Bridge Views

http://hpc.fhwa.dot.gov

Issue No. 16 — July/August 2001

INSIDE THIS ISSUE…

SPONSORED BY

U.S. Department of Transportation
Federal Highway Administration

CO-SPONSORED BY
NATIONAL CONCRETE BRIDGE COUNCIL

PORTLAND CEMENT ASSOCIATION

PRECAST PRESTRESSED CONCRETE INSTITUTE

NATIONAL READY MIXED CONCRETE ASSOCIATION

AMERICAN SEGMENTAL BRIDGE INSTITUTE

EXPANDED SHALE CLAY AND SLATE INSTITUTE

CONCRETE REINFORCING STEEL INSTITUTE

POST-TENSIONING INSTITUTE

WIRE REINFORCEMENT INSTITUTE

SILICA FUME ASSOCIATION

SOUTH DAKOTA'S FIRST HPC BRIDGE

Hadly G. Eisenbeisz, South Dakota Department of Transportation

The South Dakota Department of Transportation's first use of high performance concrete (HPC) in an entire superstructure became a reality in the summer of 1999 with the construction of a railroad overpass structure on northbound I-29. This location was chosen mainly because high traffic counts and heavy use of deicing salts provided a true test of the strength and durability of HPC. Also, a twin bridge on the southbound lanes of I-29 was scheduled for construction in the summer of 2000, and would serve for comparison purposes and additional research.

The first step in the bridge project was selection of the research team. South Dakota School of Mines and Technology did trial batches and testing to optimize mix designs for the girders and the deck. South Dakota State University instrumented, monitored, and tested the girder and deck concrete during and after construction.

The bridge consisted of a typical three-span precast, prestressed concrete girder bridge with our standard integral abutments and integral bent diaphragms. AASHTO Type II girders were used for the 54-ft (16.5-m) long end spans and the 61-ft (18.6-m) long main span. The use of HPC allowed designers to reduce the number of girders in each span from five to four. Design compressive strength of the girder concrete was 9900 psi (68.3 MPa) with a strength of 8250 psi (56.9 MPa) required at release of the strands. The deck utilized a 4500 psi (31 MPa) compressive strength concrete. To improve durability, the cementitious materials in the deck concrete consisted of cement (75%), fly ash (17%), and silica fume (8%).

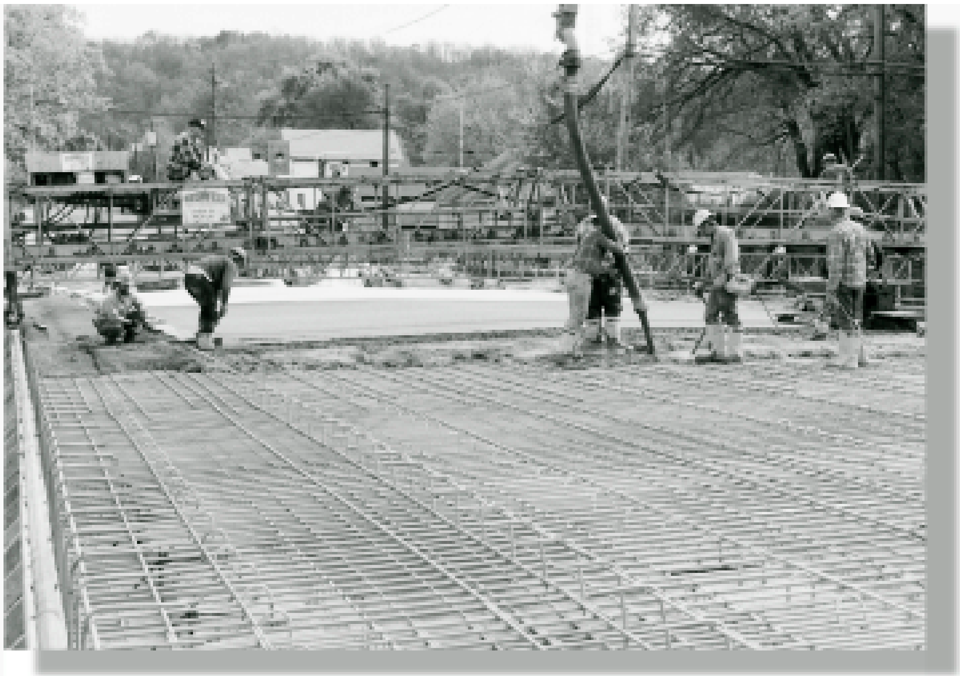
The girders were fabricated with a concrete containing silica fume and having a water-cementitious materials ratio of 0.25. Several trial batches and test placements were performed by the fabricator to obtain the desired early strength and workability. The girders were moistened continually with soaker hoses and covered with polyethylene sheeting until the release strength was achieved. Deck specifications included a trial placement and the use of fogging behind the bridge deck finishing machine. Curing was required for a minimum of seven days using wet burlap, soaker hoses, and polyethylene sheeting.

