



Bridge Views



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THE BRIDGE OF THE FUTURE

Steven B. Chase, Federal Highway Administration

Significant progress has been made over the last decade in researching, developing, and deploying high performance concrete (HPC). This progress has been aided by FHWA's promotion and demonstration of HPC in projects across the country. However, we must do more to reduce the number of substandard bridges and to anticipate future demands of the highway system.

Our vision is to get out in front of the bridge deterioration curve and stay there. Our strategy to realize this vision is a structures research and technology program with three thrust areas. The first emphasizes stewardship and management of our existing bridge inventory. The second focuses on ensuring the safety and reliability of new and existing bridges. The third and most exciting thrust area is *The Bridge of the Future*.

For the Bridge of the Future, we plan to research, develop and, in partnership with the states and industry, widely implement more durable and longer lasting bridges with fewer maintenance demands. In addition, these bridges will be able to be modified to accommodate changes in traffic or function much more quickly and in a far less intrusive manner than current technology allows. We plan to work to develop and deliver new generations of bridge systems that will provide unprecedented long-term performance. These systems will effectively use and combine high performance materials such as HPC into the most structurally efficient and cost effective systems.

The objective of this research initiative is to develop innovative bridge systems to meet the following performance objectives:

- 100-year service life with minimal maintenance
- A fraction of the current construction time
- Easily widened or adaptable to new demands
- Life-cycle costs, inclusive of user costs, at a fraction of current bridges
- Immunity to flooding, earthquakes, fire, wind, fracture, corrosion, overloads, and vessel collision
- Entire bridge from foundations to parapet designed and constructed as a system

- Lateral clearance greatly increased with longer spans
- Vertical clearance increased with shallower structures
- Constructibility to be as important as durability
- Design for easy inspection and maintenance

We recognize that these objectives will stretch our creative and technological capabilities but we plan to build upon a decade of research in high performance materials and to pursue the development of structural systems that will meet these performance objectives.

The Innovative Bridge Research and Construction Program (IBRC) will be our primary mechanism for pushing new technology. The IBRC has been very beneficial by incrementally introducing new technology into bridge construction, such as replacing steel reinforcement with fiber reinforced polymers or conventional concrete with HPC. The motto of the new IBRC program will be to "move beyond incrementalism." The goal will be to demonstrate and spur the development of totally new and innovative bridge systems.

We also plan to broaden the scope of the IBRC to include strengthening, rehabilitation, repair, maintenance, and preservation technologies. The emphasis will be to deploy and evaluate those technologies that have the potential to become the new standards for the future and have potential application on thousands of bridges. In addition to the new IBRC, FHWA plans to introduce new demonstration projects that will include both educational and hands-on elements to help move technology from research and development into practice. If we are successful in developing and delivering bridge systems that meet the performance objectives stated above, we will have realized our vision of getting out in front of the bridge deterioration curve and staying there.

Further Information

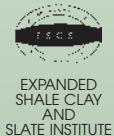
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HPC FACILITATES I-65 BRIDGE REPLACEMENT

Fred Conway, Alabama Department of Transportation



High strength precast, prestressed concrete girders were selected for fast construction.

On the morning of January 5, 2002, a fully loaded fuel tanker, northbound on I-65 through Birmingham, AL, crashed into a bridge pier. The bridge did not collapse but the resulting fire that raged for several hours caused the steel bridge to sag about 8 ft (2.44 m). The accident occurred where the northbound and southbound lanes of I-65 cross over each other as part of a braided route-to-route interchange with I-59. The pier hit by the truck supported the southbound lanes of I-65 as they cross over the northbound lanes at a skew of 60 degrees. Since I-65 is the main north-south route through Alabama and carries an estimated 100,000 vehicles per day, a rapid replacement was needed.

After checking with local suppliers, it was decided to replace the bridge using precast, prestressed concrete girders and a cast-in-place concrete deck. The precast girders could be cast and delivered to the site before steel fabricators could procure materials and start fabrication of the steel girders. All concrete for the construction utilized high performance concrete (HPC) capable of attaining high early strengths to accelerate construction.

While redesigning the bridge, the Alabama Department of Transportation (ALDOT) decided to widen the bridge to allow for a future southbound lane and to lengthen the center span by 20 ft (6.1 m) to allow for a future northbound lane. As a result, the replacement bridge has span lengths of 75, 140, and 75 ft (22.9, 42.7, and 22.9 m) made continuous for live loads. To accommodate the longer main span length while maintaining the existing

profile, the ALDOT design for the replacement bridge required 15 AASHTO Type IV girders spaced at 5.25 ft (1.6 m) centers. The specified concrete compressive strength was 9000 psi (62 MPa) at 28 days.

