Bridge Views

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HPC IMPLEMENTATION

Kenneth R. Wykle, Federal Highway Administrator

In recent years, the number of State departments of transportation (DOTs) using high performance concrete (HPC) to build or rebuild bridges has been steadily increasing. HPC uses the same basic materials as conventional concrete but the proportions are engineered to meet the demands of each project. State highway agencies are finding that HPC is more durable and, in many cases, stronger than conventional concrete. This allows them to build bridges faster, with less materials, and with less labor—and that's good news for their customers, work crews, budget offices, and traveling public.

To get the greatest benefit from this new and evolving technology, however, the many organizations and companies involved in bridge design and construction need to share information about their experiences with HPC bridge projects. Doing so will allow us to build on each other's successes and avoid any known problems.

That's why I am pleased to introduce this new bimonthly newsletter, *HPC Bridge Views*, produced jointly by the National Concrete Bridge Council (NCBC) and FHWA. The newsletter will feature articles from the many partners in the HPC for bridges implementation effort, including the AASHTO HPC Lead States Team, State DOTs, universities, ready-mixed concrete suppliers, the prestressed concrete industry, material and admixture suppliers, contractors, consultants, and FHWA. The editorial content of the newsletter will be determined jointly by NCBC, HPC Lead States team, and FHWA; NCBC will handle the printing and distribution of the newsletter.

HPC Bridge Views is the first product of a cooperative agreement between NCBC and FHWA. The purpose of the agreement is to develop and implement means to enhance the use and quality of concrete materials and bridge systems. This partnership will help us achieve a more cost-effective highway system.

The cooperative agreement has three key objectives:

- Identify needs related to HPC practices and procedures in relation to bridge design and construction
- Develop new and improved HPC practices and procedures related to concrete construction
- Implement technology transfer, training, and outreach activities on new and improved HPC practices and procedures; and develop partnership opportunities and joint efforts between Federal, State, and local governments, academia, and the private sector.

HPC Bridge Views is the next step in FHWA's extensive program of activities to put the high performance concrete products developed and evaluated under the Strategic Highway Research Program (SHRP) into the hands of highway agencies and companies. The success of those earlier activities was largely the result of the partnerships spawned and nurtured first by SHRP, and then by FHWA and AASHTO; this newsletter will draw its life from those same vital partnerships. We hope that this newsletter will be a valuable resource for all involved with HPC.

HPC BRIDGE CALENDAR

Feb. 23-24, 1999
Ohio HPC Showcase, Cincinnati, OH.
See enclosed announcement or contact Dr. R. A. Miller at 513-556-3744.

Mar. 14-18, 1999
ACI Annual Convention—Theme: High Performance Concrete, Chicago, IL.
Contact ACI Headquarters at 248-848-3800.

June 29-July 1, 1999
Regional HPC Showcase, Auburn, AL.
Contact T. Halkyard at 202-366-6765.

WHAT IS HPC FOR BRIDGES?

Basile G. Rabbat, Portland Cement Association
Suneel N. Vanikar, Federal Highway Administration

As part of the implementation of the Strategic Highway Research Program (SHRP) High Performance Concrete (HPC) products, several states have started to use HPC for bridge construction. Applications include all bridge components: superstructures (decks and girders) and substructures (piers and abutments).

What is HPC?

The term HPC is used to describe concretes that are made with carefully selected high quality ingredients, optimized mixture designs, and which are batched, mixed, placed, compacted and cured to the highest industry standards. Typically, HPC will have a water-cementitious materials ratio (w/cm) of 0.4 or less. Achievement of these low w/cm concretes often depends on the effective use of admixtures to achieve high workability, another common characteristic of HPC mixes.

According to the American Concrete Institute, high performance concrete is defined as concrete meeting special combinations of performance and uniformity requirements that cannot always be achieved routinely using conventional constituents and normal mixing, placing and curing practices.

A high performance concrete is a concrete in which certain characteristics are developed for a particular application and environment. Examples of characteristics that may be considered critical for an application are:

- Ease of placement
- Compaction without segregation
- Early-age strength
- Long-term mechanical properties
- Permeability
- Density
- Heat of hydration
- Toughness
- Volume stability
- Long life in severe environments.

In What Ways Will HPC Improve Bridges?

Because a lower w/cm is used, HPC typically has a higher strength than conventional strength concrete. However, high strength is not always the primary requirement. HPC is valuable where any of the following properties are required: high strength, high early strength, low permeability, resistance to freeze-thaw damage, resistance to chemical (e.g. sulfate) attack, abrasion resistance, low absorption, high resistivity, high modulus of elasticity, and volume stability.

