SPEED OF CONSTRUCTION, LONGER LIVES DRIVE NEW BRIDGE DESIGNS

The need for speed in construction is driving much of the bridge design in this country.

The burden to accomplish faster bridge construction, however, falls on heavy contractors, who must work tougher schedules and longer workdays while they solve site organization, demolition, and foundation and superstructure erection puzzles not taught in college. The contractors collaborate with structural and civil engineering firms, which must devise unique construction approaches to individual projects.

Together the contractors and engineers provide innovative, accelerated bridge construction (ABC) designs and schedules, albeit at a higher cost to the owning agencies. These tactics can be especially beneficial to those forced to take long detours – or who are even cut off –

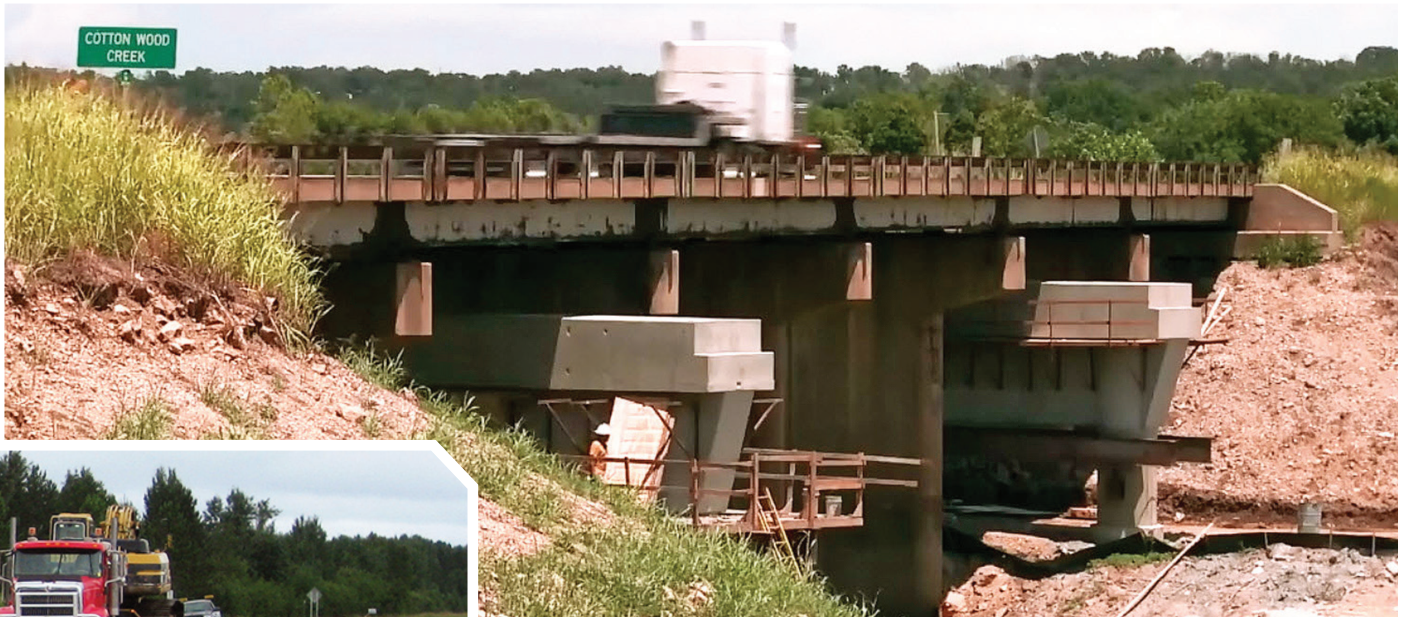

Photo: Oklahoma DOT

In 2013 in Creek County, Oklahoma, the Oklahoma DOT used accelerated bridge construction methods to replace the 300-foot-long S.R. 51 bridge over Cottonwood Creek; here new piers are constructed beneath existing bridge, which stays open during construction.

