HPC Bridge Views

Issue 47 — January/February 2008

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

CONCRETE REINFORCING STEEL INSTITUTE

EXPANDED SHALE CLAY AND SLATE INSTITUTE

POST-TENSIONING INSTITUTE

WIRE REINFORCEMENT INSTITUTE

SILICA FUME ASSOCIATION

HPC BRIDGE VIEWS GOES ELECTRONIC

Basile G. Rabbat, National Concrete Bridge Council

Welcome to the new HPC Bridge Views. Under a recent cooperative agreement between the Federal Highway Administration and the National Concrete Bridge Council (NCBC), the Council will publish 22 new issues of the HPC Bridge Views newsletter. This activity satisfies a provision of the current highway bill, SAFETEA-LU, concerning the Innovative Bridge Research and Deployment Program. A few goals of this program include (1) the documentation and wide dissemination of objective evaluations of the performance and benefits of innovative designs, materials, and construction methods, and (2) the effective transfer of resulting information and technology.

Since publication of the first issue of HPC Bridge Views in January 1999, the focus of the newsletter has been on bridge design, materials, and construction issues for high performance concrete (HPC) bridges. Under the latest agreement, a new issue of the newsletter will be released bimonthly. The emphasis will be on durability, high strength, lightweight, and self-consolidating concrete. This is in line with FHWA's vision for the Bridge of the Future having attributes of Longer-life using Innovations to accomplish Fast construction of Efficient and safe bridges. It also matches with the goals of NCBC's strategic plan for widespread implementation of HPC for bridges in the United States—Building a New Generation of Bridges available at www.cement.org/hp.

To ensure that all issues reach interested parties in a timely manner, the newsletter will only be published in electronic format. A new, dedicated website, www.hpcbridgeviews.org, houses the e-newsletters. For the readers' convenience, previous issues of HPC Bridge Views are also posted on this new website.

Given that HPC Bridge Views has been around since 1999, has the definition of "High Performance Concrete" (HPC) changed during the last decade? 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. The definition of HPC is as valid today as it was when the first issue of HPC Bridge Views was published in January 1999.

In addition to incorporating ingredients used in conventional concrete, HPC uses additional cementitious materials and admixtures. The proportions are engineered to meet the demands of each project. These demands may be to achieve high early strength, minimize creep and shrinkage effects, control heat of hydration, improve permeability and reduce chloride penetration, reduce density, increase modulus of elasticity, or provide long-service life.

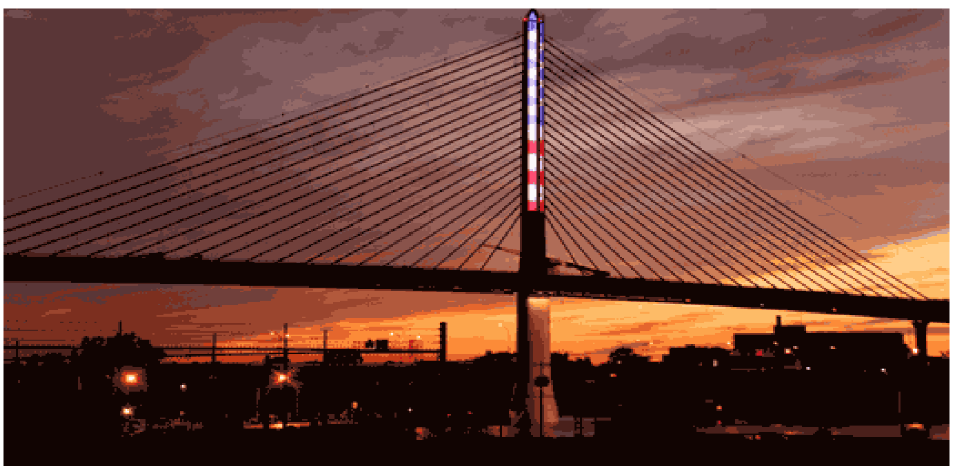
During the last decade, almost all states have implemented HPC in one form or another, on one or more bridges. Several states have developed HPC standards, which are routinely specified for construction of HPC bridges. Other states continue to improve their concrete mixes and construction practices. HPC Bridge Views is designed to keep all stakeholders abreast of the latest information on HPC and provide resources to acquire more detailed information. This includes research findings, construction practices, and technology deployment.

