Concrete results

Since 1969 Zdeněk P. Bažant has been a respected presence among McCormick's civil engineering faculty. As a world leader in scaling research in solid mechanics, he is perhaps best known for developing widely used models to assess the safety of large quasi-brittle structures, such as bridges, dams, ships, and tall buildings.

But Bažant, McCormick School Professor and Walter P. Murphy Professor of Civil and Environmental Engineering, almost saw his civil engineering career stymied before it could begin. He was born in Prague to a sociologist and a geotechnical engineering professor; four generations before him had been civil engineers. "I was lucky to have been born into a great intellectual family," Bažant says, "but my family background was politically unlucky for those times."

Communists took control of Czechoslovakia when Bažant was 10 years old. They banned his mother's profession of sociology as "bourgeois" science, and her boss, a family friend, was executed on trumped-up charges. The government seized the property of his maternal grandmother, a successful entrepreneur. As a "bourgeois child," Bažant was slated for an apprenticeship in the coal mines. He still calls this period the "biggest crisis" of his career.

Bažant's future might have been set then if it hadn't been for an illness that his family could exaggerate to disqualify him physically for the mines. Eventually he was able to enter high school, where he excelled in math and became a winner in the Mathematical Olympics of the country. In 1960 he graduated first in his class from the Czech Technical University and was asked to join the Communist party. He declined. This made him a declared opponent, and his application for graduate study was rejected; the Communists commonly denied higher education to political opponents.

Bažant was assigned to work in a state-run engineering firm that designed and built bridges and highways. "I liked it, and in retrospect it was a valuable experience," he recalls. One particular job impacted his career. While he was supervising work on an innovative arch, the reinforcement truss of the bridge began oscillating; Bažant immediately brought work to a halt. After some calculations, he realized that the spatial bracing in the structure was insufficient, and if work had continued, the entire structure would have collapsed. This episode piqued Bažant's lifelong interest in structural stability.

In the late 1950s a ski injury spurred Bažant to invent one of the earliest safety release bindings. "The way you attached your boots to your skis back then was to tie them tightly with belts," he says. "It caused terrible injuries." He patented the device, and by the early 1960s one-third of all skiers in Czechoslovakia were using his invention. (Today the binding is on display at the New England Ski Museum in Franconia, New Hampshire.)

But Bažant still wanted to get a PhD. He exploited the fact that under Communism it was possible to obtain a PhD "externally," provided one had a recommendation from the party cell of the firm. He managed to get it. "It meant I had to study alone while working full-time and then take course exams without ever setting foot in a classroom," he says. "I saw my adviser twice: once when I explained what I wanted to do and three years later when I brought my dissertation."

Bažant received his PhD in engineering mechanics from the Czechoslovak Academy of Sciences in 1963. Four years later he got married in a small village, where authorities would be slow to register the union. Thanks to a period of political relaxation that preceded his country's Prague Spring reforms, Bažant and his wife managed to leave the country. They left separately—married couples were not allowed to leave together—and reunited in America.

After research appointments in Toronto and Berkeley, Bažant joined Northwestern's faculty in 1969 and began studying concrete creep and hygrothermal effects in nuclear reactor structures. He invented the age-adjusted effective modulus method, which allows simple prediction of long-term concrete creep effects and is now featured in virtually all design standards. At McCormick Bažant also devised his size-effect law—a short formula that reflects the fact that quasi-brittle failure is decided not only by material strength but also by dissipated energy. The formula—his most widely known result—now forms the basis for a standardized fracture test. His related crack band model, a law to explain a type of concrete failure, is widely used in industry and special commercial software and became his most cited research.

In a current project Bažant is collecting data about bridges that have deflected excessively. "These deflections and the associated cracking cannot be attributed to poor construction," Bažant says; they are the consequence of procrastination in updating design codes. "I have been saying for years that the design codes are incorrect, and finally we got the evidence."

The result of this work will be a probabilistic prediction of creep effects in concrete structures for hundred-year lifetimes. The project has also intensified another of Bažant's passions: seeking transparency in his field. Collecting data about the 69 prestressed bridges has proven very difficult for the international committee he founded because of a common practice in civil engineering failures: the sealing of technical data after litigation. Bažant fights for the end of this practice. "In commercial aviation, data concealment is a crime"—and with good reason, he says. "Understanding failures means you can prevent them next time."

Among his other accomplishments, Bažant's work has helped in the development of lighter, more fuel-efficient cars with improved crashworthiness; his laws have also helped the navy design large sandwich panels for the hulls of long superlight ships. He developed better material models for the penetration of missiles into hardened concrete structures, and he used his size-effect law to calculate the load capacity of floating sea ice plates. He has published six books and is working on a seventh.

Bažant remains one of the most respected figures in his field, evidenced by his induction into the National Academy of Engineering (1996), National Academy of Sciences (2002), American Academy of Arts and Sciences (2008), and five European national academies, as well as by his impressive collection of medals and seven honorary doctorates. Of all his accomplishments, Bažant points to his best-known result as his proudest. "My size-effect law has been my highest achievement, because it is simple and useful," he says. "Simplicity and usefulness are the most satisfying attainments in science." M Sarah Ostman

LEAVING COMMUNIST CZECHOSLOVAKIA BEHIND, ZDENĚK BAŽANT HAS MADE HIS MARK IN AMERICAN CIVIL ENGINEERING