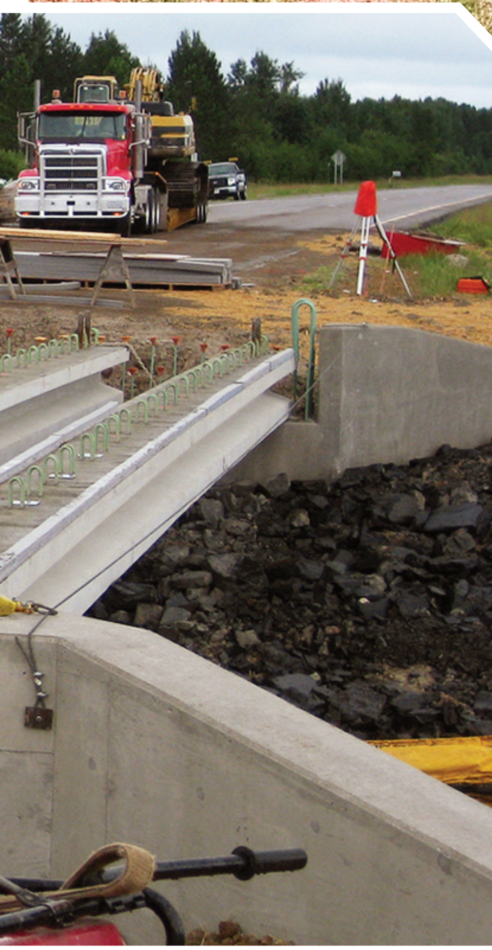

Photo: FHWA

In 2012 in Minnesota, precast girders await precast deck panels as part of PBES-enabled accelated bridge construction process.

during bridge replacement jobs.

Helping make it all possible is a revolution in construction materials and methods, like carbon fiber-reinforced columns and deck panels.

At the same time, the design and construction of longer-life bridges is gaining new attention. New research details how bridges may be constructed to exceed a century of service life. This is significant, as many precast, prestressed, post-tensioned cable-stay bridges constructed in the 1980s already have experienced one-third of their projected service lives.

Now, both of these trends – accelerated bridge construction and longer lives – have received new momentum from the second Strategic Highway Research Program (SHRP 2) which sought to create breakthroughs in transportation problems by using concentrated resources over a short time frame.

The nine-year SHRP 2 program ended in March 2015 and research "products" are making their way into the field (see SHRP 2 Research sidebar on page 69). Together they comprise a powerful resource for state departments of transportation to use to re-evaluate bridge designs for longer life spans.

Accelerated bridge construction

Accelerated bridge construction (ABC) requires a completely different approach to the design and erection of bridges than was conventional just a decade ago. Driven by the Federal Highway Administration's Every Day Counts initiative – which intends to shorten project delivery while enhancing roadway safety and protecting the environment – innovative, accelerated bridge designs are being promoted by FHWA among the state DOTs.

"DOTs can replace bridges within 48 to 72 hours and reduce planning and bridge construction efforts by years," FHWA maintains. "The accelerated project times significantly reduce traffic delays and road closures and could potentially reduce project costs." Moreover, they produce safer, more durable bridges with longer service lives than conventional bridges, FHWA says.

Reflecting this trend was the launch in 2011 of a dedicated center for ABC at Florida International University. The Center for Accelerated Bridge Construction-University Technology Center (abc.fiu.edu) provides engineers and contractors the tools needed to use ABC to enhance mobility and safety, and produce safe, environmentally friendly, long-lasting bridges.

The center's research team now includes the University of Nevada-Reno, and Iowa State University, and in addition to research, conducts monthly webinars on ABC. In 2014 the center hosted the first National Accelerated Bridge Construction Conference, which drew 750 delegates, including 150 state bridge engineers and more than 40 FHWA bridge engineers.

This year's conference will be held Dec.7-8 at the Hyatt Regency Hotel in downtown Miami (2015abc.fiu.edu/).

ABC technologies

The three ABC technologies being promoted under the Every Day Counts program are prefabricated bridge elements and systems (PBES), slide-in bridge construction, and geosynthetic reinforced soil-integrated bridge systems (GRS-IBS).

• **PBES are structural** components of a bridge that are built offsite, or adjacent to the alignment, and include features that reduce the onsite construction time. These prefab components typically are of prestressed concrete and are post-tensioned after erection on the jobsite, but sometimes are made of steel.

PBES includes innovations in design and high-performance materials and can be combined with the use of fast track contracting methods. Because PBES are built off the critical path and under controlled environmental conditions – such as precast plants – improvements in safety, quality and long-term durability can be better achieved.

Prefab deck elements eliminate conventional deck construction features like on-site installation of deck forms, overhang bracket and formwork installation, reinforcing steel placement, paving equipment set up, concrete placement and concrete curing – all of which typically occurs in a sequential manner. They can include partial-depth precast deck panels, full-depth precast deck