The contractor proposed a value engineering redesign of the girders for the main span utilizing modified BT-54 bulb-tee girders at the same spacing. The modification to the bulb-tee was to increase the width of the standard section by 2 in. (51 mm) to efficiently accommodate 48 0.6-in. (15.2-mm) diameter prestressing strands. The specified concrete strength at release of the strands was 7000 psi (48 MPa). Fifteen modified bulb-tee girders were used in the main span and eight standard width bulb-tee girders in each side span.

Speed of construction was a major factor in selecting the use of high strength precast, prestressed concrete girders for the bridge. The precaster was able to fabricate them offsite within 15 days and achieve the specified strengths.

For the deck, formwork consisted of stay-in-place corrugated metal forms. Specified compressive strength for the 7.25-in. (185-mm) thick cast-in-place concrete deck was 4000 psi (28 MPa) at 14 days. The continuous deck was constructed in five placements and cured with a curing compound. The last deck placement was 7 days old when the bridge was opened to traffic.

Specified compressive strength for the substructure was 3000 psi (21 MPa) at 28 days. This strength was achieved in 7 days. The bridge was completed on February 26, 2002, only 52 days after the accident

occurred. The total construction time was 37 days. This construction period is the shortest construction time for a complete bridge project in the history of bridge building in Alabama.

The low bid for the project was \$2,096,421 with an incentive or penalty of \$25,000 for each day of early or late completion, respectively. As a result of finishing 53 days earlier than the 90-day completion time, the contractor received a \$1,325,000 incentive payment – the largest cash incentive ever paid by ALDOT.

DATE	EVENT
Jan. 5	Accident
Jan. 7	NB opened to traffic
Jan. 14	Pre-bid conference
Jan. 16	Bids opened
Jan. 18	Contract awarded
Jan. 21	Construction started
Jan. 26	First footing concrete placed
Feb. 7, 8	Main span girders erected
Feb. 20	Deck concrete complete
Feb. 26	Bridge complete
Feb. 27	Bridge open

Further Information

For further information, see “Precast Helps Rebuild Bridge in Record Time,” ASCENT®, Summer 2002, pp. 32-34 or contact the author at 334-242-6007 or conwayf@dot.state.al.us.

HPC COMES TO NEW MEXICO

Sherman Peterson, New Mexico State Highway and Transportation Department



The viability of using HPC in New Mexico was established with construction of the Rio Puerco Bridge.

In the fall of 2000, the State of New Mexico constructed its first high performance concrete (HPC) bridge. The Rio Puerco Bridge is located on Old Route 66 west of Albuquerque. The purpose of the project was to establish the viability of HPC in New Mexico. The project required the introduction of new construction methods and quality control requirements.

HPC was used throughout the superstructure of the Rio Puerco Bridge. The bridge has three spans of 96.1, 101.1, and 96.1 ft (29.3, 30.8, and 29.3 m), which are made continuous for live loads. Each span consists of four 63-in. (1.6-m) deep bulb-tee beams spaced at 12.6 ft (3.8 m) centers and supporting a 47.6-ft (14.5-m) wide, 8.7-in. (220-mm) thick cast-in-place concrete deck.

Precast, Prestressed Concrete Beams

The beams had specified concrete compressive strengths of 7000 psi (48 MPa) at release and 10,000 psi (69 MPa) at 56 days. Cementitious materials consisted of cement, silica fume, and Class F fly ash. A 3-day steam curing period was required to achieve the concrete strengths. Actual average strengths at release and 56 days were 7500 and 10,340 psi (51.7 and 71.3 MPa), respectively.

The beams were also instrumented and monitored by New Mexico State University for prestress losses using fiber-optic sensors. The average measured prestress loss at

one year was 13 percent compared with final values predicted by the AASHTO LRFD lump sum method and AASHTO LRFD refined method of 22 and 27 percent, respectively.

Cast-In-Place Concrete Deck

The specified strength for the deck concrete was 6000 psi (41 MPa) at 28 days with a mix requirement of 7500 psi (52 MPa) at 56 days. Acceptance was based on the 28-day strength. In addition, the fresh concrete was required to have a higher slump than usual. Thus a maximum slump of 9 in. (230 mm) was established provided segregation checks were made. The concrete mix included Class F fly ash to mitigate the potential for alkali-silica reactivity, and a combination of water reducers to achieve the desired workability.

Placement of the HPC deck required a number of special procedures. First, a fogging system was developed to maintain a high localized relative humidity for the finished concrete in the otherwise arid New Mexico climate. The system consisted of a series of thin tubes suspended above the finished deck with small misting nozzles arranged in a grid pattern. Movable wind breaks surrounded the sides and rear of the fogging system. The entire apparatus was mounted on the finishing machine rails and followed the finishing operations across the bridge. Static wind breaks were also utilized. After finishing the deck surface, a curing compound was applied, and

the deck was covered with wet burlap and polyethylene sheeting for a minimum of 14 days.

