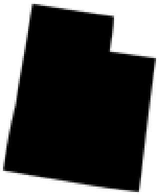

ACCELERATED BRIDGE CONSTRUCTION:

Tradition meets innovation at the Utah Department of Transportation

by Catherine Higgins, Utah Department of Transportation

The Utah Department of Transportation (UDOT) has experienced great success with Accelerated Bridge Construction (ABC) methods in the past 4 years. ABC, which applies traditional design principles in an innovative way, promises a faster approach to building concrete bridges. UDOT's intent is to reduce project duration and save time and money for road users and other stakeholders such as utility companies and railroads.

The transportation community in the United States is familiar with UDOT's recent bridge moving projects–19 bridges have been built off site then moved into place using various new technologies. However, projects using other ABC methods have not received as much national attention.

UDOT's less familiar projects have served as the impetus to develop new standards and specifications for structural elements. "This is new technology," says Fred Doehring, deputy structures engineer at UDOT. "We're doing a lot of research and development not only for Utah but for the rest of the country right now."

UDOT seeks to design and build quickly as soon as project funding is secured. And because concrete is made of readily available materials, components are quick to produce. A bridge deck on I-70 and three bridges on U.S. 6 provide good case studies about how UDOT has partnered with the private sector to pioneer ABC methods that deliver high-quality concrete bridges much faster than traditional means.

I-70 Bridge over Eagle Canyon

A concrete bridge deck replacement project in a remote Utah location proved to be an ideal application for an ABC approach.

The Eagle Canyon Arch Bridge, originally built in 1966, is located on I-70 at Mile Post 118 between Salina and Green River in southern Utah, over 200 miles from Salt Lake City. The bridge crosses a 480-ft-wide canyon and is 289 ft high.

The bridge deck replacement was designed by Horrocks Engineers of Pleasant Grove, Utah, and constructed by Granite Construction Company of Salt Lake City. UDOT used a construction manager/general contractor (CMGC) contracting approach that brings design engineers and construction contractors on board throughout the process.

According to Larry Reash with Horrocks Engineers, the CMGC process intent is to "form a partnership between UDOT, the owner, the designer working for UDOT, and the contractor. This partnership is developed during the design phase to minimize risk, develop a project schedule, identify potential innovations, and develop a project cost model."

During design, the Granite and Horrocks team worked together to analyze construction loading on the bridge. The investigation showed that removing the entire deck at once would potentially lead to instability of the arches so the deck panels would need to be removed and replaced section by section.

The remote location and proximity to sensitive cultural and scenic resources made

During redecking of this arch bridge over Eagle Canyon, sections of the old deck were removed and replaced with groups of five new full-width precast concrete panels until reaching midspan. The work then moved to the opposite end. Photo: Granite Construction Company.

Deck panels being installed on the I-70 Bridge over Eagle Canyon. Photo: Granite Construction Company.

The Emma Park Bridge on U.S. 6 features precast, prestressed concrete girders and full-depth precast concrete deck panels. Photo: Utah Department of Transportation.

Shown during fabrication, deck panels are pretensioned in the plant. GFRP reinforcement is used in both top and bottom mats. Photo: Utah Department of Transportation.

the prospect of trucking-in and operating a concrete batch-plant expensive and impractical. In addition, casting the deck in-place was ruled out as an option because curing times of 14 to 28 days would have extended the duration of the project past UDOT's comfort level and road users expectations. Deck panels would need to be precast and trucked to the bridge.

During construction, a newer bridge close by served as an alternate route and allowed crews to work away from live traffic. A 600-ton crane, with one million pounds of counter-weight and a 324-ft-long boom, was used to remove sections of deck and erect new panels. In order to reduce crane loads as well as dead loads, lightweight concrete was used for the new full width deck panels. The panels were 34 ft wide and 13 to 14 ft long. The contractor installed, longitudinally post-tensioned, and grouted five panel sections at one time. This removal and installation process proceeded to the middle of the bridge before switching sides.