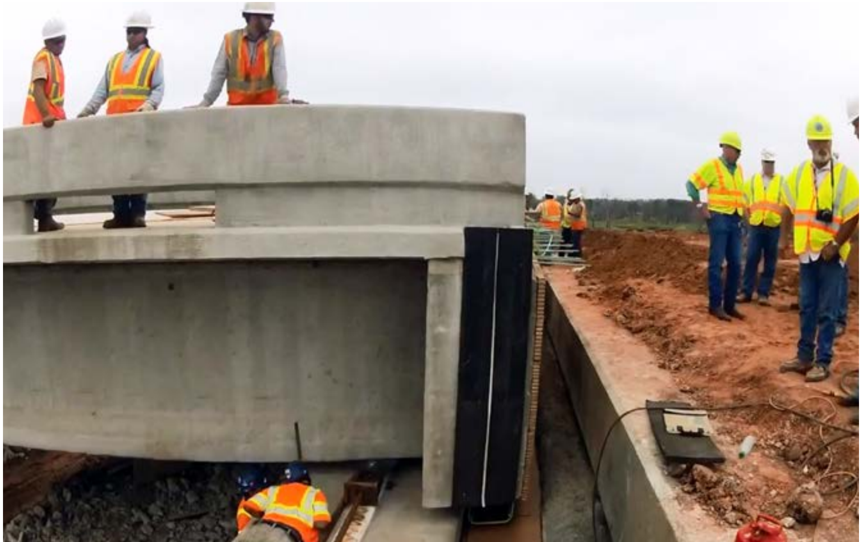

Photo: Oklahoma DOT

During the 2013 Cottonwood Creek ABC, Oklahoma DOT engineers supervised a "slide-in" of a new span built adjacent to an existing span.

Photo: FHWA

An hour-long bridge slide on hydraulic skids on a Saturday morning led to opening to traffic on Sunday evening at Elk Creek Tunnel near Elkton, Oregon; detour bridges at this location were impossible since these bridges were only a short distance from either portal.

panels with and without longitudinal post-tensioning, lightweight precast deck panels, synthetic fiber reinforced deck panels, steel grids open or filled with concrete and steel orthotropic deck.

Prefab beam elements are of two types: deck beam elements, and full-width beam elements. Deck beam elements eliminate conventional on-site deck forming and typically are placed in an abutting manner, FHWA says. Examples include adjacent deck bulb tee beams, adjacent double tee beams, adjacent inverted tee beams and adjacent box beams.

Full-width beam elements eliminate conventional on-site beam placement and typically are rolled, slid or lifted into place to allow deck placement operations to begin immediately after they are situated. These can include truss spans without decks and arch spans without decks.

Pier elements that are prefabricated can preclude form installation, rebar placement, concrete placement, and concrete curing, and include prefab caps for caisson or pile foundations, precast spread footings and prefab columns and caps.

Prefabricated abutment and wall elements avoid form installation, reinforcing steel placement, concrete placement, and concrete curing, all occurring in sequence. Prefabricated abutment and wall elements may be built in a phased manner using conventional construction methods, but under or near an existing bridge, without disrupting traffic.

• **Slide-in bridge** construction is a cost-effective technique for deploying PBES, or quickly replacing an existing bridge, FHWA says. The process involves constructing a new bridge next to, and while maintaining traffic on, the existing bridge.

The new superstructure is fabricated on temporary supports adjacent to the existing bridge. Once construction is complete, the road is closed, the existing bridge structure is demolished or slid to a staging area or temporary supports for demolition, and the new bridge is slid into its final, permanent location.

Once in place, the roadway approach tie-ins to the bridge are constructed.

The replacement time ranges from overnight to a several weeks. A variation of this method is to slide the existing bridge to a temporary alignment, place traffic on the temporary alignment, and construct the new bridge in place.

This is a complex undertaking and each job is unique. For example, as described in this magazine*, Provo River Constructors (PRC), a Fluor Corporation-led joint venture, used slide-in techniques to reconstruct some of the 63 bridges restored or replaced during the 24-mile-long stretch of the $1.1 billion I-15 widening south of Salt Lake City.

Using ABC principles, PRC constructed four bridges on the side of I-15; these bridges were as heavy as 3.8 million tons, and as long as a football field, including end zones. With the use of a remote-controlled, self-propelled modular transporter, the bridges were moved into place overnight, allowing for full freeway closure without impacting the safety or travel times of motorists.

Last year in Connecticut, ABC was used to achieve early replacement of the Route 17 bridge over Long Hill Brook in Middletown. The project was finished ahead of schedule over one weekend using ABC. For this work, the new bridges were built adjacent to the existing spans, and were lifted into place when ready.

