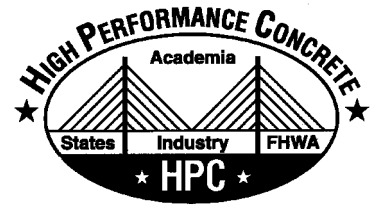




Bridge Views



<http://hpc.fhwa.dot.gov>

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Implementing HPC Bridges in Nebraska

Michael W. Beacham, Nebraska Department of Roads

Construction began on Nebraska's first high performance concrete (HPC) bridge in the summer of 1995. The 225-ft (68.6-m) long bridge utilizes seven lines of pretensioned concrete girders, with three spans of 75 ft (22.9 m) each. The site was selected for two reasons. A conventional concrete bridge with identical geometry would be constructed less than a half mile (0.8 km) from the HPC bridge. The conventional bridge is used as a control structure to help evaluate the service life of the HPC bridge. In addition, the HPC bridge was already designed using conventional concrete. This allowed the Nebraska Department of Roads to establish incremental costs for design and construction with relative ease.

The success of this project centered on the partnership of numerous stakeholders, which was formed at the outset. Input from people in industry, academia, and local, state, and federal governments was invaluable in determining the project strategy. The shared goal of this team was clear: "In lieu of optimizing the design, implement a strategy that eliminates or reduces the fear of producing, placing, and curing HPC." Because of this partnership, we developed a methodology that was realistic, achievable, and cost effective.

The project specifications required only one performance characteristic for the concrete girders—compressive strength of 12,000 psi (83 MPa) at 56 days. The girder design required only 8,000 psi (55 MPa). The deck concrete required two performance characteristics—strength and chloride permeability. A concrete strength of 8,000 psi (55 MPa) at 56-days was specified, while the required design strength was 4,000 psi (28 MPa). The specified strengths for the girders and deck were intentionally higher than required by design as part of the implementation strategy. A chloride penetration of less than 1800 coulombs at 56 days measured in accordance with AASHTO T277 was also required for the deck concrete.

On a warm July day in 1996, the Governor, State Engineer, local politicians, and distinguished

guests gathered under a blue fabric tent. To many, the ribbon cutting ceremony announced that just another bridge was being opened to the public. To others, it symbolized the willingness of department managers to take the steps necessary to advance the philosophy of engineering concrete to enhance long-term performance.

An important outcome of this project was the initiation of a strategic plan for the implementation of HPC on a statewide basis. Strategic implementation plans will vary from state to state, but the plans should include forming partnerships. The plan goals must be realistic, achievable, and cost effective. Plan goals may include documenting current concrete practices for pavement, cast-in-place structures, and precast structures. These practices include design, batching, placing, finishing, and curing. The data representing current practice can then be evaluated for comparative analysis with other states using the HPC Lead States web site information. Existing materials, concrete mixes, and construction practices should be tested in order to determine their performance characteristics as defined by the FHWA HPC definition. The next step is to determine target performance characteristic values for each use of concrete and to identify specification changes that are needed to achieve those values. A critical partnering step is to develop and test prototype mix designs and construction practices to achieve the desired performance characteristics. During the entire implementation effort, it is essential to educate upper management, designers, contractors, producers, and construction inspectors on the new practices and benefits of HPC. This is critical for the acceptance of, and successful transition to HPC. At the present time, Nebraska is continuing to develop its strategic plan for HPC implementation.

Every visionary state that commits to using HPC expands the collective experience. The potential to extend the service life of bridges and pavements, while reducing maintenance and replacement costs, should far outweigh the concerns of resource allocation to implement HPC.



HPC resulted in a longer span-to-depth ratio and improved sight distance.

I-25 over Yale Avenue— The Thin Solution

Mark A. Leonard, Colorado Department of Transportation

The replacement bridge for Interstate 25 over Yale Avenue in Denver, Colorado, is an excellent example of using high performance concrete (HPC) to meet the demands of urban bridge replacement. In growing urban centers, designers need to replace deteriorating bridges without changing existing vertical alignments, while providing for wider roadway sections on and beneath the bridges. This calls for longer spans at reduced superstructure depths, and bridges that can be built quickly with little disturbance to traffic.

The new bridge replaced a four-span, cast-in-place T-girder bridge that was structurally deficient, largely due to deck deterioration. This necessitated traffic closures when portions of the deck fell to the roadway below. The Colorado Department of Transportation (CDOT) needed to build the new bridge without lane closures or grade changes to either I-25 or Yale Avenue because of the high traffic volumes and the restrictive urban setting. CDOT also wanted to improve the vertical clearance over Yale by 18 in. (460 mm). This resulted in a span for the new bridge of 112 ft (34 m) with a superstructure depth of only 3 ft (0.9 m).