Given these improved material characteristics, bridge decks built with HPC can be expected to last much longer than those built with conventional concrete. High strength concrete girders can span longer distances and/or can be used at wider spacings than conventional concrete girders, thus reducing the number of required girders and resulting in economies. Alternatively, bridge designers have the option of selecting shallower girders to increase clearances without changing grades. Again, the net result is economy. HPC can be used to both reduce the size and extend the service life of superstructure and substructure elements, particularly in severe environments. HPC also allows for more graceful structures; aesthetics, although hard to measure can be an important benefit.

Which States Are Building HPC Bridges?

The States listed to the right are participating in the Federal Highway Administration (FHWA) sponsored HPC Bridge Showcase program.

The intent of this program is to give the States an opportunity to see how they can benefit from the use of HPC. So far, the program appears to be a success: Virginia, for example, has completed two additional HPC bridges on their own, they have another one under construction and five in design.

A number of other States including Delaware, Indiana, Louisiana, Minnesota, Missouri, and New York aren't participating in the FHWA program but are using HPC.

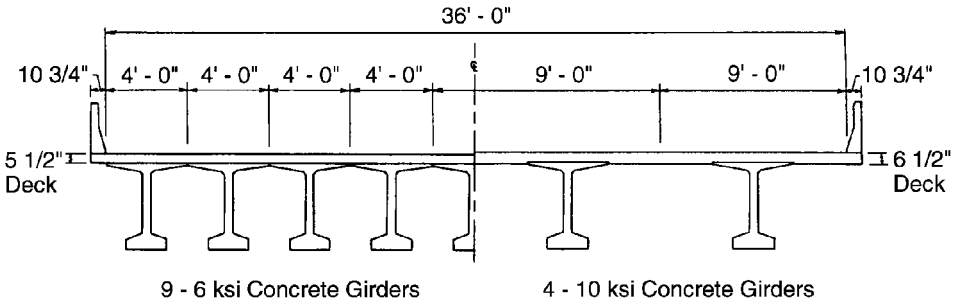
Summary

HPC is clearly a great improvement on previous formulations of high quality concrete made possible by the use of modern admixtures and supplementary cementitious materials. In almost all forms of construction, HPC offers a superior solution that should have lower service-life costs than conventional concrete. The ingrained traditional first cost approach to construction and lack of reliable and accurate models for predicting life-cycle costs may make it difficult to obtain widespread or rapid acceptance of this material. Ultimately, however, the superior qualities of HPC will result in its increased acceptance on the basis of life-cycle costs. In some instances, initial economies will result even though the material itself may be more expensive. In such applications, HPC offers a clear advantage.

REFERENCE

1. Jobse, H. J., and Moustafa, S. E., "Applications of High Strength Concrete for Highway Bridges," PCI Journal, Vol. 29, No. 3, May/June 1984, pp. 44-73.

State	Complete	Design/ Const.
Alabama		1
Colorado	1	
Georgia		1
Nebraska	1	
New Hampshire	1	1
New Mexico		1
North Carolina		2
Ohio		1
South Dakota		1
Tennessee	1	1
Texas	2	
Virginia	2	
Washington	1	



Reduced number of girders with high performance concrete[1]

Conversion Factors:
1 ft = 0.305 m
1 in. = 25.4 mm
1 ksi = 6.895 MPa

HPC is used in the superstructure and substructure of the Louetta Road Overpass in Houston, Texas.

LOUETTA ROAD OVERPASS —LESSONS LEARNED

Mary Lou Ralls, Texas Department of Transportation

Louetta Road Overpass near Houston, Texas, is one of the first projects in the Federal Highway Administration (FHWA) national high performance concrete (HPC) bridge implementation program. The overpass, which consists of two parallel bridges, utilizes precast, prestressed and cast-in-place HPC in both the superstructure and substructure.

The superstructure consists of simple span pretensioned trapezoidal-shaped 54-in. (1.37-m) deep U-beams with design compressive strengths as high as 13,100 psi (90.3 MPa). This concrete strength allowed a maximum span length of 135.5 ft (41.3 m) and a maximum girder spacing of 15.8 ft (4.82 m).

The superstructure also includes precast, pretensioned concrete deck panels supported on the U-beams' top flanges with a cast-in-place composite concrete topping. The overpass was selected as a 1998 Precast/Prestressed Concrete Institute (PCI) Bridge Design Award winner for spans greater than 135 ft (41.1 m).

Construction of the Louetta Road Overpass provides a valuable learning experience for future bridges. Several of the lessons from the project are described below.

Optimum Concrete Compressive Strength for Beams

The use of high strength concrete allows for longer spans. However, the longer spans and the U-beam's large cross section necessitate the use of hauling systems and erection cranes with larger capacities than typically used in Texas bridge construction. In addition, routing to the jobsite and site access are areas of concern for beams longer than about 120 ft (37 m). In view of these constraints, beam compressive strengths in the 10,000 to 13,000 psi (69 to 90 MPa) range appear to be a practical upper limit for design optimization.

