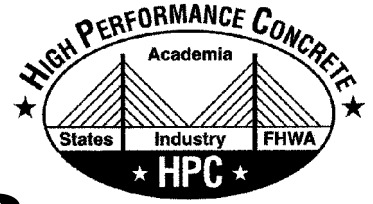




# Bridge Views



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

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## HPC BRIDGES FOR THE 21<sup>ST</sup> CENTURY

John M. Hooks, Federal Highway Administration

**B**ridge engineers across the country are working with new, innovative uses for high performance concrete (HPC). Whether it is durable bridge decks, optimized girder cross sections, or creative admixtures for overlays, HPC is increasingly the material of choice for bridge construction, renovation, and repair. In an effort to encourage innovative uses of HPC in bridges, the Federal Highway Administration (FHWA) has an incentive for State, county, and local bridge owners to use HPC—and other high performance material technology—as they build and maintain bridges and other highway structures.

### The FHWA Innovative Bridge Research and Construction Program

The 1998 Transportation Equity Act for the 21st Century (TEA-21), through the Technology Deployment Program [sec. 5103], launched the Innovative Bridge Research and Construction Program (IBRC). The FHWA's strategic goals promote mobility, increased productivity, and enhanced safety. The IBRC supports these goals by championing high-performance materials that reduce bridge maintenance and life-cycle costs and by encouraging construction techniques that decrease traffic congestion and enhance driver safety.

Currently in the second year of a six-year program, the IBRC encourages the use of high performance materials and technology transfer through grants to State Departments of Transportation (DOTs) for specific repair, rehabilitation, and construction projects. Grants can be made for the entire scope of the innovation process, including engineering, repair or construction, and post-construction monitoring and evaluation. Total funding for construction is \$102 million over six years.

### IBRC Promotes Research on Innovative HPC Applications

The Illinois DOT (IDOT), in cooperation with the City of Chicago, has an IBRC grant to research

and evaluate the concrete mix for 1,100 HPC segmental, post-tensioned deck panels to replace the existing superstructure for almost a mile-long section of Wacker Drive in one construction season. Wacker Drive, a two-level roadway structure, is one of the main access routes within downtown Chicago.

According to IDOT's John Morris, "This is an unusual project because it will use a type of construction for the superstructure that has not been used before. Our decision to use HPC is based on service life and durability. We need a structure with a 75- to 100-year life that can withstand Chicago weather, de-icing agents, abrasive materials, and the pounding of more than 30,000 vehicles daily. HPC meets those criteria in that it is resistant to chlorides and less prone to shrinkage and cracking."

### Partnerships Leading to Innovative HPC Designs

Virginia DOT (VDOT) is aggressively using HPC for bridge structures with 62 HPC projects built, under construction, or under design. One of the tenets of the IBRC is the incentive to work closely with public and private transportation partners to build better bridges. VDOT, as a member of the Mid-Atlantic Prestressed Concrete Economical Fabrication (PCEF) committee, is working with other State DOTs, FHWA, industry, and private consultants to develop new prestressed concrete bulb-tee bridge girder standards.

VDOT's Malcolm Kerley could be speaking for bridge engineers across the Nation when he notes that, "HPC is giving us new options for building stronger, longer lasting, more cost-effective, safer bridges. The IBRC program has helped us research new applications, and what we have is a new recognition of the kinds of things we should be doing with HPC."

### Further Information

For further information on IBRC, visit the web site at <http://ibrc.fhwa.dot.gov>, or call John Hooks at 202-366-6712.

