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Evaluation of Accelerated Bridge Construction (ABC) – A Forensic Analysis

In the latest State of the Union address, President Obama reported to the American public on the status of our national infrastructure: over 25 percent of the Nation's 600,000 bridges are considered "structurally deficient" or "functionally obsolete." In other words, these critical links to public safety, economic vibrancy, and quality of life are in need of replacement or repair. However, a wide array of structure types, material characteristics, ages, daily traffic volumes, and climate conditions makes bridge replacement increasingly difficult.

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Decommissioning of the two year old PBES 8th North Bridge on I-15 in Salt Lake City, Utah.

To combat these issues, a number of new methods have emerged to expedite bridge construction. Accelerated Bridge Construction (ABC) technologies are one of the top priorities of the Every Day Counts 2 (EDC2) initiative —a Federal Highway Administration program that encourages keeping infrastructure in a constant "state of good repair" through effective management and innovative technologies.

Unlike traditional construction that could take months to complete, ABC technologies help replace bridges more quickly and cost-effectively. EDC2 promotes three methods of ABC: Prefabricated Bridge Elements and Systems (PBES), Geosynthetic-Reinforced Soil – Integrated Bridge System (GRS-IBS), and Slide-In Bridge Construction. Each of these implements a combination of state-of-the-art techniques and materials to expedite construction schedules, minimize congestion, reduce construction costs, and improve safety for construction workers and motorists.

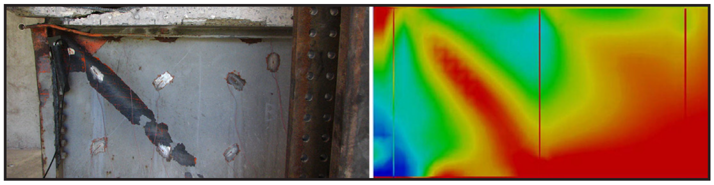
The Utah Department of Transportation (UDOT) is considered to be a national leader of ABC adoption, with over 100 PBES bridges completed; PBES bridges are comprised of elements that are constructed offsite and assembled at their designated locations.

With so many PBES bridges in close proximity, Utah State University (USU) civil engineering professor Paul Barr, Ph.D., in partnership with Bridge Diagnostics, Inc., led several studies to assess the structural performance of the state's ABC bridge network.

One of these studies provided Barr and his team an unprecedented test specimen. Due to a roadway rerouting, UDOT decommissioned the PBES 8th North Bridge on I-15 in Salt Lake City, Utah, after only 2 years service. This afforded USU and their collaborative research partners, Bridge Diagnostics, Inc., to use this bridge as a living laboratory to evaluate the impacts of real-world loading conditions and simulated stressors on precast bridge decks.

Testing such a young bridge gave USU researchers a unique opportunity to quantify the rate of structural performance decline near the beginning of the bridge's service life.

First, they conducted extensive field tests to analyze the effects of weight and pressure on new bridges.



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Forensic evaluation of PBES buckled web due to extreme load testing in laboratory (left) and modeling of principal tensile stress (right).

"We found these loads caused the bridge deck to shift unevenly near the supports due to insufficient placement of the shear pockets. This phenomenon is called noncomposite behavior," Barr said.

"Conversely, the loading had little to no effect near the middle of the girder—the shear pockets, girder, and deck all behaved symbiotically, or displayed 'composite behavior.'"

The bridge was decommissioned after the completion of the load tests. For the second part, Barr's team was able to do something no research team has ever done before. His team transported two full-scale bridge sections that included five of the PBES deck panels and four girders—each over 35 feet long—to the USU Systems, Materials, and Structural Health (SMASH) laboratory for forensic testing.

"Based on our extensive performance tests, we recommended using a smaller shear pocket spacing near the supports to reduce the potential for the noncomposite behavior observed in the field," Barr said.

Barr's team suggested several other long-term recommendations to improve the service life of PBES bridges. One of those suggestions, Barr said, is investing in higher grade concrete used in these bridge decks. Higher grade concrete is more resistant to stressors presented by severe weather situations, continued weight stress, and layer separation.

The application of post-tensioning—or pulling bridge decks and girders together like a set of dental braces—can significantly extend a bridge's service life, though it affects time and cost. As an alternative to post-tensioning, Barr's team found that tying deck panels together with reinforced shear keys resulted in comparable structural performance.

As ABC implementation becomes standard practice, nationwide research—such as that conducted by USU—will be vital to ensuring proper construction and longevity of these structures.

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Full-scale decommissioned PBES specimens transported (left) and then tested in USU SMASH laboratory (right).

"Accelerated Bridge Construction has been shown by many agencies to be beneficial in terms of reduced construction time, minimal traffic interruption, and in many cases, significant cost savings," Barr said. "While there may never be a bridge that lasts forever, ABC provides the means to replace deficient structures quickly, safely, and with respect to the environment. It is the *future* of bridge construction."

About This Project

Paul Barr, Ph.D. (paul.barr@usu.edu), professor of civil engineering at USU, led this research. The support of the following people is gratefully acknowledged: Marv Halling, Ph.D., professor of civil engineering at USU; and Patrick Szary, Ph.D., associate director of Rutgers' Center for Advanced Infrastructure and Transportation (CAIT). The team also thanks Jeff Schulz of BDI, and Joshua Sletten and Cameron Kergaye of UDOT for their valued support on this project. USU is a Tier II UTC program and part of a UTC Tier I consortium led by Rutgers' CAIT under the direction of Ali Maher, Ph.D. (mmaher@rutgers.edu)