The first 46 issues of HPC Bridge Views have included over 180 articles covering the full spectrum of applications of HPC to bridge superstructures and substructures: mix design, test procedures for improved quality control, construction practices, and bridge design. The new HPC Bridge Views will continue to serve as a vehicle to share success stories and lessons learned to help improve the condition of our nation's bridges.

We are delighted that Dr. Henry G. Russell will continue to be Editor of HPC Bridge Views. Henry has maintained a high level of technical and editorial excellence starting with the first issue. We appreciate his thorough professionalism.

Veterans' Glass City Skyway—10,000 psi Mass Concrete

Jeff E. Baker, Ohio Department of Transportation and Wade S. Bonzon, FIGG Bridge Inspection, Inc.



The pylon of the Veteran's Class City Skway used 10,000 psi (69 Mpa) mass concrete.

The new I-280 Veterans' Glass City Skyway, recently completed in Toledo, Ohio, is the centerpiece of the largest single project ever undertaken by the Ohio Department of Transportation (ODOT). This cable-stayed river crossing features a single 435-ft (133-m) tall concrete pylon supporting a 1525-ft (465-m) long main span structure using a single plane of stay cables. The main span unit is designed to carry three 12-ft (3.7-m) wide lanes of highway traffic with two 10-ft (3.0-m) wide shoulders in each direction.

A minimum concrete compressive strength of 10,000 psi (69 MPa) was required for the pylon to support the dead and live loads for the main span unit and to resist significant lateral wind and ship impact loads.

The pylon is divided into two areas of radically different cross sections. The portion below the deck is considered the lower pylon. The upper pylon above the roadway has a unique cruciform-shaped cross-section that features glass panels on four sides, which are lit with variable-color LED lights at night to celebrate the City of Toledo's long heritage in the glass-making industry.

Specification Requirements

The project's special provisions governing mass concrete required curing temperatures to be monitored with redundant embedded thermocouples located 2 in. (50 mm) from the concrete surface as well as at the center of mass of each pylon lift. The provisions also required the contractor to prevent the maximum curing temperature from exceeding 160°F (71°C).

In addition, maximum allowable thermal gradients were established that increased as concrete gained strength providing greater capacity to resist the tensile stresses without cracking. The maximum thermal gradients at up to 2 days were 40°F (22°C). At both 7 and 14 days, they were increased by 10°F (6°C).

Mix Designs

The Contractor selected concrete mix designs within the allowable parameters set forth by the project's special provisions. The portions of the pylon above the footing were required to reach a minimum compressive strength of 10,000 psi (69 MPa) at 56 days.

For the mix, 50 percent of the cementitious materials was ground-granulated blast-furnace slag (GGBFS). Slag cement cures more slowly than portland cement, effectively delaying and reducing the maximum temperatures gained during the curing process. It also provided lower permeability and a lighter concrete color.

The table above lists the concrete mix proportions as 410 lb of Type I cement, 410 lb of GGBFS, 1150 lb of fine aggregate, 1660 lb of coarse aggregate, 262 lb of water, 2 fl oz of air entrainment, and 12.3 fl oz of water-reducing admixture for a water-cementitious materials ratio of 0.32.

HPC Mix Proportions

Materials	Quantities (per yd^3)	Quantities (per m^3)
Cement, Type I	410 lb	243 kg
GGBFS	410 lb	243 kg
Fine Aggregate	1150lb	682 kg
Coarse Aggregate	1660 lb	985 kg
Water	262 lb	155 kg
Air Entrainment	2 fl oz	77 mL
Water-Reducing Admixture	12.3 fl oz	476 mL
w/cm ratio	0.32	0.32

