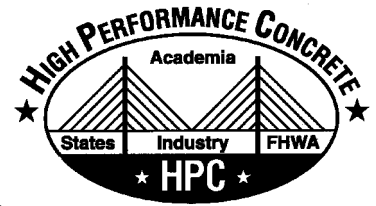




Bridge Views



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

Issue No. 2

March/April 1999

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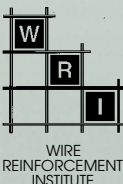
HPC Bridge Calendar

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AASHTO LEAD STATE IMPLEMENTATION

James A. Moore, *New Hampshire Department of Transportation*

In 1987, Congress initiated the five-year Strategic Highway Research Program (SHRP) to investigate various products to improve the constructibility and reduce the maintenance of the nation's highways and bridges. High Performance Concrete (HPC) or "engineered concrete" is one of the products from the SHRP program. To implement these products, Congress authorized additional funding over the following six years. The American Association of State Highway and Transportation Officials (AASHTO), in cooperation with the Federal Highway Administration (FHWA), created a Task Force for SHRP implementation. The Task Force's approach for technology transfer was through the use of teams consisting of the states that took the lead on various products; hence, the *AASHTO Lead State Team for HPC Implementation* was formed.

The Team, along with other Lead State Teams, first met in September 1996 to put together our mission, goals, strategies, and action plans. The team members represent industry, FHWA, and the States (currently Arizona, Iowa, Missouri, Nebraska, New Hampshire, Texas, Virginia, and Washington). Our mission is to promote the implementation of HPC technology for use in pavements and bridges and to share knowledge, benefits, and challenges with the states and their customers. To date, seventeen states are utilizing this technology for bridge projects. Many other states will be using HPC in their bridge decks; taking advantage of the characteristics of low permeability, increased abrasion resistance, and improved durability.

In order to spread the word on HPC, the Team makes presentations at various AASHTO meetings, to other professional organizations, and to states adjacent to the lead states; writes papers for various publications; and supports other efforts such as *HPC Bridge Views*. Also, we have conducted a survey about each state's current use of both conventional concrete and HPC (if used).

The results are available at the web site listed below. In addition, a point of contact has been established in each state and the lead states have established focus teams in their geographical locations. The focus teams meet on a regular basis and consist of representatives from the states, industry, academia, and FHWA. Their mission is to promote HPC projects.

One measure of the viability of a product or technology is its cost, both initial and long term. HPC is viewed as one of the seven high payoff SHRP technologies. To that end, the Team is developing guidelines on condition, repair, and maintenance data for use in determining bridge life-cycle costs by utilizing data collected for bridge management systems. Two bridge life-cycle cost analysis programs are currently being investigated.

Another effort is the Team's work in partnering with FHWA and industry to develop a generic HPC bridge implementation workshop. The workshop will be available to each state. The purpose will be to educate the states through various modules on the benefits of HPC and how to design, fabricate, and construct an HPC bridge. The modules will be designed to be given independently so each state may pick and choose how many they want. Modules will include structural design, fabrication, construction, costs and monitoring, research, FHWA demonstration projects, and an executive section which will give an overview of issues facing management.

Working together, we can achieve the overall goal which is to make HPC the standard product for use in bridges.

Further Information

Activities of the Lead State Team are described in more detail at their web site: <http://leadstates.tamu.edu> under "High Performance Concrete." The survey results are available at <http://hpc.fhwa.dot.gov> under "Lead States Surveys."



HPC was used in the girders and deck of Washington State HPC showcase bridge.

WASHINGTON STATE HPC SHOWCASE BRIDGE

M. Myint Lwin, Formerly Washington State Department of Transportation

Washington State Department of Transportation (WSDOT) has developed and used high performance concrete (HPC) mixes containing fly ash and silica fume in several highway bridges since 1992. The concrete has high compressive strength attaining 10,000 psi (69 MPa) by 28 days, low chloride permeability averaging less than 1,000 coulombs by 56 days, and generally lower shrinkage and creep values than conventional concrete.

