers fire protection, geotechnical engineering, metallurgy, applied mechanics, and movable bridge engineering services. The firm is therefore uniquely positioned with its in-house field-testing abilities and laboratory support. Osborn describes the importance of WJE's internal testing capabilities as "vital to our business."

## Professional Contributions

WJE believes in doing the right thing, especially with lessons learned in the aftermath of a tragedy. WJE team members share findings through their participation in professional associations, webinars, white papers, presentations, and articles. Each year, technical staff from WJE author nearly 100 published papers and present more than 300 talks at professional conferences or meetings. In addition, the firm's employees contribute to the advancement of their professions by serving in leadership positions at PCI, the American Concrete Institute, the American Society of Civil Engineers, ASTM International, and other technical organizations and committees.



## Jack Janney, Special Investigator

WJE has conducted many research projects on behalf of PCI and others regarding concrete curing temperatures, interface shear, strand bond, ledger-beam behavior, headed stud anchors, dapped-end double-tee beams, and, most recently, ultra-high-performance concrete (UHPC). "These were all important topics to the industry, and we like to think we made contributions with those research projects," says Osborn.

Since grout voids in post-tensioning ducts were identified as a condition that could potentially promote a corrosive environment within post-tensioning (PT) tendons, WJE has been frequently consulted. For example, in Oahu, Hawaii, investigators used ground-penetrating radar to identify tendon ducts with potential voids. The voids were detected with MIRA ultrasonic tomography, and grout samples were collected for further laboratory studies. No tendon corrosion was found, and the use of nondestructive testing methods helped develop a work plan for future inspection of the pre-2003 PT bridge inventory.

On the materials side, WJE recently collaborated with PCI, e.construct USA, the University of Nebraska-Lincoln, North Carolina State University, and Louisiana Tech University on the advancement of nonproprietary UHPC. "We have to stay ahead of other competing materials,

Jack Janney founded the one-person engineering firm Janney and Associates in 1956. More than 60 years later, Wiss, Janney, Elstner Associates (WJE) has evolved into a prominent company that has been involved in investigating and mitigating some of the world's most challenging construction-related problems.

Janney had worked at the Portland Cement Association (PCA) before venturing out on his own. At first, his firm provided regular design services as well as testing and investigation services, but the partners gravitated to the latter. Janney's neighbor, John (Jack) Wiss, an expert in sound and vibration, joined Janney in 1957. In 1962, Richard (Dick) Elstner, also from PCA, joined them to form WJE in Northbrook, Ill., just north of Chicago. Janney and his partners quickly earned a worldwide reputation and became industry titans.

Over his career, Janney investigated at least 500 major structural collapses and more than 4000 cases of suspected structural distress. When he wasn't conducting research or supervising investigations, he pioneered the use of three-dimensional structure models as design aids before the use of computer software.

In the early years, the firm investigated significant events such as the Silver Bridge collapse over the Ohio River, the MGM

Grand Hotel fire in Las Vegas, Nev., the Hyatt Regency Hotel walkway failure in Kansas City, Mo., and the Cline Avenue Overpass Collapse in East Chicago, Ind. Janney was also instrumental in the early use and testing of prestressed concrete beam bridges along the Illinois Tollway in the 1960s.

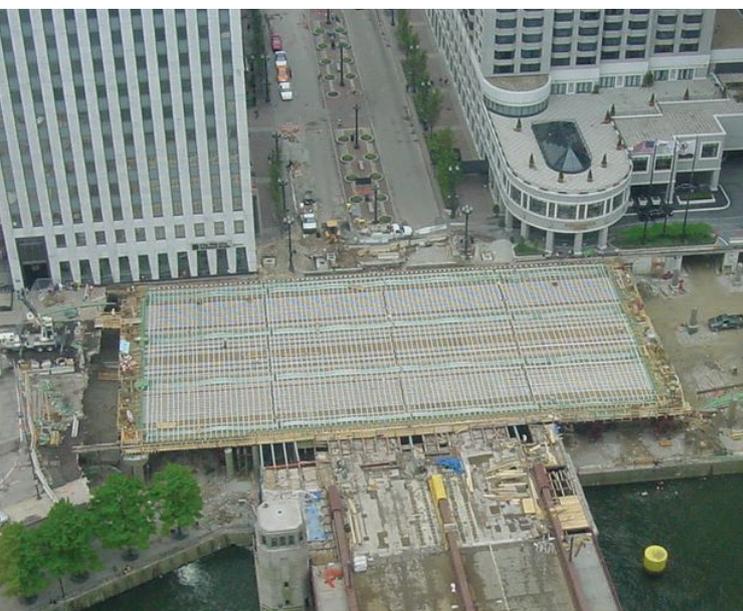
Janney was involved in professional organizations such as the American Society of Civil Engineers (ASCE), the American Concrete Institute, the American Society for Testing and Materials (now ASTM International), and PCI.

He even found time to write. In the 1950s, he authored the first edition of PCI MNL 115, *Fundamentals of Prestressed Concrete Design*. In the 1970s, he wrote an ASCE textbook titled *Guide to Investigation of Structural Failures*, and various articles for ASCE Special Technical Publications.

Janney was instrumental in the formation of the Architects and Engineers Insurance Company in the late 1980s, which offered professionals errors and omissions insurance, and he was an advocate for dispute resolution procedures to resolve construction and engineering issues.

Janney received numerous professional honors throughout his career, including being named one of *Engineering News-Record's* top 20 structural engineers of the last 125 years.