The ABC approach was amazing even to a "field guy," said Steven Archuleta, project supervisor for Granite Construction Company. "We removed a bridge deck, built a precast deck in Salt Lake City, and assembled it on site," says Archuleta. Using precast concrete deck panels meant that curing happened at the precasting plant, not on I-70 where the traveling public would have been bothered by a lengthy project.

Emma Park Bridge

Emma Park Bridge, located on U.S. 6 between Spanish Fork and Price in central Utah, is in an area "notorious for wildlife hits," says UDOT structural designer Rebecca Nix. "The new bridge is an effort to reduce those accidents." Over several years, there have been multiple projects in the area to improve safety by widening the road or adding crossings, including the Emma Park Bridge.

Before construction, the area consisted of a piped creek under the roadway. During construction the area was excavated to provide a wildlife crossing in conjunction with the creek crossing. The bridge itself consists of 24 precast concrete deck panels on precast, prestressed concrete girders with cast-in-place concrete abutments. The deck panels were transversely pretensioned and longitudinally post-tensioned.

An important innovative feature of the bridge is the use of glass fiber reinforced polymer (GFRP) bars for the top and bottom reinforcing mats of the precast concrete deck panels. By using GFRP, UDOT engineers hope to extend the service life of the bridge deck beyond 50 years. "The number one cause of degradation of bridges is rusting steel inside concrete," says Doehring. Bridges are designed to last 75 years or longer while decks only last 40 to 45 years.

Building bridges using GFRP is relatively new technology, and more information is needed about how the material functions in bridge decks. UDOT is partnering with the University of Utah, Department of Engineering, to monitor the panels for 2 years in order to evaluate the suitability of GFRP for future use.

Sensors to measure strains, temperatures, and deflections were installed during the precasting process. Monitoring of the sensors began at the precasting plant and continued during transport to the construction site and through the post-tensioning operations. The sensors will continue to be monitored for more than 5 years.

In addition, an on-site camera takes a photo when sensors indicate the deck experiences stresses reaching predefined trigger values. The photos are sent by cell phone connection to the University of Utah researchers and are shared with UDOT.

The work UDOT and the University of Utah are doing will make a significant contribution to future use of GFRP. Nix is helping to evaluate the new information, and believes that by using GFRP data collected in a real-world setting, UDOT will eventually know how to "design based on what's actually happening."

This end panel with integral barrier will connect with the cast-in-place concrete end closure diaphragm. The panels are also connected together with a cast-in-place longitudinal closure strip along the center of the bridge. Photo: Utah Department of Transportation.

Tucker Bridge

UDOT has built several fully precast "Lego" bridges, including the Tucker Bridge located on U.S. 6 at Mile Post 204 in Spanish Fork Canyon. Precast concrete elements of the Tucker Bridge included girders, abutments, back walls, wing walls, deck panels with parapets attached, approach slabs, and sleeper slabs. Steel elements included intermediate diaphragms.

Accelerated construction allows little time to resolve fit-up issues during construction. Accounting for fabrication and construction tolerances in the design of the connections between precast elements is critical. The Tucker Bridge, with a 120-ft-long span and a 25 degree skew, is "a simple bridge" by design, says Ray Cook, structural designer for UDOT, because precast elements were designed to simplify the fabrication and construction as much as possible.

Though the bridge is on a curved alignment, the deck edges were designed to be straight

The Tucker Bridge on U.S. 6 is shown nearing completion. It is almost totally precast concrete. Formliner finishes were provided on the abutments, wing walls, and parapets. Photo: Utah Department of Transportation.

and parallel to simplify the fabrication and construction of the precast deck and approach slab elements and to minimize the number of unique precast panels. The uniform pieces also saved time and money during fabrication.

The Tucker Bridge is UDOT's second totally precast concrete bridge supported on drilled shafts. Drilled shafts were required to support the wing walls as well as abutments because of the wing wall length. Each abutment consists of four precast concrete segments, which were placed over the reinforcing steel cages extending from the drilled shafts. The first abutment was placed in less than a day and the second abutment placed in less than 4 hours. All cast-in-place concrete closures were made with high early strength concrete.