Earlier in 2014, ConnDOT utilized ABC to replace the I-84 bridges

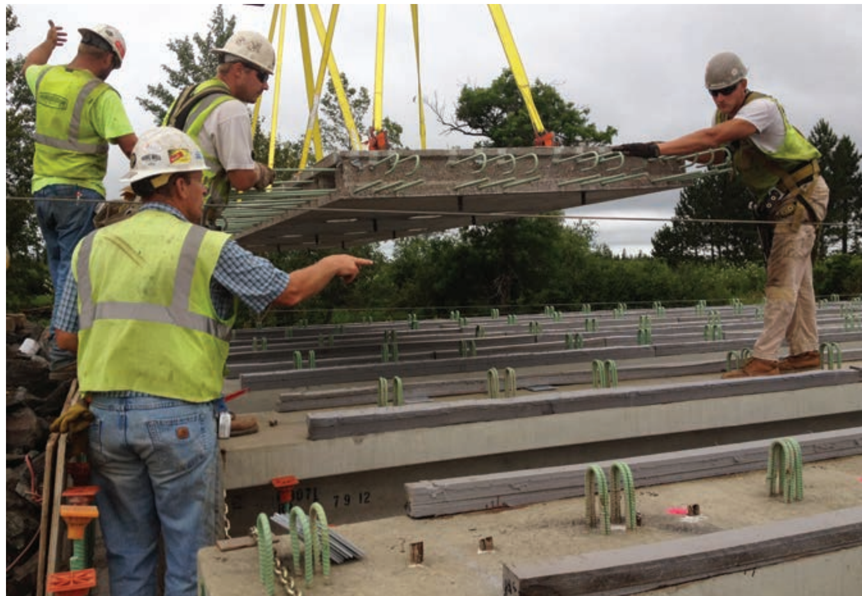

Photo: FHWA

PBES at work: Precast deck panels are placed and aligned on top of precast girders in a FHWA-supported Minnesota DOT demo of bridge replacement using ABC principles and innovative post-tensioned precast concrete panels for deck construction.

** Environmental Streamlining: States Must Take Initiative, January 2015, pp 40-47.*


Photo: FHWA

The ABC bridge over Tiffin River in Defiance County, Ohio, used Geosynthetic Reinforced Soil-Integrated Bridge System (GRS-IBS) design, with GRS abutment in foreground.

in Southington over Marion Ave., which marked the first time that the technique was used on a large-scale construction project in that state. By employing ABC principles on the Southington project, ConnDOT virtually eliminated what would have been many months or even years of traffic disruptions and congestion on I-84 and local roads, the DOT said.

For Route 17, the old bridge was replaced with a new box culvert that is 31-feet long and supports a 41-foot-wide roadway with two 12-foot travel lanes with shoulders. The project was completed in November 2014. The new bridge features nine 29-foot-long precast concrete rigid-frame sections with a 7-foot rise and a 4-foot, 11.5-inch width. The structure also includes four bridge footings, four wing walls, and four wing wall footings.

"We've used precast concrete on many projects but not on this rapid schedule," says Mike Appleby, structural engineer with Anchor Engineering Services in Glastonbury, Connecticut, the design engineer. "Precast concrete is our go-to method for rapid construction. It tends to be the most economical material for projects of this size and simplifies field work a lot."

• **GRS-IBS** – for Geosynthetic Reinforced Soil-Integrated Bridge System – is a construction method combining closely spaced geosynthetic reinforcement and granular soils into

SHRP 2 RESEARCH

Last October, SHRP 2 released a guide to accelerated bridge construction – Innovative Bridge Designs for Rapid Renewal (search for Report S2-R04-RR-1) – that provides guidance for highway agencies and their contractors and engineers who seek to implement ABC projects.

Also in 2014, SHRP 2 released Bridges for Service Life Beyond 100 Years: Innovative Systems, Subsystems, and Components (Report S2-R19A-RW-1). This was followed in early 2015 by Bridges for Service Life Beyond 100 Years: Service Limit State Design (Report S2-R19B-RW-1). The latter document carries the practical aspects of its predecessor report into a theoretical realm.

a new composite material. It consists of three main components: the reinforced soil foundation, the abutment, and the integrated approach.

The reinforced soil foundation is composed of granular fill material that is compacted and encapsulated with a geotextile fabric, providing embedment and increasing the bearing width and capacity of the GRS abutment.

It also prevents water from infiltrating underneath and into the GRS mass from a river or stream crossing. This method of using geosynthetic fabrics to reinforce foundations is a proven alternative to deep foundations on loose granular soils, soft fine-grained soils, or soft organic soils, according to research*.

The abutment uses alternating, closely spaced (less than 12-inch deep) layers of compacted fill and closely spaced geosynthetic reinforcement to provide support for the bridge, which is placed directly on the GRS abutment without a joint and without cast-in-place concrete. GRS is also used to construct the integrated approach to transition to the superstructure. This bridge system therefore alleviates the "bump at the bridge" problem caused by differential settlement between bridge abutments and approach roadways.

The GRS-IBS is easy to build and maintain, FHWA says, and is 25 to 60 percent more cost effective than conventional construction methods. EW

** Geosynthetic Reinforced Soil Integrated Bridge System Synthesis Report (FHWA-HRT-11-027 January 2011).*