The Chicago Department of Transportation asked Wiss Janney Elstner Associates (WJE) to confirm that the planned replacement of the Wacker Drive Viaduct (shown under construction on the left) would last 100 years. To achieve that goal with relative certainty, WJE developed and tested concrete mixture proportions for improved durability and built a full-size prototype of a portion of the upper deck of the structure (right) to test structural response. Photos: WJE.



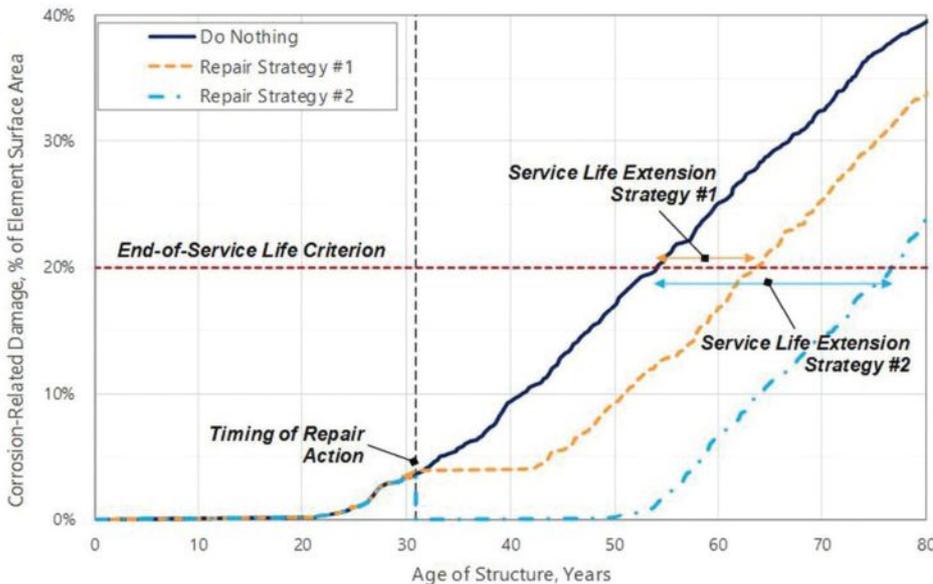
and through the UHPC project, we like to think we are contributing to those advances," says Osborn.

### Corrosion Assessment Software

"Deterioration of concrete bridges is all driven by exposure to water," explains Osborn. "We have done extensive research on sealants, cathodic protection, and other solutions used to protect areas that are vulnerable to corrosion."

WJE developed Corrosion Assessment and Service Life Evaluation (WJE CASLE) software to predict corrosion-related damage in concrete structures. Using models generated from decades of data from testing corrosion damage in concrete structures, coupled with the firm's extensive knowledge and work on durability and minimizing corrosion, CASLE software predicts the probability that a structure will last a certain number of years. The input parameters include items such as stainless steel and epoxy-coated reinforcing bars and sealants, which typically contribute to a longer service life. The corrosion assessment conducted using this tool can assist with decisions on asset management.

Wiss, Janney, Elstner Associates developed Corrosion Assessment and Service Life Evaluation (WJE CASLE) software to predict service life of concrete structures. This WJE CASLE-generated plot compares alternate repair strategies: Strategy 1 slows the progression of corrosion-related damage, whereas Strategy 2 repairs existing damage and removes the cause of the deterioration (for example, chloride-contaminated concrete). Comparisons such as this can be used to evaluate the costs and benefits of different repair strategies. Figure: WJE.



### Solving for Why

WJE has been called upon to examine many major structural collapses in the United States. "Our work is somewhat like that of a forensic pathologist, but for the built world," observes Osborn. "We uncover lessons that can help society prevent similar occurrences in the future."

**"Our work is somewhat like that of a forensic pathologist, but for the built world. We uncover lessons that can help society prevent similar occurrences in the future."**

When tunnel ceiling panels fell several years after construction was completed in a section of the Big Dig in Boston, Mass., WJE completed a "stem-to-stern safety audit" in 90 days. Klein recalls that the challenge was to prioritize what areas and components were most vulnerable to deterioration and failure. The ability to distinguish between what

was in good shape and which areas needed attention was critical.

Clients seek WJE expertise when there is no obvious cause for a failure. Many collapses happen during construction or demolition, when there is increased instability. "One of the advantages in this business is 20-20 hindsight," says Osborn. "In these cases, we are able to conduct our investigation after the fact instead of trying to anticipate what could go wrong," he concludes.

The firm is involved in resolving insurance and litigation disputes, and employees frequently serve as expert witnesses. Osborn's work with insurance companies began with the bombing of the World Trade Center in 1993 and has grown to the point where almost half of the work he does deals with insurance and litigation.

While WJE will continue to be involved in promoting a better understanding of past performance, the firm is also experiencing a shift toward prevention as an industry priority. Requests for peer reviews are on the rise as clients consult with WJE as a proactive measure.

### Infrastructure Solutions

Bridges are subjected to harsh conditions and require maintenance for improved long-term performance. By investigating thousands of bridges and bridge failures, WJE engineers have learned that with better understanding of potential problems comes better design and construction techniques.

Using the latest technology, such as three-dimensional imaging, WJE bridge engineers are able to re-create or reassemble the aftermath of a collapse to determine the root cause. "We still rely on tried-and-true methods like pulse velocity and impact echo. Having all these capabilities in house makes a huge difference for us," says Klein.

WJE's diverse and extensive expertise allows the firm to consistently deliver practical solutions. "We offer insights to those designing and building our infrastructure," says Klein. "This firm got its start with concrete bridges and after almost seven decades, it is still the heart and soul of what we do and what we are all about."