In 1995, WSDOT was interested in expanding the use of high performance concrete and participated in a demonstration project sponsored by the Federal Highway Administration (FHWA). The project, known as SR 18 over SR 516 east-bound in King County, consists of a three-span continuous prestressed concrete bridge. The center span has a length of 137 ft (42 m) and the end spans are each 80 ft (24 m) long. The roadway deck is 38 ft (11.6 m) wide, carrying two 12-ft (3.7-m) lanes and 4-ft (1.2-m) and 10-ft (3.0-m) wide shoulders. The bridge is located in earthquake zone "C" with an earthquake acceleration coefficient equal to 0.25g. The design complies with the new AASHTO LRFD Bridge Design Specifications. Construction of this project started in July 1996 and the bridge was completed and opened to traffic in October 1997.

High Performance Concrete

High performance concrete is used in the WSDOT W74G prestressed concrete

I-girders and in the deck. The specified HPC properties for the girders are as follows:

- 56-day compressive strength > 10,000 psi (69 MPa)
- Freeze-thaw durability > 80%
- 56-day chloride permeability < 1,000 coulombs.

Use of HPC in the prestressed concrete girders allowed a reduction in the number of girder lines from seven to five. In the future, this will result in savings in the superstructure cost.

The design compressive strength of the deck concrete is 4000 psi (28 MPa), but it has enhanced durability due to the use of fly ash and the requirement of a 14-day wet cure.

Lessons Learned

High performance concrete is constructable and can be cost effective in highway bridges for both cast-in-place construction and precast, prestressed applications. Fly ash and silica fume are two key ingredients that have important effects on the performance of concrete. Air entrainment is considered essential for freeze-thaw resistance. However, entrained air reduces the compressive strength of HPC. Proper curing is essential for the success of HPC. Water or moisture must be supplied to the concrete surfaces of flatwork or unformed members soon after finishing and initial set to avoid shrinkage cracks. The cast-in-place concrete surfaces should be kept continuously wet for 14 days.

HPC containing fly ash and silica fume is very cohesive and has good workability when properly proportioned. With the use of

high-range water-reducers, the concrete can be mixed with a low water-cementitious material ratio and placed with a slump as high as 9 in. (230 mm) with no loss of strength or uniformity. The concrete flows laterally with ease in the forms and can be dropped without segregation.

Conclusions

Significant short- and long-term benefits can be realized with the use of HPC in bridges. These include more efficient designs longer spans, fewer beams, and shallower structural depths; improved performance; faster construction; reduced maintenance; longer service life; and lower life-cycle costs.

The successful use of HPC has made it a material of choice by the bridge designers in Washington State. The designers will use HPC whenever and wherever there is benefit in the design.

HPC will help bridge engineers fulfill the vision of "Building Bridges for the 21st Century" to meet traffic and environmental demands with low life-cycle costs.

Further Information

Further information about SR18 is available in Proceedings of the PCI/FHWA International Symposium on High Performance Concrete (1997) available from PCI or by contacting the author at 360-705-8797 or MyintLwin@aol.com.

Material	Approved HPC Mix Design Quantities	
	per yd ³	per m ³
Portland Cement	728 lb	432 kg
Fly Ash	222 lb	132 kg
Silica Fume	50 lb	30 kg
Fine Aggregate	890 lb	528 kg
Course Aggregate	1870 lb	1109 kg
Water	265 lb	157 kg
Water Reducer	29 oz	1126 ml
Superplasticizer	215 oz	8316 ml
Air Entrainment	None	None
Properties		
Water/Cementitious Material Ratio	0.27	0.27
Slump	6 in.	152 mm
56-day Compressive Strength	10,730 psi	74 MPa
Chloride Permeability (56 days)	1010 coulombs	

EFFECT OF CURING TEMPERATURES ON COMPRESSIVE STRENGTH DEVELOPMENT

John J. Myers and Ramon L. Carrasquillo, The University of Texas at Austin

Temperature development during concrete hydration and curing conditions dramatically impact both mechanical and material properties of high strength/high performance concretes. During the fabrication of precast, prestressed beams for two HPC bridges in Texas, the temperature development during hydration was monitored to investigate the effect of concrete temperature and curing conditions on concrete compressive strength.* A commercially available match-curing system was utilized during the production of the precast, prestressed beams to more closely investigate the concrete properties within the members and to evaluate the use of match-curing technology as a quality control (QC) tool in the precast industry.