A two-span replacement bridge was selected to reduce construction time and

disturbance, and to improve sight distances below the bridge. After investigating precast, cast-in-place, and structural steel alternatives, a side-by-side precast, pretensioned box girder bridge, with a partial-depth composite deck, was selected as the optimum solution. The partial depth deck was used to minimize superstructure depth. Given the sensitivity of the composite partial-depth system to chloride intrusion and the severe deterioration of the old bridge deck, durability of the new deck concrete was a primary concern. HPC was the solution.

The use of 10,000 psi (69 MPa) concrete in the girders was necessary to achieve the desired span-to-depth ratio. In the deck, 5,000 psi (35 MPa) concrete was needed to provide the necessary compression block for the flexural strength of the superstructure. To provide enough prestressing, CDOT's practice of using 0.5-in. (12.7-mm) strands at 1.75-in. (44-mm) spacing was inadequate—0.6-in. (15.2-mm) diameter strands spaced at 2 in. (50 mm) were needed. The prestressing density and the concrete strengths, however, exceeded CDOT's limits at the time.

The Federal Highway Administration (FHWA) HPC implementation program allowed CDOT to use the greater prestressing density and higher concrete strengths

by funding testing and verification before construction. A partnership was formed between FHWA, the University of Colorado (CU), and CDOT's Bridge, Materials, and Research offices to conduct the testing and verification. This work was continued through construction to provide field verification of the laboratory information. FHWA's program also allowed CDOT to investigate different practices and materials to improve the durability of concrete decks in the state.

CU conducted scale model testing of the actual bridge girders and successfully verified the development and transfer lengths of the strands, and the ultimate flexural strength behavior at the high reinforcement index. The production of the test girders also demonstrated that the girders could be successfully fabricated with the high strength concrete and 0.6-in. (15.2-mm) diameter strands. CDOT's Materials Office conducted a series of tests before and during construction to define the durability characteristics of CDOT's standard bridge deck concrete and the concrete used for the Yale Avenue project. CDOT's Research Office instrumented the completed bridge to provide the field performance cross reference to CU's laboratory results.

The HPC concrete used in the deck was also specified for the piers. This provided high durability for the columns in the splash zone of Yale Avenue, and high strength for the economical reduction of the number of columns beneath the bridge; thereby, improving aesthetics and sight distance. The previous bridge was 215 ft (65.5 m) long by 110 ft (33.5 m) wide and had three piers with a total of forty-five columns. The new bridge is 215 ft (65.5 m) long by 138 ft (42 m) wide, and has one pier with four columns. This is a dramatic example of how deliberate use of current materials technology during design can yield significant benefits. The repeated use of the I-25/Yale Avenue solution at other sites in Colorado shows standard practice can be changed through the use of new technology.

Further Information

For further information about the I-25/Yale Avenue demonstration project or to obtain a copy of CU's report, *Study on Transfer and Development Length of Prestressing in HPC Girders*, contact the author at Mark.Leonard@dot.state.co.us.

Specifying Durable Bridge Decks

H. Celik Ozyildirim, Virginia Transportation Research Council

Over the years, concrete has performed well in bridge decks. However, with increasing use of deicing salts and changes in concrete constituent materials, many decks are exhibiting distress that requires costly repairs. The distress may be the result of corrosion of reinforcement, freeze-thaw deterioration, alkali-aggregate reactivity, or sulfate attack. In each case, water and solutions penetrating into the concrete initiate the deterioration. Therefore, when exposed to these environments, concretes must have a high resistance to the penetration of water and harmful solutions if the concrete is to achieve longevity. This can be achieved with a low permeability concrete. In addition, for resistance to damage from freezing and thawing, a proper air-void system is needed.

Most specifications require a minimum compressive strength, a maximum water-cementitious material ratio (w/cm), and a minimum cementitious material content. It is well established that lowering the w/cm reduces the permeability of concrete. However, at a low w/cm, the workability of concrete becomes a concern. Presently, fly ash, slag, or silica fume are used to reduce the permeability of bridge deck concretes at a conventional w/cm of 0.40 to 0.45.

The concept that strength, cementitious material content, and w/cm requirements will ensure durable concretes is misleading. Controlling w/cm in field concretes has been difficult. Recent cements are finer and have larger amounts of fast-reacting compounds. The hydration reaction occurs faster and the hydration products are not as uniform. Even though satisfactory strengths are achieved, low permeability is not always attained.