Lower Pylon Lifts

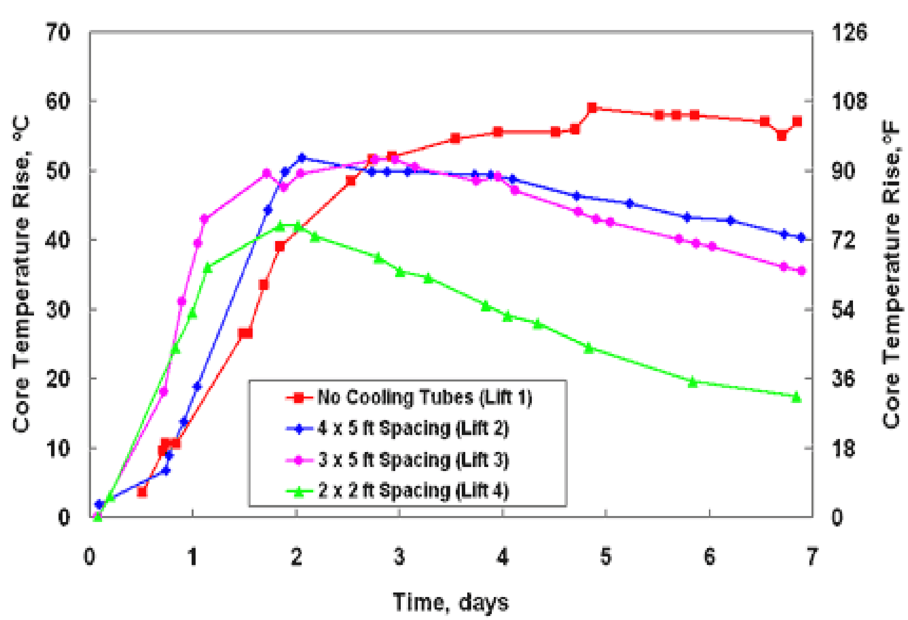
The lower pylon was divided into 10 lifts with heights ranging from 13 to 18 ft (4.0 to 5.5 m). The two lifts with the largest cross-sectional areas at the base of the pylon contained concrete volumes as large as 680 cu yd (520 cu m).

The contractor utilized a finite element program to predict the curing temperatures in the lower pylon lifts. ODOT's engineer used a 2-D Schmidt model. The higher temperatures predicted by the Schmidt model closely matched the measured temperatures when they were adjusted for the actual concrete temperatures at the time of placement.

The 10 lifts of the lower pylon were placed primarily during the summer months, which made control of the initial concrete temperature more difficult, but reduced thermal gradients between the core and the surface. Still, one or two layers of insulating blankets and/or foam insulation were used to cover the tops and sides of the lifts, where necessary, to limit the thermal gradient.

Concrete is a very good insulator and has a large thermal mass, which makes it difficult to transfer heat from the core to the outside. By reducing the concrete's temperature at the time of placement, the peak temperature can be reduced by nearly the same amount. It was necessary to cool the aggregate and use ice to keep the initial concrete temperature below 60°F (16°C) and to maintain core temperatures below the specified maximum value.

After the first lift, it was apparent that post-placement cooling would be necessary to supplement the efforts to cool the concrete during batching. The contractor cooled the concrete using river water pumped through a



network of pipes. The piping system was made up of 1-in. (25-mm) diameter polyethylene tubes arranged horizontally in layers throughout the volume of each lift. The volume of water flowing through each row of this grid could be manually controlled using a system of valves. After the cooling tubes were no longer needed, they were blown out and filled with high strength, non-shrink grout.

The relative effectiveness of the various cooling tube layouts is illustrated in the chart. It is readily apparent that the cooling tubes were more effective in reducing the temperature rise in the core as the grid spacing decreased. This allowed the contractor to begin the next lift cycle sooner. In addition, cooling the core helped to minimize the thermal gradients.

The heat transfer through the polyethylene pipe wall was relatively inefficient. The thermal mass of the concrete was too great for the cooling water to affect curing temperatures quickly. The cooling water was most effective in reducing peak temperatures when it was kept flowing constantly throughout the curing period through all portions of the lift.

Upper Pylon Lifts

In many ways, the mass concrete lifts of the upper portion of the main pylon above the bridge deck level differed significantly from the lower pylon lifts. The volumes of these lifts were much smaller, ranging from 113 to 40 cu yd (86 to 31 cu m). For the upper 28 lifts, the typical lift height of 9 ft (2.7 m) was substantially less than the lift heights of the lower pylon.

Due to the cold weather and large surface area, insulating the formwork and concrete surface was critical. The contractor installed a wind-resistant full enclosure surrounding both the most recently placed and previously cast lifts and added propane heaters. Thermal blankets were placed over the tops of the forms and reinforcement for the next lift to create a heated air space above the top surface of the concrete.