The future of HPC looks promising in South Dakota. The twin southbound bridge was also constructed using HPC. Both bridges are instrumented and are being monitored to evaluate the performance of HPC. South Dakota bridge design engineers continue to use higher strengths for precast, prestressed concrete girders, and the use of fly ash in bridge decks is becoming a standard for durability.

Further Information

For further information or a copy of the research report, contact Hadly Eisenbeisz at Hadly.Eisenbeisz@state.sd.us.

High strength concrete allowed the number of girder lines to be reduced from five to four.



HPC is used on county bridge decks to enhance durability.

COUNTY BRIDGES IN OHIO

Stephen Mary, Hamilton County, Ohio and Richard A. Miller, University of Cincinnati

Many bridges in the USA are designed and maintained by city and county engineers. These bridges must meet the same strength, serviceability, and durability requirements as state-owned bridges. County engineers, like their state counterparts, have found that high performance concrete (HPC) can be beneficial for both strength and durability.

In Ohio, HPC has been used for state-owned bridges for almost a decade. In the early 1990s, Ohio Department of Transportation (ODOT) created an HPC specification for bridge deck concrete. In 1997, ODOT installed their first HPC precast, prestressed concrete bridge as part of the Federal Highway Administration Showcase program. This bridge superstructure consisted of adjacent box girders. Availability of 10,000 psi (69 MPa) compressive strength HPC enabled the span of the Ohio B42-48 section [42 in. deep by 48 in. wide (1.07 m by 1.22 m)] to be extended to 116 ft (35.4 m).

Since that initial installation, three Ohio counties have built precast, prestressed HPC bridges. Columbiana County built a 120-ft (36.6-m) long box girder bridge, again using an Ohio B42-48 section and 10,000 psi (69 MPa) concrete. Mercer County has a 130-ft (39.6-m) long adjacent box girder bridge under construction. This bridge uses 8000 psi (55 MPa) concrete with a modified Ohio B42-36 section. A regular B42-36 has a 5-in (127-mm) thick bottom flange, which allows for only one bottom row of 17 strands, a second row of four strands, and then rows of two strands in the webs. The modified girder has a 6-in. (152-mm) thick bottom flange to allow for two full rows of 17 strands. The completed girder has 38 bottom strands.

In Hamilton County, HPC is used to increase durability of precast, prestressed concrete elements. Over 20 HPC bridges have been built in the last ten years. The Hamilton County specification for precast concrete allows the fabricator to use the regular bridge girder concrete mix, but requires 7 percent silica fume by weight of cement, either as a replacement or as an addition. HPC designed for durability normally has a water-cementitious materials (w/cm) ratio of 0.40 or less. Since the precast industry tends to use low w/cm ratios in order to get high early strengths, the w/cm ratio is usually less than 0.36. Hamilton County requires a release strength of 4000 psi (28 MPa) for box girders and 4500 psi (31 MPa) for other girders. The fabricators must submit the proposed mix design for approval before casting the beams. Although not designed for high strength, the precast elements often have concrete compressive strengths approaching 9000 psi (62 MPa) at 28 days.

