

The Current Slow Pace of Precast, Prestressed Concrete Bridge Innovation in the United States

by Gregg Reese, Modjeski and Masters

Prestressed concrete was arguably the most significant innovation in bridge construction in the 20th century. When a superior technology like this becomes widely used, methodologies are eventually established and further innovations become incremental rather than transformative.

In his work on modern economic history, economist Joseph Schumpeter characterized the concept of cycles of innovation as a series of waves.^{1,2} Each wave represents the process of how a change progresses when new technologies that transform society are introduced. He described the process as occurring in three stages: invention, innovation, and diffusion. Invention is the research and development stage, innovation is the implementation stage, and diffusion occurs as the concept is successfully adopted and integrated into everyday life.

Prestressed concrete is now in the late diffusion stage and has become what is known as a “mature technology.”

As a result, innovation has slowed and there is resistance to further change. In recent years, I have witnessed a growing reluctance to consider even the simplest of new ideas in precast, prestressed concrete bridge construction, which is troubling.

A mature technology represents a comfortable status quo. Human beings are predisposed to favor the familiar and resist change. For innovation to move into the marketplace, you need a compelling reason to abandon a comfortable status quo. The most common incentive is superior technology that produces significant financial advantage. Is that all it takes? Unfortunately, no. While superior technology and economic advantage are necessary, they are not sufficient in a risk-averse environment.

Economists and academics have studied resistance to innovation in construction and found that resistance manifests itself in many ways.³ Innovation can be incremental and structural, but it can also be radical and disruptive.

Innovation is perceived by many as a threat: change equals risk.

The construction industry has numerous barriers that discourage innovation. Most projects are constructed as a unique solution. The project is built by a temporary organizational team that is dismantled upon completion, and subcontractors and employees tend to scatter. Successful new ideas are often forgotten and frequently reinvented, but not established in the organization's culture.

Project delivery systems rely on low-cost selection that puts a premium on speed of construction. Work is performed by a fractured assortment of subcontractors and subconsultants working under a cascade of risk-shedding and risk-sharing contractual arrangements. Relationships among the contractor, designer, and owner tend to become adversarial, all of which results in an overreliance on “tried-and-true” methods and discourages risk taking and innovation.

The Southbound Interstate 95 to Eastbound State Road 202 (J. Turner Butler Boulevard) Flyover Bridge in Jacksonville, Fla., is an example of curved, spliced precast concrete U-girders that are post-tensioned to form continuous spans (see the Project article in the Winter 2018 issue of *ASPIRE*[®]). This innovative structure type was developed in Colorado in the 1990s and refined through contributions from all parts of the bridge industry. Photo: Modjeski and Masters.





A 230-ft-long ultra-high-performance-concrete (UHPC) U-girder being erected for the Setiawangsa-Pantai Expressway, part of the Duta-Ulu Kelang Expressway system in Kuala Lumpur, Malaysia. UHPC is a relatively recent innovation in the precast concrete industry. Photo: Dura Technology.

Infrastructure investment in the United States as a percentage of gross domestic product lags behind the rest of the developed world.⁴ Funding has been inconsistent and has steadily declined since the mid-1960s. All of this results in a scarcity environment that discourages risk taking.

Innovation occurs when opportunity meets a champion operating in a supportive environment. Any stakeholder who sees an advantage in promoting a new idea and gets support can be a champion. Research has consistently shown that the most significant influencer in fostering innovation is the owner or client.⁵ The essential elements of an environment that incubates new ideas are owners who are open to new ideas, future opportunities for use of an idea, and stakeholders who are willing to struggle through the learning curve and make necessary initial investments. Future projects are key; a one-off project is a tough sell. Finally, the idea itself must be worth the trouble and produce improved results and financial performance for the stakeholders.

What situations have successfully fostered a climate favorable to innovative ideas? Some examples follow.

- The Walnut Lane Bridge, completed in Philadelphia in 1951, was the first prestressed concrete bridge in the United States.⁶ The project

was constructed as a value-engineering option to a stone arch. The innovative design was bid at 30% cost savings to the city. The city chose a design concept that had never been used in the United States—a bold move that resulted in adoption of a new technology and had a game-changing effect on the interstate highway system and how we build bridges today.

- Segmental bridges were introduced in the United States in Texas⁷ in 1972 (see the Project article about the JFK Memorial Causeway Bridge in the Summer 2021 issue of *ASPIRE*®) and California in 1974. In the late 1970s the Florida Department of Transportation committed to building four long bridges in the Florida Keys that were the first large-scale application of this technology.⁸ The success of these projects inspired the industry to embrace segmental construction, making it a major force in bridge designs in the United States over the last 50 years.
- The Colorado Department of Transportation developed bridge design standards for curved precast concrete girders for interchanges and longer-span bridges in the late 1990s, and used those standards to successfully construct several bridges in the early 2000s. This is another example that illustrates how significant leadership by owners is to promoting innovation (see related article in Summer 2015 issue of *ASPIRE*®). Since that time, this novel concept has been used on numerous projects over the last 20 years.
- Malaysia is currently a great incubator of bridge innovation. Yen Lei Voo, PhD, has designed and constructed more than 150 bridges in Malaysia over the last 10 years using ultra-high-performance concrete (UHPC) as the primary material (see related articles in the Summer 2016 and Spring 2017 issues of *ASPIRE*). This is an amazing achievement—nowhere else is this technology being used at a similar level. How did this happen? According to Dr. Voo, it was not easy, and UHPC had to prove its worth to be accepted. Early projects were designed as value engineering alternatives to more conventional designs. The UHPC designs were

consistently more economical and resulted in superior solutions. Dr. Voo is convinced that without owner support, none of this would have been possible. Currently he is working on major projects in China and India as well as in Malaysia.

In summary, innovation is how we advance our world. Resistance to innovation is part of the process; it weeds out the bad ideas, but hopefully it does not kill the good ones. Precast, prestressed concrete can continue to be an indelible force in bridge construction if we, like those who came before us, have the courage to keep an open mind, be bold, and continue to try new things.

References

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