Another special requirement for this project was the placement of a test slab. A 44.5 x 30.2 ft (13.6 x 9.2 m) slab was placed using the proposed concrete mix, fogging system, and finishing machine. In the test, the measured slump was 8-3/4 in. (220 mm) and the air content was 5.2 percent. The concrete finishing machine produced a good surface finish with little hand finishing required.

The positive experiences from the test slab placement assured the Department and the contractor that the deck placement would be a smooth operation. These assurances proved to be valid, as the deck placement went just as smoothly as the test placement. The concrete for the bridge deck had a slump of 6-1/4 in. (160 mm) and an air content of 6.2 percent. Inspection of the deck after curing revealed only a few plastic shrinkage cracks.

Conclusions

The effects of New Mexico's initial experience with HPC at Rio Puerco Bridge have been significant and lasting. HPC has since been used on the I-40/I-25 interchange in Albuquerque and more HPC projects are planned. In addition, the success of the HPC precast, prestressed concrete beams has resulted in an increased confidence level with prestressed concrete construction in general, and conventional designs are now produced with design concrete strengths of 7000 psi (48 MPa) compared to 6000 psi (41 MPa) used previously.

The material costs for HPC were 20 percent higher than conventional concrete on the Rio Puerco Bridge resulting in an overall increase of about 10 percent in the bridge cost. However, it is anticipated that, as more HPC projects are built, material costs will decrease to those of conventional concrete. In addition, the enhanced workability that can be achieved with HPC has been demonstrated to result in lower labor costs. In short, high performance concrete has proven to be a viable and effective alternative for bridge construction in New Mexico.

SPECIFICATION CHANGES FOR HPC—CURING CONCRETE BRIDGE DECKS

The AASHTO Standard Specifications for Highway Bridges – Division II and the AASHTO LRFD Bridge Construction Specifications currently require all newly placed concrete to be cured so as to prevent loss of water. The specifications also require that curing commences immediately after the free water has left the surface and finishing operations are completed. Curing is required for seven days unless pozzolans in excess of 10 percent of the portland cement are used in the mix. When such pozzolans are used, the curing period shall be 10 days.

Cast-in-place concrete may be cured by one or more of the following methods: forms-in-place, water, liquid membrane curing compound, or waterproof cover. For the top surface of bridge decks, a combination of the liquid membrane curing compound method and the water curing method is required. The curing compound is required to be placed progressively and immediately after finishing operations are complete. Water curing must be applied not later than four hours after completion of deck finishing or, when finishing is completed after normal working hours, water cure must be applied not later than the following morning. For high performance concrete (HPC) bridge decks, changes in curing specifications are needed.

Proposed Specifications

For cast-in-place HPC used in bridge

decks, water cure shall be applied immediately after finishing of any portion of the deck is completed and shall remain in place for a minimum period of 7 days. If conditions prevent immediate application of the water cure, either an evaporation retardant shall be applied immediately after completion of finishing or fogging shall be used to maintain a high relative humidity above the concrete to prevent drying of the concrete surface. Following the water curing period, liquid membrane curing compound may be applied to extend the curing period.

Proposed Commentary

HPC tends to have very little bleed water. Consequently, the evaporation protection of the bleed water on the fresh concrete is lost. The most effective way to protect the concrete is by application of water curing as soon as screeding or tining of the concrete is complete and no later than 15 minutes after the concrete is placed in any portion of the deck. In the water cure method, the concrete surface is kept continuously wet. The most appropriate method is to cover the deck with materials such as cotton mats, multiple layers of burlap, or other materials that do not discolor or damage the concrete surface and to keep these materials continuously and thoroughly wet for at least 7 days.

For a series of articles on curing HPC bridge decks, see *HPC Bridge Views*, Issue No. 15, May/June 2001.

Editor's Note

This article is the third in a series that addresses specification changes that are needed to facilitate the implementation of HPC. The proposed revisions are based on work performed as part of FHWA Project No. DTFH61-00-C-00009.

HPC BRIDGE CALENDAR

October 19-22, 2003

Third International Symposium on High Performance Concrete, Orlando, FL. Jointly sponsored by FHWA, PCI, and NCBC. Deadline for abstracts March 7, 2003. Contact Paul Johal, Precast/Prestressed Concrete Institute at 312-786-0300, info@pci.org, or www.pci.org

ERRATA

HPC Bridge Views No. 24, Page 1: The Confederation Bridge connects Prince Edward Island and New Brunswick.

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