Hamilton County now uses a performance-based specification for HPC in bridge decks. Previously, the county used the ODOT Class S specification. The concrete used was a prescriptive mix with a standard aggregate gradation and a cement content of 715 lb/cu yd (424 kg/cu m). It was felt that this mix was prone to increased shrinkage, which could cause full-depth deck cracking. The county now requires the contractor to submit a mix design for approval. The mix design must have a w/cm ratio less than 0.40, maximum slump of 6 in. (150 mm), minimum compressive strength of 4500 psi (31 MPa) at 28 days, and 2 lb/cu yd (1.2 kg/cu m) of polypropylene fibers not less than 3/4 in. (19 mm) long to minimize plastic shrinkage cracking. Thirty days prior to deck placement, a test placement must be made on the project site to check air, slump, workability, and compressive strength. The deck must be cured using a combination of liquid membrane curing compound and seven days of water curing.

HPC has also been used for bridge deck overlays. These overlays are specified to have 7 percent silica fume by weight of cement, a maximum water/cement ratio of 0.36, and a bonding agent in addition to the above requirements for bridge decks.

County Engineer Bill Brayshaw has been pleased with the HPC specification. Three large full-depth decks have been placed with very little or no apparent cracking. Some cracking has occurred on two of the bridges that received an HPC overlay. "Overall, HPC has been well worth the additional material cost due to the quality of the final product. It has superior durability due to increased density and lower chloride permeability. This office will continue to provide the highest quality bridges to the traveling public through the use of innovative methods and materials," said Mr. Brayshaw.

Further Information

For further information, contact Stephen Mary at steve.mary@hamilton-co.org or 513-761-7872.

LETTERS TO THE EDITOR

The following letters were received concerning the article entitled *"Capping Cylinders for Testing High Strength Concrete,"* in Issue No. 14.

Nicholas J. Carino, *National Institute of Standards and Technology (NIST)*

In 1994, NIST and FHWA published the results of a study on the effects of testing variables on the measured strength of concrete cylinders.(1) Two concrete mixtures were used: an ordinary strength mixture of about 6500 psi (45 MPa) and a high strength mixture of about 13,000 psi (90 MPa). End preparation consisted of sulfur capping and grinding. An industrial grinder manufactured by the Blanchard Machine Co. was used to grind the ends of the cylinders. A total of 48 cylinders were tested with each end condition. The average strength of the ground cylinders was about 2 percent higher than those with sulfur caps. However, for the 13,000 psi (90 MPa) concrete, the measured strength for some of the ground cylinders was as much as 6 percent higher than for the capped cylinders.

In a study(2) by the National Ready Mixed Concrete Association (NRMCA), the strengths of cylinders with ground ends were compared with the strengths of cylinders with two different types of sulfur caps and cement paste caps. The Blanchard grinder was also used in this study. Nominal compressive strengths were 7,000, 11,000, and 17,000 psi (48, 76, and 117 MPa). Measured strengths as a percentage of the strength of cylinders with ground ends are given in Table 1. The NRMCA study demonstrated that sulfur capping compound could be used successfully to test high strength concrete if the caps are 1/8 in. (3 mm) thick and the sulfur compound is allowed to harden for seven days before testing. In several cases, the strength of the cylinders with sulfur caps exceeded the strength of the ground cylinders. The difference, however, was less than three percent.

The 15 percent lower strength of the ground cylinders obtained in the FHWA study appears to be unusual. A comparative study should be performed with cylinders prepared with the Blanchard grinder and those prepared with the grinder used in the FHWA work. There are obviously differences between the two grinding operations and we need to understand the nature of the differences.

Capping Material	Strength as Percentage of Ground Cylinders		
	7,000 psi	11,000 psi	17,000 psi
1/8-in. thick caps			
Cement Paste	100.4	100.8	101.1
Sulfur 1	97.9	101.2	101.6
Sulfur 2	97.3	99.5	102.8
1/4-in. thick caps			
Cement Paste	101.6	100.5	100.0
Sulfur 1	93.3	99.8	96.2
Sulfur 2	95.2	100.5	96.8

Table 1. Effects of Cap Thickness(1)

Richard D. Gaynor, *Formerly NRMCA and Chairman ASTM Task Group C 09.61*

The most recent version of ASTM C 1231-00, entitled "Standard Practice for Use of Unbonded Caps in Determination of Compressive Strength of Hardened Concrete Cylinders," includes the requirement that qualification tests are required for concrete strengths from 7,000 psi (50 MPa) to 12,000 psi (80 MPa). Use of unbonded caps is not permitted at strengths above 12,000 psi (80 MPa). The FHWA tests are consistent with this latest change and, hopefully, other users will be encouraged to make qualification tests at even higher strength levels.