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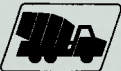
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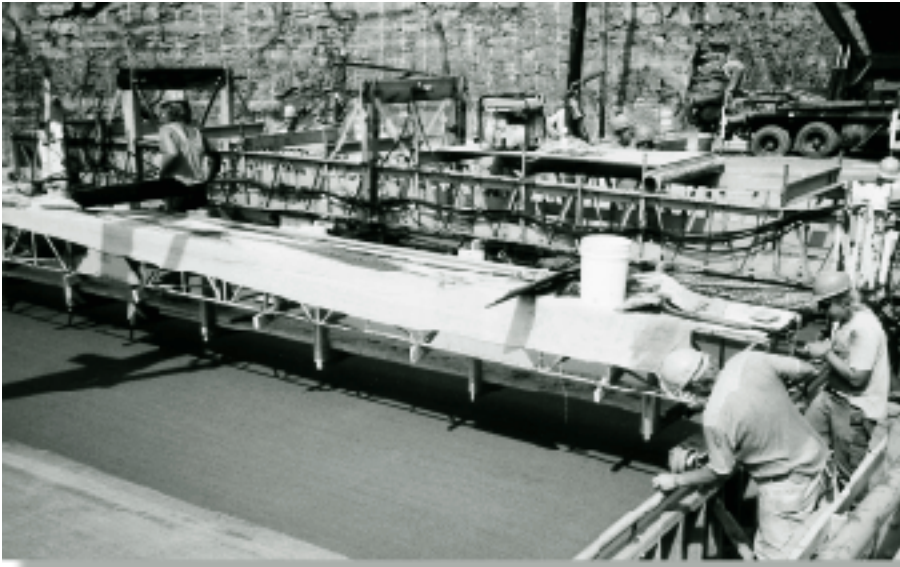
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*Minimizing the time between concrete placement and curing is essential in bridge deck construction.*

## **HPC IN NEW YORK STATE BRIDGE DECKS**

*Donald A. Streeter, New York State Department of Transportation*

**T**he New York State Department of Transportation (NYSDOT) developed a high performance concrete (HPC) mix in 1994 in an effort to produce longer lasting, more durable bridge decks. Positive results from the initial placements led to the issuance of specifications for use of high performance concrete. The HPC developed by NYSDOT, designated Class HP, was designed to be more durable, less permeable, more resistant to cracking, and easily placed and finished. The changes were achieved by reducing the cement content, mainly by substituting pozzolans, and lowering the water-cementitious material ratio by using normal-range water-reducing admixtures. Over 125 placements have been made on approximately 100 new bridge decks. High performance concrete overlays have been placed on approximately 25 structures either for rehabilitation of the decks or as bonded wearing surfaces. With the establishment of guidelines, substructure use is now growing.

### **Construction**

Attention to detail makes HPC perform much better than conventional concrete. The NYSDOT Materials Bureau has been working with contractors, producers, engineers, and inspectors to ensure quality concrete. Training sessions are used to present highlights of the procedures that

must be followed. This provides all the necessary information to achieve the quality concrete desired prior to any concrete batching or placement.

The control of batching and construction operations is important. Batching HPC is similar to batching conventional concrete. However, the addition of microsilica and water-reducing admixtures must be closely controlled. Cementitious materials are batched within a 1/2 percent tolerance, which is tighter than the 1 percent tolerance used for conventional concretes. Class HP concrete has no bleed water and dries out quickly. Therefore, it is important not to leave the concrete exposed for extended periods. Concrete is only placed 5 to 8 ft (1.5 to 2.4 m) ahead of a properly set-up finishing machine. If there are any delays in placement, all concrete not yet finished or textured is protected from evaporation by either covering with plastic sheeting or wet burlap. If the set-up and finishing are performed properly, the concrete requires no additional handwork. Finishing should not result in a glass-like surface since texturing and saw-cut grooving will be applied to roughen the surface. A turf drag texturing is applied immediately after finishing, with saw-cut grooving applied to the hardened concrete. Continuous curing for seven days using wet burlap is initiated immediately

after texturing is complete. A burlap imprint left on the plastic concrete is of less concern than a delay in the application of curing. In future projects, 14 days of wet curing will be required.

### **Performance**

Performance of Class HP concrete has been very good to date. The average 28-day compressive strength is 5,400 psi (37 MPa), which is an increase of about 20 percent over conventional concretes. Permeabilities in the field average 1600 coulombs at 28 days, which is 30 to 50 percent of the values for conventional concretes. Cracking has been reduced and those cracks that do form are finer than in the past. The concrete has been easy to handle and place in the field provided sufficient water-reducing or set-retarding, water-reducing admixtures are used.