Figure 1 illustrates concrete temperatures during hydration for a 54-in. (1.37-m) deep U-beam used in the Louetta Road Overpass. The results are representative of all the U-beam casting dates with minor variations due to ambient conditions during casting. The U-beams have end blocks that range in thickness from 18 to 48 in. (455 to 1220 mm).

Temperature profiles for four locations in the member are shown in Fig. 1. The bracketed value following each monitoring location indicates the height of the thermocouple from the base of the member in inches. In addition, the temperature of a standard QC member-cured cylinder is presented. Member-cured cylinders are cured adjacent to the precasting bed prior to release of the prestressing strands. To date, member-cured cylinders are used as the standard QC specimen by the Texas Department of Transportation to determine when the prestressing strands may be released.

Figure 2 illustrates the compressive strength of 4x8-in. (102x203-mm) cylinders at release (24 hours) and 56 days for different curing conditions. The first and second pairs of data are for specimens that were moist cured per ASTM and member cured, respectively. The other four pairs of data represent match-cured specimens corresponding to different locations in the U-beams. The match-cured specimens were stored with the beams following initial curing. Clearly, the curing condition that attained the highest early temperature displayed the highest release strength, but the lowest 56-day strength.

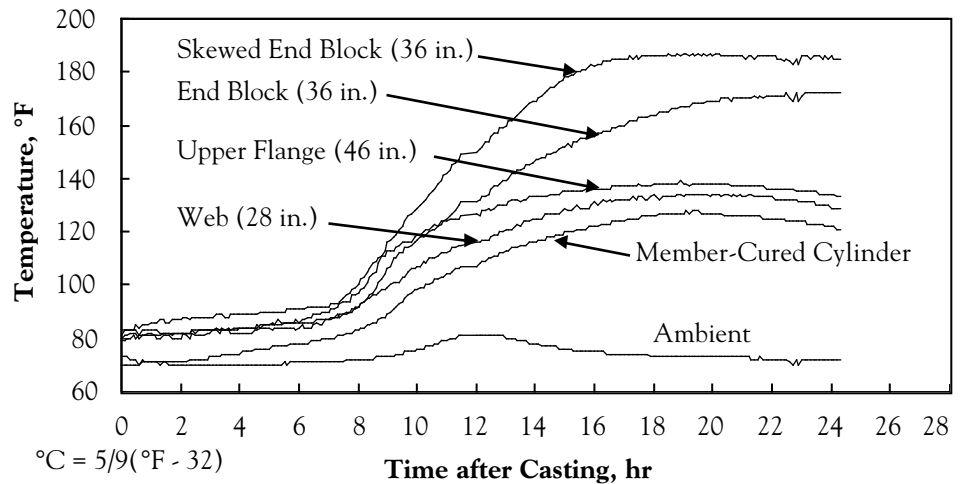


Fig. 1. Concrete temperatures during hydration

Both the ASTM moist-cured and member-cured cylinders underestimated the strength of the concrete within the member at release, but overestimated the concrete strength within the member at later ages. For the data shown in Fig. 2, the member-cured cylinders underestimated the strength of the concrete in the member at release by as much as 8 percent compared to the match-cured specimens. The ASTM moist-cured specimens overestimated the concrete strength at 56 days by as much as 17 percent. Therefore, the strength of the member is typically underestimated at release, but overestimated at later ages if ASTM moist-cured or member-cured cylinders are used for strength verification.

Further Information

Further information about the Texas HPC bridges is available in Proceedings of

the PCI/FHWA International Symposium on High Performance Concrete (1997) available from PCI and in the following two reports:

Myers, J. J. and Carrasquillo, R. L., Production and Quality Control of High Performance Concrete in Texas Bridge Structures, Center for Transportation Research, The University of Texas at Austin, Preliminary Research Report 580/589-1, to be published.

Gross, S. P. and Burns, N. H., Field Performance of Prestressed High Performance Concrete Highway Bridges in Texas, Center for Transportation Research, The University of Texas at Austin, Preliminary Research Report 580/589-2, to be published.