In his letter, Dr. Carino refers to the testing at NRMCA. The 2-in. (50-mm) cubes made of the sulfur capping materials were tested at ages from 2 hours to 28 days. Both materials showed appreciable strength gain between 6 hours and 7 days as shown in Table 2. The 7000 psi (50 MPa) concretes were capped with sulfur at least 2 hours before testing as permitted in ASTM C 617-94. As shown in Table 1, concrete strengths were reduced 2 percent with thin caps and 5 to 7 percent with the 1/4-in. (6-mm) thick caps. However, when 11,000 and 17,000 psi (76 and 117 MPa) cylinders were capped 7 days before they were tested, the thin caps provided strengths equal to the ground specimens. With the 1/4-in. (6-mm) thick caps, the results were satisfactory at 11,000 psi (76 MPa) but not at 17,000 psi (117 MPa).

The current ASTM C 617-98 has tightened the requirements for sulfur mortars. When sulfur mortar is used for cylinders stronger than 5000 psi (35 MPa) the cylinders are to be capped at least 16 hours before testing. For concrete strengths greater than 7000 psi (50 MPa), the manufacturer or user of the capping materials must provide qualification test data indicating that test results using the capping material indicate compliance with requirements. It would be helpful to know how much qualification testing has been done and whether the 16-hour requirement has been adequate to obtain the required concrete strength performance.

Ronald G. Burg, *Construction Technology Laboratories, Inc.*

The authors' findings that high strength concrete (HSC) test specimens had higher and less variable measured compressive strengths when tested with neoprene pads or sulfur caps as compared to ground ends is contrary to what is reported in most of the published literature. ACI Committee Report 363.2R-98, Guide to Quality Control and Testing of High-Strength Concrete, states "the problems associated with capping can be eliminated by grinding the ends of test cylinders with equipment made for that purpose" and goes on to state "cylinders with ends prepared by grinding have less variable test results and a higher average strength for concrete stronger than 70 MPa (10,000 psi)." The writer's own experience with testing HSC suggests that both grinding and capping of HSC test specimens can produce statistically equivalent measured compressive strengths when the appropriate capping compound is used and particular care is taken in preparing the ends of the specimens for test.

In an inter-laboratory study, that included concretes with nominal

Age	Cube Strength, psi	
	Sulfur 1	Sulfur 2
2 hours	6830	9130
6 hours	6930	9690
1 day	7210	11,800
7 days	11,790	13,200
28 days	12,290	13,130

Table 2. Sulfur Mortar Cube Strengths(2)

(continued from pg. 4)

strengths of 9,000, 14,000, and 18,000 psi (62, 97, and 124 MPa), measured compressive strengths of specimens with capped ends were 100.1, 97.0, and 99.1 percent of the measured strengths of specimens with ground ends for each respective strength level.[3] This study also found that capping compound with the higher 2-in (50-mm) cube strength resulted in measured concrete strengths that were significantly less than those of companion specimens with ground ends.

Clearly, the issue of quality control testing for HSC is an important one for which additional work is needed. The differing results obtained by this writer and Mullarky and Wathne emphasizes that we don't fully understand the complexities of a seemingly simple test upon which many important decisions are based. I encourage more work in this area so that the industry can develop technically sound testing standards for high strength concrete.

Peter G. Snow, *Burns Concrete, Inc.*

For the LDS Conference Center in Salt Lake City, the engineer required a modulus of elasticity of 7 million psi (48 GPa). To achieve this value, a concrete with a compressive strength of 17,000 to 18,000 psi (117 to 124 MPa) was required. This raised the question about which capping system to use. Comparison testing prior to construction using 4x8 in. (100x200 mm) cylinders indicated a standard deviation for ground cylinders of 650 psi (4.5 MPa) whereas the standard deviation with neoprene caps of 70 durometer hardness was less than 300 psi (2.1 MPa). These results were developed for multiple batches of concrete as opposed to the single batch utilized in the FHWA study. Based on the data, pad caps were selected for the capping system.