The core of the cruciform cross-section near the centerline of the pylon was still large enough to behave as mass concrete with additional concerns for thermal gradients between the hot core and the relatively thinner and cooler "arms" of the cruciform. For these reasons, cooling tubes were concentrated in a tight spiral pattern near the pylon centerline.

The tubes were used to circulate cooling water through the upper pylon lifts during both the summer and winter months. As the pylon became taller, the contractor's pumps could not maintain flow by drawing water directly from the river. Cooling water was then recirculated through a large holding tank placed on a diaphragm inside the pylon.

Mass Concrete and the Benicia-Martinez Bridge

Ric Maggenti and Bob Brignano, California Department of Transportation

Crossing the east end of the Carquinez Strait at the confluence of the Sacramento and San Joaquin Rivers just prior to entering the San Francisco Bay, stands a new 1.4-mile (2.2-km) long Benicia-Martinez Bridge on the lifeline Route 680 in Solano and Contra Costa counties. The bridge has 335 cast-in-place, lightweight concrete, single cell, box girder segments with spans up to 660 ft (200 m) between 11 piers, 10 of them rising out of the waterway. The specified compressive strength for the lightweight concrete was 6500 psi (45 MPa) at 28 days. The bridge is built to withstand any maximum credible earthquake generated from major faults running through the region. The bridge is 82 ft (25 m) wide, accommodating five lanes of traffic and is engineered for future light rail.

Over 100 piles with diameters of 8.2 to 9.1 ft (2.5 to 2.8 m), the massive pier footings, pier walls and columns, and pier tables and diaphragms were cast-in-place normal weight, high performance concrete (HPC). Most of these HPC elements are greater than 6.6 ft (2 m) thick and were treated as mass concrete with thermal control measures being necessary. However, the high-strength lightweight HPC with its lower mass but much higher cementitious materials content resulted in much thinner elements needing thermal control.

The mass concrete temperature control measures were both passive and active. The main passive control measure consisted of lowering the initial concrete temperatures prior to placement although fly ash and coarse grind cement were also used. The former was achieved with the use of chilled batch water, ice replacement of batch water, and liquid nitrogen injection as necessary. Active control was achieved by casting polyvinyl chloride pipes in the concrete elements. During the setting and hardening of the concrete, cold water pumped from the strait was circulated through the network of piping to remove the heat generated by hydration of the cement.

There were over 200 mass concrete placements with normal weight HPC. The measured temperature exceeded the specified maximum of 160°F (71°C) on only two placements. All but a few placements used 3/4-in. (19-mm) diameter cooling pipes spaced at 2 to 5 ft (0.6 to 1.5 m) apart. The normal weight concrete cementitious materials content ranged from 615 to 800 lb/cu yd (365 to 475 kg/cu m). The highest recorded temperature was 165°F (74°C) in a 9.2-ft (2.8-m) diameter pile with a concrete having a cementitious materials content of 792 lb/cu yd (470 kg/cu m) and no cooling pipes.

The 335 single-cell box girder segments, nine hinge segments with large diaphragms, nine mid-span closures, a two-span section cast on falsework, and various secondary concrete placements were all cast with lightweight HPC. With a cementitious materials content of 980 lb/cu yd (581 kg/cu m) coupled with a low fly ash percentage of 5 percent and metakaolin at 10 percent, the mix generated more heat than any of the normal weight HPC. Thermal control measures were implemented to limit peak temperatures to 160°F (71°C).

For the lightweight HPC, pre-cooling with ice and liquid nitrogen was necessary for most of the concrete and cooling pipes were necessary for many elements. Thin elements that are not normally considered mass concrete can still reach an undesirable peak temperature if enough heat is generated and it cannot dissipate fast enough to the nearby surfaces. Cooling pipes were used in the thin elements cast with lightweight HPC, with the cooling pipe spacing ranging from 6 to 18 in. (0.15 to 0.46 m)—much less than for the normal weight concrete elements.