Although most placements have been properly completed, some problems have occurred. Open crack surfaces have resulted when the fresh concrete was exposed to the environment for extended periods of time. This problem becomes worse when the initial slump is low due to a lack of sufficient water-reducing admixtures. In areas where excessive hand finishing has been performed in an attempt to close the surface, scaling has resulted. Occasionally, microsilica balling has occurred, usually associated with a batching problem or improper mixing. Cracking results from a variety of reasons. If there is not sufficient retardation during placement, cracks have developed, primarily on multi-span, continuous structures. Shrinkage cracks occur if curing is delayed. Also, if fresh concrete is placed on existing concrete that is not in a saturated, surface-dry condition, shrinkage occurs. This problem is prevented by placing soaker hoses or sprinklers on the existing concrete for 12 or more hours prior to concrete placement.

### **Summary**

Overall, NYSDOT is pleased with the performance of Class HP concrete. It can be placed and finished easily resulting in an improved concrete that is more durable and less permeable than conventional concretes.

Editor's Note: The next edition of HPC Bridge Views will contain an article quantifying the improved deck performance in New York State.

# COMPRESSION TESTING OF HIGH STRENGTH CONCRETE

Ronald G. Burg, Construction Technology Laboratories, Inc.

**H**igh performance concrete (HPC) used in the construction of a bridge or bridge element often includes high strength concrete (HSC). To date, concrete with design compressive strengths of up to 19,000 psi (131 MPa) have been used in building construction while concrete with design compressive strengths up to 14,700 psi (101 MPa) have been used in bridge construction.

An important aspect in the successful use of high strength concrete is implementing the required quality control measures. For concrete, the most common quality control parameter, and basis for acceptance, is compressive strength. The various AASHTO and ASTM standards that prescribe the methods to cast, cure, prepare, and test concrete specimens were developed based on concretes with compressive strengths in the range of 1500 to 6000 psi (10 to 41 MPa). In the past several years, there has been considerable work done to determine if these standards are suitable for HSC or if modifications are required. However, it often takes several years for existing standards to be revised based on recently completed work. Therefore, this article summarizes some of the important findings from recently completed and on-going work that can be implemented on a project that uses HSC.

## Specimen Size

Because of the high loads required to break cylinders made with HSC, many laboratories and test agencies prefer to use 4x8-in. (102x203-mm) cylinders in lieu of 6x12-in. (152x305-mm) cylinders. With the smaller cylinder, 20,000 psi (138 MPa) concrete can be tested using a 300,000-lb (1.33-MN) machine, whereas a 6x12-in. (152x305-mm) cylinder requires at least a 600,000-lb (2.67-MN) machine. On average, 4x8-in. (102x203-mm) cylinders have measured compressive strengths approximately 2 percent higher than 6x12-in. (152x305-mm) cylinders when testing high strength concrete. Given the small magnitude of this difference, the smaller specimens can be used to judge the acceptance of concrete based on compressive strength. However, due to the greater variability in measured strength exhibited by

the 4x8-in. (152x305-mm) specimens, it may be necessary to test more specimens to obtain a representative value of compressive strength.

## Cylinder Molds

As concrete strength increases, the dimensional consistency of the test specimen, and thus the mold used to cast the specimen, becomes more critical. Although heavy gauge steel molds result in cast specimens that are closer to perfectly round, plastic single-use molds yield cast specimens that do not noticeably affect measured compressive strength. Plastic molds can be used with HSC. However, care must be taken to ensure that the bottom of the mold is not damaged while rodding the fresh concrete, and in no circumstances should single-use plastic molds be reused.