*The two bridge projects were co-sponsored by the Texas Department of Transportation and the Federal Highway Administration.

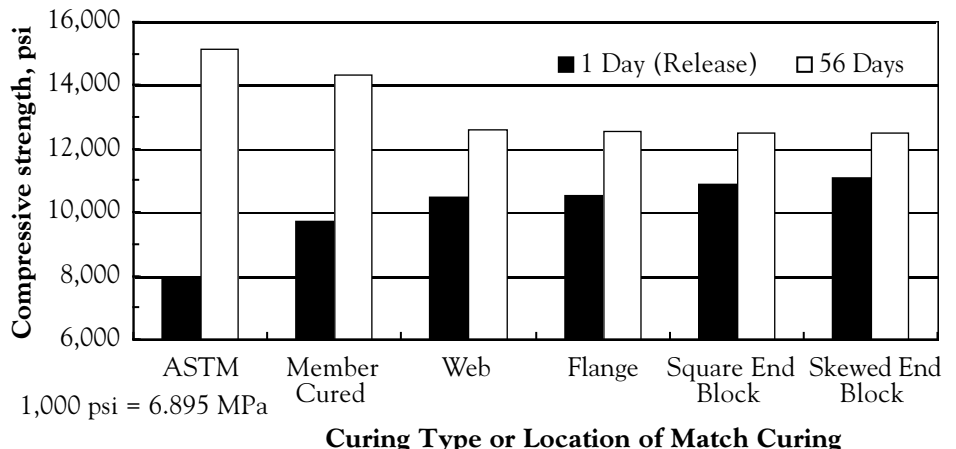


Fig. 2. Compressive strength gain versus curing regime or match-curing location



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:

What is match curing and can I use it to determine specified release strengths and design strengths?

Answer:

Match curing is a system in which a standard concrete cylinder—usually 4x8 in. (102x203 mm)—is cured at the same temperature as that measured in a concrete member. The system includes a temperature sensor in the member, a controller, a special insulated cylinder mold with a built-in heating system, and a temperature sensor in the mold.

A reference sensor is located in the member to obtain the temperature of the freshly placed concrete. The reference sensor and the sensor from the cylinder mold are connected to the controller. The controller continuously compares the reference temperature with the temperature of the cylinder mold. When the reference sensor temperature exceeds the cylinder temperature, the controller activates the heater on the cylinder until the cylinder temperature and reference temperature are equal. One controller can be used with several molds. The controller can be replaced with a personal computer that can also record temperature versus time.

As illustrated in the article on Page 3, curing temperature can have a significant effect on measured concrete compressive strength at release and a lesser effect on later-age strengths. This effect is more significant with HPC because the higher amounts of cementitious materials produce more heat of hydration and higher temperatures.

Whether or not the match-curing technique can be used to determine specified strengths will depend on the specifications. Several state DOTs now allow its use to determine release strengths but still use member curing or moist curing for design strengths. Some states use the technique for HPC bridges only. Other states are experimenting with the technique. As research data indicate, a match-cured cylinder produces a compressive strength that more closely matches the strength of the concrete in the member than the strength measured using other curing methods. This is particularly true at early ages. If your specifications do not currently permit the use of match curing and you are producing high strength HPC, it is time to consider a change to your specifications.

**HPC BRIDGE
CALENDAR**

Mar. 14-18, 1999

ACI Annual Convention—Theme: High Performance Concrete, Chicago, IL. Contact ACI Headquarters at 248-848-3800.

June 20-24, 1999

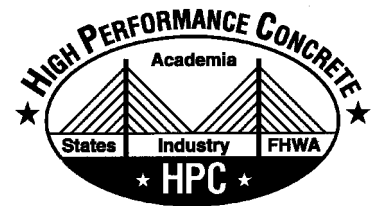
Fifth International Symposium on Utilization of High Strength/High Performance Concrete, Sandefjord, Norway. Contact Siri Engen, Norwegian Concrete Association at Phone: 47 22 94 75 00, Fax: 47 22 94 75 02.

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/alhpc/hpc.htm>.

October, 2000

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



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

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