Use of 0.6-in. (15.2-mm) Diameter Prestressing Strand

The majority of the Louetta Road beams use 0.6-in. (15.2-mm) diameter strands at 1.97-in. (50-mm) spacing. The 0.6-in. diameter strand is more efficient than 0.5-in. (12.7-mm) diameter strand because 40 percent more force can be provided in each strand. For the Texas designs, 0.6-in. diameter strand was required to take full advantage of concrete strengths in excess of about 10,000 psi (69 MPa).

At many beam fabrication plants, pretensioning beds are designed for 0.5-in. (12.7-mm) diameter strands. These beds may not have adequate capacity for the number of 0.6-in. (15.2-mm) diameter strands needed to utilize higher concrete compressive strengths. Modifications to existing beds or construction of new beds may be required prior to fabrication of high strength HPC beams. It is, therefore, important for designers to work with local producers concerning bed capacities. If bed capacity is not available, a combination of pretensioning and post-tensioning provides another solution.

Concrete Compressive Strength for HPC Decks

Typical bridge decks in Texas use 5000 psi (34 MPa) compressive strength concrete in pretensioned concrete panels and a 4000 psi (28 MPa) cast-in-place composite topping. The Louetta Road overpass has a similar deck system, except that the precast panels use 8000 psi (55 MPa) design strength and the cast-in-place topping is 8000 psi (55 MPa) on the southbound bridge and 4000 psi (28 MPa) on the northbound bridge.

Little benefit is gained from using the higher compressive strengths in the deck. In Texas, design compressive strengths of 5000 psi (34 MPa) and higher for cast-in-place bridge decks require a significant change from typical practice. In order for the contractor to be assured of getting the higher strengths, a lower water-cementitious materials ratio is used. In addition, a high-range water-reducer may be required to facilitate placing, consolidating, and finishing. The resulting mix behaves differently from typical mixes and can make construction more difficult. These low-bleedwater mixes are also more susceptible to plastic shrinkage cracking which can occur prior to the application of interim curing compound and wet cotton mats. Consequently, Texas is currently specifying 4000 psi (28 MPa) HPC for decks and substructures. In practice, the actual 28-day concrete compressive strengths may be considerably higher due to the use of pozzolans to achieve improved durability. The current durability specification for decks and substructures requires a permeability less than 2000 coulombs at 28 days by AASHTO T277 and 5 to 8 percent total air content.

Further Information

Further information about the Louetta Road Overpass is available in Proceedings of the PCI/FHWA International Symposium on High Performance Concrete (1997) available from PCI or by contacting the author at 512-465-7963 or mralls@mailgwdot.state.tx.us

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:

Are there quantitative measurements for HPC?

Answer:

The most common measurement for HPC is concrete compressive strength. The American Concrete Institute recognizes that concrete with a specified compressive strength of 6000 psi (41 MPa) or greater is a high strength concrete and, therefore, a high performance concrete. However, there are many other measurements that can be used to specify HPC. For structural properties, these may include tensile strength, modulus of elasticity, shrinkage, or creep. For durability, performance can be measured using freeze-thaw resistance, de-icer scaling, abrasion resistance, or chloride permeability. Concretes may also require a special density or low heat of hydration. The goal is to specify quantifiable performance to match the intended application. In many cases, this will mean that performance requirements other than strength will be specified. For more information on this topic, go to FHWA's HPC web site and open "Grades of Concrete."

HPC WEB SITES

A wealth of valuable information about the use of HPC is provided at the FHWA's HPC web site: http://hpc.fhwa.dot.gov. Activities of the AASHTO HPC Lead States Team are described at http://leadstates.tamu.edu under "High Performance Concrete."

OTHER NEWS

The National Cooperative Highway Research Program has announced the tentative selection of a new research project entitled "Use of Supplementary Cementitious Materials to Enhance Durability in Concrete." A detailed project statement is being developed. Further information is available at http://www2.nas.edu/trbcrp under the heading "Anticipated Projects."

NCBC

Founded in 1988, the National Concrete Bridge Council (NCBC) is comprised of the eight national organizations listed on the front page of this newsletter. The objectives of NCBC are to:

1. Promote quality in concrete bridge construction
2. Gather and disseminate information on design, construction, and condition of concrete bridges
3. Establish communication with federal and state departments of transportation, city and county public works departments, and consulting engineers, and
4. Provide information on behalf of the concrete industries to codes and standards groups.

In September 1997, NCBC signed a "cooperative agreement" with FHWA to assist in transfer of HPC technology for bridges developed under SHRP. *HPC Bridge Views* is one of the products of this agreement.

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