The Virginia Department of Transportation (VDOT) is attempting to obtain low permeability concrete by testing concretes for their resistance to chloride penetration. The chloride permeability test is described in AASHTO T 277 or ASTM C 1202, "Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration." In this test, the charge (in coulombs) passed through a saturated concrete specimen 2-in (50-mm) thick and 4-in (100-mm) in diameter in a

six-hour period is determined. Low values indicate high resistance to penetration by chloride solutions. It is well known that permeability decreases with concrete age, and the rate of reduction depends on the type of cementitious material. For example, fly ash concretes do not show the expected low permeability at 28 days since it takes longer for fly ash to react and exhibit its effectiveness. Therefore, an accelerated curing method is included in the VDOT special provisions. The specimens are cured one week at 73°F (23°C) and three weeks at 100°F (38°C). Results are similar to those obtained after six months of curing at 73°F (23°C). The specified maximum coulomb value is 2,500 for bridge deck concretes. This limit can be achieved with a conventional w/cm of 0.40 to 0.45 as long as sufficient amounts of Class F fly ash, slag or silica fume are added into the mixture and proper construction practices are followed.

Construction practices including consolidation and curing are also addressed in the VDOT special provisions. For bridge decks, moist curing is required for a minimum of seven days and until 70 percent of the minimum 28-day design compressive strength is attained. Protection by fogging is required to prevent rapid drying of the concrete surface until application of wet burlap and plastic

sheeting. After moist curing, a curing compound is applied. Curing of one of the decks constructed in accordance with the low permeability special provisions is shown in the photograph. For the 1995-97 construction seasons, five decks were successfully built using these provisions. More are under construction or planned. Proper consolidation is emphasized. Internal vibrators and screeds with vibrating elements are specified with lower limits on the vibration frequencies.

The low-permeability provisions will become a part of an end-result specification (ERS) being developed. In the ERS, limits on air content, slump, and temperature are specified as screening tests. Acceptance will be based on concrete properties such as strength and permeability as determined by the rapid permeability test, and construction practices such as concrete cover, deck thickness, and surface smoothness. Studies are continuing on a test to address the volumetric changes attributable to moisture. The new specifications addressing durability directly are expected to result in long-lasting and cost-effective bridge decks.

Further Information

Further information about VDOT's approach to specifying durable bridge decks is available from the author at 804-293-1977 or hco9e@virginia.edu.

Construction of a low permeability bridge deck in Virginia.





Many questions arise about HPC and its applications. If you have a question that you would like answered in HPC Bridge Views, please submit it to the Editor.

Question:

Is there special federal funding available for HPC bridges?

Answer:

Yes. Section 1503 of TEA-21 provides for an Innovative Bridge Research and Construction Program which allocates annual funding to promote the use of new materials and techniques to reduce maintenance and life-cycle costs of bridges. A total of \$108 million is targeted to demonstrate the application of innovative material technology in the construction and repair of bridges and other structures. Under this program, FHWA issues a call for proposals each year. HPC bridges are eligible for consideration. The proposals from various states are evaluated for conformance with the program goals, projects are selected, and funds are awarded. For more information regarding this program, contact George Romack at 202-366-4606 or John Hooks at 202-366-6712, or check the web site at <http://www.fhwa.dot.gov/bridge>.

RECENT PUBLICATIONS

- "High-Performance Concrete Bridges, Building Bridges for the 21st Century," (Publication No. FHWA-SA-98-084). Contact FHWA Research and Technology Report Center at 301-577-0818.
- "High-Performance Concrete," 2nd Edition by Pierre-Claude Aitcin, E & FN Spon. Contact Routledge Customer Service at 1-800-634-7064.
- "High-Performance Concrete for Bridge Decks," *Concrete International*, Vol. 21, No. 2, February 1999, pp. 58-68, American Concrete Institute, Detroit. A series of articles describing HPC bridge deck construction in Virginia, New Hampshire, Texas, and Nebraska.
- Lane, S. N., "A New Development Length Equation for Pretensioned Strands in Bridge Beams and Piles," FHWA, U.S. Department of Transportation, Report No. FHWA-RD-98-116, 1998, 131 pp.
- Hassanain, M. A. and Loov, R. E., "Design of Prestressed Girder Bridges Using High Performance Concrete—An Optimization Approach," *PCI Journal*, Vol. 44, No. 2, March/April, 1999, pp. 40-55.

HPC BRIDGE CALENDAR

June 20-24, 1999

Fifth International Symposium on Utilization of High Strength/High Performance Concrete, Sandefjord, Norway.
Contact Siri Engen, Norwegian Concrete Association at Phone: 47 22 94 75 00, Fax: 47 22 94 75 02.

June 29-July 1, 1999

Regional HPC Showcase, Auburn, AL. Contact Terry Halkyard, FHWA at 202-366-6765 or the web site at <http://www.eng.auburn.edu/center/allhpc/hpc.htm>.

September 24-27, 2000

Second International Symposium on High Performance Concrete, Orlando FL. Jointly sponsored by PCI and FHWA. Contact Paul Johal, Precast/Prestressed Concrete Institute at 312-786-0300

PREVIOUS ISSUES

HPC Bridge Views, Issues 1 and 2 are available at <http://www.portcement.org/newslet1.htm>



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