Fit-up of some precast concrete elements was an issue and lessons learned will be valuable in the future. Overall, it's important to "design construction tolerance into all connections," says Cook. For example, placing the approach slab and sleeper slabs was tricky. UDOT and the contractor resolved constructability issues by placing and leveling the approach slab panels on the sleeper slabs, then grouting between pieces to provide uniform bearing. This process is now part of the standard detail and works well to place the approach slab panels properly.

Mile Post 200 Bridge

The Mile Post 200 Bridge on U.S. 6 in Spanish Fork Canyon was designed by UDOT and emulated traditional design with prefabricated elements for a mostly precast concrete structure.

Mountainous geography and a geometrically complex Union Pacific Railroad (UPRR) crossing made the bridge a challenge to design. The old structure, a three-span steel girder bridge, needed to be replaced on a new alignment. UDOT's new bridge, which resembles a giant box culvert is "definitely different," says in-house structures design engineer Michael Romero. "There are not a lot of structures like this around." Romero liked the complexity of the project which involved "doing things that haven't been done before."

U.S. 6 and the UPRR cross at a sharp 60-degree skew. Transition spirals are used at each approach. Additionally, the roadway superelevation reverses in the middle of the bridge.

Taking all potentially conflicting conditions into account, Romero designed an extra wide, single span bridge with the U.S. 6 traffic alignment running skewed across the deck. The abutments are parallel with the railroad and the girders span on a small skew. Precast deck panels were placed longitudinally on the girders.

The Tucker Bridge also utilizes full-depth precast concrete deck panels with attached parapets. The panels are connected with both transverse and longitudinal closure strips. Photo: Utah Department of Transportation.

The Mile Post 200 Bridge provides a new alignment of U.S. 6 over UPRR tracks. Type VI AASHTO girders bear on an abutment framed with precast concrete blocks stacked 33 ft high. The blocks are keyed and post-tensioned to the footing. Photo: Utah Department of Transportation.

The old Mile Post 200 Bridge is seen in the background. The new alignment will have U.S. 6 traverse a reverse curve diagonally across the new bridge in the foreground. The new concrete girders span nearly up and down in the photo. Granular fill is being placed on the structure to create the reverse superelevation of the new alignment. The roadway will be paved with asphalt. Photo: Utah Department of Transportation.

Granular fill was placed on the structure to achieve the changes in superelevation. Asphalt is used for the riding surface.

Because the structure is large, with a 107-ft-long span and a 303-ft width, more than 480 precast concrete pieces were required. The 33-ft-tall abutments were built with stacked, keyed blocks that were also keyed into the footing. The abutment blocks are held together with post-tensioning rods threaded through corrugated ducts filled with high-strength grout. The project used 35 AASHTO Type VI precast, prestressed concrete girders. Precast concrete deck panels with cast-in-place longitudinal and transverse closures were used.

A combination of deep foundations and spread footings were used to support the structure using traditional cast-in-place concrete construction methods.

Benefits of ABC

Through using ABC methods, UDOT and road users have benefitted from reduced project duration resulting in:

- Saved user costs—Reducing the duration of construction also reduces the duration of traffic delays, which has a real measurable cost to road users because of increased time spent in traffic.
- Improved safety—Fewer accidents related to construction occur because project duration is reduced and construction is limited to off-peak travel times. Road users and construction crews have less exposure to risk.
- High quality—Construction of substructures or superstructures in a controlled environment off site gives workers "time to build these elements correctly," says Doehring. Better workmanship can happen when construction takes place out of the pressure of working in live traffic.

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For more information on Utah's bridges, visit www.dot.state.utah.gov.

The Mile Post 200 Bridge is 303 ft wide, allowing U.S. 6 to traverse the bridge and the railroad tracks below on a sharp skew. Full-depth precast concrete deck panels were placed in a longitudinal configuration on the girders. Photo: Utah Department of Transportation.