## Cylinder Curing

Most HSC has a high cementitious material content and a low water-cementitious material ratio. Some of these types of concretes are prone to a condition known as self-desiccation whereby the interior of the concrete dries at a more rapid rate than the exterior. Because of this condition, some researchers have suggested that HSC cylinders should be cured underwater rather than in a moist room. However, work on concrete with compressive strengths as high as 18,000 psi (124 MPa) shows that underwater curing is not required for HSC. A conventional moist-curing room meeting the relevant requirements can be used.

## Cylinder Ends

Properly prepared cylinder ends are paramount to obtaining representative compressive strength data. At concrete strengths below 10,000 psi (69 MPa), conventional methods of end preparation, capping with sulfur-based compounds, or the use of pad caps are suitable. At

concrete strengths in excess of 10,000 psi (69 MPa), surface grinding of cylinder ends is the most suitable method. However, if appropriate capping techniques are used, in particular thin caps, it appears that some capping materials may be suitable for testing high strength concrete. Selection of a suitable capping compound cannot be based on the compressive strength of the capping compound. The most direct means to judge the adequacy of a particular capping compound is comparative testing against cylinders with surface-ground ends. Without conducting this type of comparative analysis, capping compounds should only be used on concrete with compressive strengths up to 10,000 psi (69 MPa) and concrete with compressive strengths above 10,000 psi (69 MPa) should be tested using surface-ground ends.

## Summary

All relevant standards should be strictly followed when testing HSC, as any deviation from the prescribed methods will have a significant impact on measured compressive strength.

## Further Information

For further information on compression testing, see: Burg, R. G., Caldarone, M. A., Detwiler, G., Jansen, D. C., and Willems, T. J., "Compression Testing of HSC: Latest Technology," Concrete International, Vol. 21, No. 8, August 1999, pp. 67-76.



Compression testing of high strength concrete requires special care.



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 are the pros and cons of the Rapid Chloride Permeability Test?

**Answer:**

The so called “Rapid Chloride Permeability Test” is being used as a measure of the “permeability” of concrete to chloride ions. The more proper term would be chloride penetration. Many highway agencies have adopted the test and it has been included in HPC bridge specifications. The test was developed in the late 1970’s under an FHWA contract and has been standardized as AASHTO T277 and later as ASTM C 1202. There has been considerable debate regarding appropriate applications and interpretation of test results. Because of this, it is instructive to review the “pros and cons” of this test.

**Pros:**

- The test is rapid and can be completed in two days including specimen preparation. Other permeability tests take weeks or months to complete.
- Equipment for the test can be constructed from relatively simple components and is also commercially available.
- As the test has been in use for approximately 20 years, there is a large database of test results available.
- Though information is limited, the test has been correlated with chloride ponding and other tests of concrete permeability.

**Cons:**

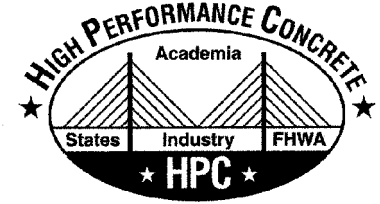
- The test has poor correlation with ponding tests when different mixes are compared.
- The test is not a direct measure of chloride “permeability.” It only measures electrical conductivity of the concrete.
- Chloride ions only carry a small proportion of the current during the test, so the test is not specific to chloride.
- It has been claimed that the test yields erroneous results when applied to silica fume concrete.
- Self-heating of the specimen during the test affects test results.

Space prohibits addressing each pro and con. Most of the “cons” are related to the fact that this is not a direct test of chloride penetration. While this is scientifically correct, the test was developed as an empirical indicator of chloride penetration, not as an exact measure. ASTM C 1202 states: “This test method is applicable to types of concrete where correlations have been established between this test procedure and long-term chloride ponding procedures such as those described in AASHTO T259.” If such correlations have indeed been developed for a given concrete, then the Rapid Chloride Permeability Test can be confidently applied.

*Answer contributed by David A. Whiting of Construction Technology Laboratories, Inc.*

**PUBLICATIONS  
ON HPC**

A catalog of HPC Publications Related to FHWA-Sponsored Bridge Projects is now available at <http://www.tfhrc.gov/structur/hpc/bridgepubs.htm>



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

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