Authors' Response

The results of this small-scale investigation were surprising to the authors. Consistent with most literature, the authors expected the ground cylinders to have a higher strength and lower variability than the specimens with either of the other two end conditions. The opposite occurred. Comments suggest that the lower strengths may be related to how the cylinders were ground, and that end grinding is an issue that deserves more attention, particularly in the context of high strength concrete. For this study, cylinders were ground using Humboldt's Endgrinder IV Model H2965—a machine made specifically for the purpose of grinding the ends of test cylinders. Every cylinder was checked for both planeness and perpendicularity prior to testing and met the requirements of ASTM C 39. Sulfur caps were made 24 hours prior to test with Forney's HI-CAP having a nominal strength of 9000 psi (62 MPa).

It should be noted that the neoprene caps met the qualification guidelines of ASTM C 1231 only because the guidelines ignore strength differences between the two capping methods when the strengths of the neoprene capped specimens are greater than those of the ground (reference) specimens. A better understanding of the impact of different grinding methods is needed before allowing ground specimens to be used as qualification reference specimens. A substantial amount of qualification and verification testing is required to use sulfur mortar or neoprene caps for high strength concrete, whereas end grinding requires none.

This study, as well as others mentioned in the discussion, suggests that sulfur caps and neoprene caps improved the precision of the test when compared to ground specimens. The implications of lower variability on HPC mixture design and quality control should not be ignored.

The authors agree with Mr. Burg's assessment that the complexities of a seemingly simple test are not fully understood and we encourage further work to establish technically sound testing standards for high strength concrete. A comparative study of the effects of end grinding is currently being discussed between FHWA, NIST, and Virginia Transportation Research Council.

Editor's Comment

The original intent of asking the authors to write an article was to answer the question—"Can unbonded neoprene caps be used to test high strength concrete?" The authors' results seem to indicate that the answer is Yes. However, the qualification procedure of ASTM C 1231 is based on the assumption that cylinders tested with ground or capped ends provide a "true" measure of the cylinder strengths. As indicated by the test results in the original article, this may not always be the case, even though all appropriate procedures were apparently followed.

The ASTM qualification procedure is silent on what to do when the strengths of the cylinders with unbonded caps are substantially higher than the strengths of cylinders with ground or capped ends. Since the industry is now capable of producing concrete strengths well in excess of the 12,000 psi (85 MPa) used in the authors' tests, there is a need for both unbonded caps and capping materials that can be used for concrete cylinder strengths above 12,000 psi (85 MPa). At the same time, a national research program is needed to answer the questions raised in this discussion so that the cylinder test can continue to be used with confidence for high strength concrete.

References

1. Carino, N. J., Guthrie, W. F., and Lagergren, E. S., "Effects of Testing Variables on the Measured Compressive Strength of High-Strength Concrete," NISTIR 5405, NIST, October 1994.
2. Lobo, C. L., Mullings, G. M., and Gaynor, R. D., "Effect of Capping Materials and Procedures on the Measured Compressive Strength of High-Strength Concrete," Cement, Concrete, and Aggregates, Vol. 16, No. 2, Dec. 1994, pp. 173-180.
3. Burg, R. G., Caldarone, M. A., Detwiler, G., Jansen, D. C., and Willems, T. J., "Compressive Testing of HSC: Latest Technology," Concrete International, Vol. 21, No. 8, August 1999, pp. 67-76.

More Information

More information about the use of neoprene caps is contained in the following references:

Carrasquillo, P. M. and Carrasquillo R. L., "Effect of Using Unbonded Capping Systems on the Compressive Strength of Concrete Cylinders" ACI Materials Journal, Vol. 85, No. 3, May-June, 1988.

Richardson D. N., "Testing Variables Effects on the Comparison of Neoprene Pad and Sulfur Mortar-Capped Concrete Test Cylinders," ACI Materials Journal, Vol. 87, No. 5, September-October, 1990.

BENEFITS OF SILICA FUME IN HPC

Terence C. Holland, Silica Fume Association

Many designers still look at silica fume as though it were a new material. Silica fume is not new any longer—it has been used in concrete since the 1950s in Norway and since the mid 1970s in the USA. During its introduction in the USA, silica fume was heavily marketed for durability applications. This was, perhaps, the beginning of the era of HPC. Today, the use of silica fume is specified by several state transportation agencies while others have yet to try the material. This article provides a brief summary of how this concrete ingredient is used and its contribution to HPC.

Silica Fume

Silica fume is a highly reactive material that is used in relatively small amounts to enhance the properties of fresh and hardened concrete. Silica fume is a by-product of producing certain metals in electric furnaces. The benefits of adding silica fume are achieved by changes in the microstructure of the concrete. These changes result from two different but equally important processes. The first of these is the physical contribution of silica fume and the second is its chemical contribution.

Physical contribution—Adding silica fume brings millions of very small particles to a concrete mixture. Just like fine aggregate fills in the spaces between coarse aggregate particles, silica fume fills in the spaces between cement grains. This phenomenon is frequently referred to as particle packing or micro filling. Even if silica fume did not react chemically, the micro-filler effect would bring about significant improvements in the nature of the concrete.

Chemical contribution—Because of its very high silicon dioxide content, silica fume is a very reactive material in concrete. As the portland cement in concrete reacts chemically, it releases calcium hydroxide. The silica fume reacts with the calcium hydroxide to form additional binder material, which is very similar to that formed from the portland cement.

The use of silica fume in concrete did not become widely used until the development of high-range water-reducing admixtures or superplasticizers. When used in bridge girders or bridge decks, the amount of silica fume usually ranges from 5 to 10 percent of the total cementitious materials. Silica fume is used to increase mechanical properties, improve durability, and enhance constructibility. Designers and builders of HPC bridges can take advantage of all three of these contributions.

Increase Mechanical Properties

Silica fume gained initial attention in the concrete industry because of its ability to create concrete with very high compressive strengths. Improvements in other mechanical properties, such as modulus of elasticity or flexural strength, are also achieved. The increased compressive strength of silica fume concrete was initially put to use in columns of high-rise structures. More recently, silica fume has been used to produce high strength concrete bridge girders. Using silica fume in HPC will typically allow a reduction in the total amount of cementitious material. This can reduce the maximum temperature reached in a girder during production.

Improve Durability

Although the use of silica fume to produce very high strength concretes has gained a lot of attention, a much larger amount of silica fume is used in applications where durability rather than strength is the primary concern. For most durability applications, the contribution of silica fume is to reduce the permeability of the concrete. Reducing permeability simply extends the time that it takes for any aggressive chemical to penetrate the concrete to a level where it can cause damage.

By far the largest amount of silica fume used for durability has been in structures exposed to chlorides such as bridge decks, marine structures, and parking structures. When using silica fume in HPC bridge decks, it is important to remember that the property of interest is a reduction in permeability. While the strength of this concrete will be increased over that typically used in such an application, it is not practical to try to achieve savings in deck thickness by taking advantage of this increased strength.

Enhance Contructibility

A final contribution of silica fume concrete is its enhancements to constructibility. Here are three examples:

1. Silica fume concrete does not bleed. This property means that there are no capillary channels left after the bleed water evaporates. It also allows for earlier finishing and curing. The downside of the lack of bleeding is the need for protection against plastic shrinkage cracking during placing and finishing.

2. Fresh silica fume concrete is very cohesive. This property is used in shotcrete applications for both repair and new construction. The increased cohesion allows for higher lift thickness and causes significantly less rebound.

3. Silica fume enhances the use of other cementitious materials. Fly ash and ground granulated blast-furnace slag are being used in increasing amounts in all types of concrete. Although the use of these materials can provide excellent long-term concrete performance, their use may not provide the early age properties that a contractor requires to complete a project in a timely fashion. Combining silica fume, portland cement, and fly ash or slag can provide both the early and long-term properties that are required by the designer and the contractor.

Silica fume is not for all concrete. However, in the correct application and when used properly, silica fume can provide concrete with performance levels that are difficult or impossible to achieve with other materials.

Further Information

The information in this article is taken from the Silica Fume User's Manual, currently being prepared by the SFA. For further information about silica fume and availability of the manual, go to www.silicafume.org.

Editor's Note

This article is the first in a series that addresses the benefits of specific materials used in HPC.

Q&A

Question:

What is Reactive Powder Concrete?

Answer:

Reactive Powder Concrete is a high strength ductile material formulated from a special combination of constituent materials. These materials include portland cement, silica fume, quartz flour, fine silica sand, high-range water-reducer, water, and steel or organic fibers. The technology of the material is covered by one of many patents in a range known as Ultra-High-Performance Concretes, all under the trademark—Ductal®.

This new family of materials has compressive strengths of 25,000 to 33,000 psi (170 to 230 MPa) and flexural strengths of 4000 to 7000 psi (30 to 50 MPa), depending on the type of fibers used. The ductile behavior of this material is a first for concrete. The material has a capacity to deform and support flexural and tensile loads, even after initial cracking. These performances are the result of improved micro-structural properties of the mineral matrix—especially toughness—and the control of the bond between the matrix and the fiber.

The durability properties are those of an impermeable material. There is almost no carbonation or penetration of chlorides and sulfates, and high resistance to acid attack. Resistance to abrasion is similar to that of rock. The superior durability characteristics are due to the low and disconnected pore structure, which is generated as a result of the use of a combination of fine powder materials (maximum grain size of 600 microns), selected for their relative grain size and chemical reactivity. The net effect is a maximum compactness and a small disconnected pore structure.

There is almost no shrinkage or creep, which makes the material very suitable for applications in prestressed concrete. The use of this material for construction is simplified through the elimination of reinforcing steel and the ability of the material to be virtually self-placing or dry-cast. It can be produced with customary industrial tools by casting, injection, or extrusion.

Due to the use of powder-like components and the fluidity, the material has the ability to replicate the macro- and micro-texture of the formwork. The result is a final product that can have a full range of colors and textures with a high quality surface.

Applications with Ductal® use less materials; are lighter in weight; more elegant; easier, faster, and safer to construct; lower in maintenance; and have a longer life than conventional materials. This new technology is consistent with the construction trends and demands for reducing labor, materials, construction time, and environmental impact, while increasing safety, security, durability, and the service life.

The first bridge project using this material was a pedestrian bridge in Sherbrooke, Quebec, Canada, constructed in 1997. The bridge was manufactured in a precast operation in six segments each 33 feet (10 m) long, transported to the site, and post-tensioned together. The bridge is a 3-D space truss with a clear span of 198 ft (60 m) and a top deck 1.25 in. (30 mm) thick. Currently under construction in Seoul, Korea, is a pedestrian bridge with a clear span of 390 ft (120 m) and a structural depth of 3.6 ft (1.1 m) using a modified double bulb-tee with a deck thickness of 1.25 in. (30 mm). Several other bridge projects are presently under development in North America, Europe, Australia, and Asia.

Answer contributed by Vic Perry of Lafarge Group, France. He may be contacted at vic.perry@lafarge.com.

WEB SITES

The National Concrete Bridge Council (NCBC) web site is at www.nationalconcretebridge.org.

The Federal Highway Administration HPC web site is at http://hpc.fhwa.dot.gov

HPC Bridge Views is published jointly by the Federal Highway Administration and the National Concrete Bridge Council. Previous issues can be viewed and downloaded at http://www.portcement.org/br/newsletters.asp.

For a free subscription to this newsletter, change of address, or copies of previous issues, contact NCBC at 5420 Old Orchard Road, Skokie, IL 60077-1083; 847-966-6200; (fax) 847-966-9781; email: ncbc@portcement.org.

For further information on High Performance Concrete, contact:

FHWA Headquarters: Terry D. Halkyard, 202-366-6765; (fax) 202-366-3077; e-mail: terry.halkyard@fhwa.dot.gov

AASHTO Subcommittees on -

Bridges and Structures: Richard L. Wilkison, 512-416-2276; (fax) 512-416-2557; e-mail: rwilkiso@dot.state.tx.us

Materials: John B. Volker, 608-246-7930; (fax) 608-246-4669; e-mail: john.volker@dot.state.wi.us

Construction: Gene R. Wortham, 208-334-8426; (fax) 208-334-4440; e-mail: gwortham@itd.state.id.us

NCBC: Basile G. Rabbat, PCA, 847-966-6200; (fax) 847-966-9781; e-mail: brabbat@portcement.org