Besides the heat generated from the high cementitious materials content, the temperature rise was also higher. The red and blue curves in Fig. 1 show the different peak temperatures of lightweight concrete and normal weight concrete, respectively for 3 ft (1 m) test blocks. The concrete blocks differ only in the type of coarse aggregate. Both blocks have the same cementitious materials content generating the same heat rates in the same environment, but the lesser mass block rises to a higher temperature with mass being the only difference between the blocks. For comparison, the green curve shows the behavior of a large, low-heat generating element cast with normal weight HPC.

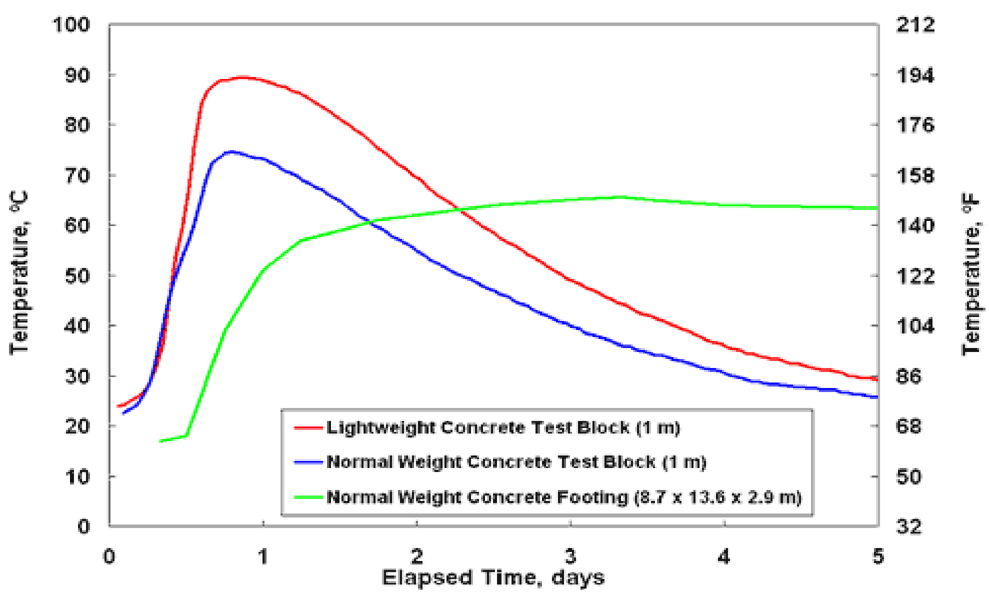


Fig. 1. Comparison of concrete temperatures.

Though only segment elements 3.3-ft (1-m) thick or more were initially thought to need thermal control, after the first few placements and thermal analysis it was concluded that all lightweight concrete elements needed thermal control. This included the 1.8-ft (0.55-m) thick stems and deck elements as thin as 0.92 ft (0.28 m). Overall for the job, thermal control went well. Most of the elements where the temperature exceeded the 160°F (71°C) limit occurred during the first placements as the properties and thermal control procedures for this high strength lightweight concrete mix design were being developed. In fact, 15 of the first 20 segments cast had elements with measured temperatures greater than 160°F (71°C) with four of these exceeding 176°F (80°C).

The highest temperature recorded was 196°F (91°C) in a lightweight concrete segment soffit where only the passive method was used. However after casting these first 20 segments, the measured temperature rarely exceeded 160°F (71°C), while most elements were kept below 131°F (55°C). The frequency curve of peak temperatures of stems, soffits, and decks is shown in Figure 2. Note the higher temperatures of the deck elements although these are the thinnest sections. This is because cooling pipes were not used as often in the deck elements, and most of the peak temperatures were recorded in areas without active thermal control measures. In contrast, only the first 17 of the 335 stem pairs did not have cooling pipes and cooling pipes were not used in about half of the soffits, with those being at the thinnest locations.

With many factors influencing the characteristics and measures to cope with the heat of mass concrete, ACI Committee 207—Mass Concrete was set up in 1930 to gather information on theory and practice regarding construction of large concrete dams. Since then, the theory and practice of mass concrete has come to apply to much smaller concrete elements made with HPC. Experiences on the Benicia-Martinez have demonstrated the importance of measuring the heat characteristics of the concrete prior to casting the actual structure and using demonstration placements to verify the thermal analysis and proposed concrete temperature control procedures.

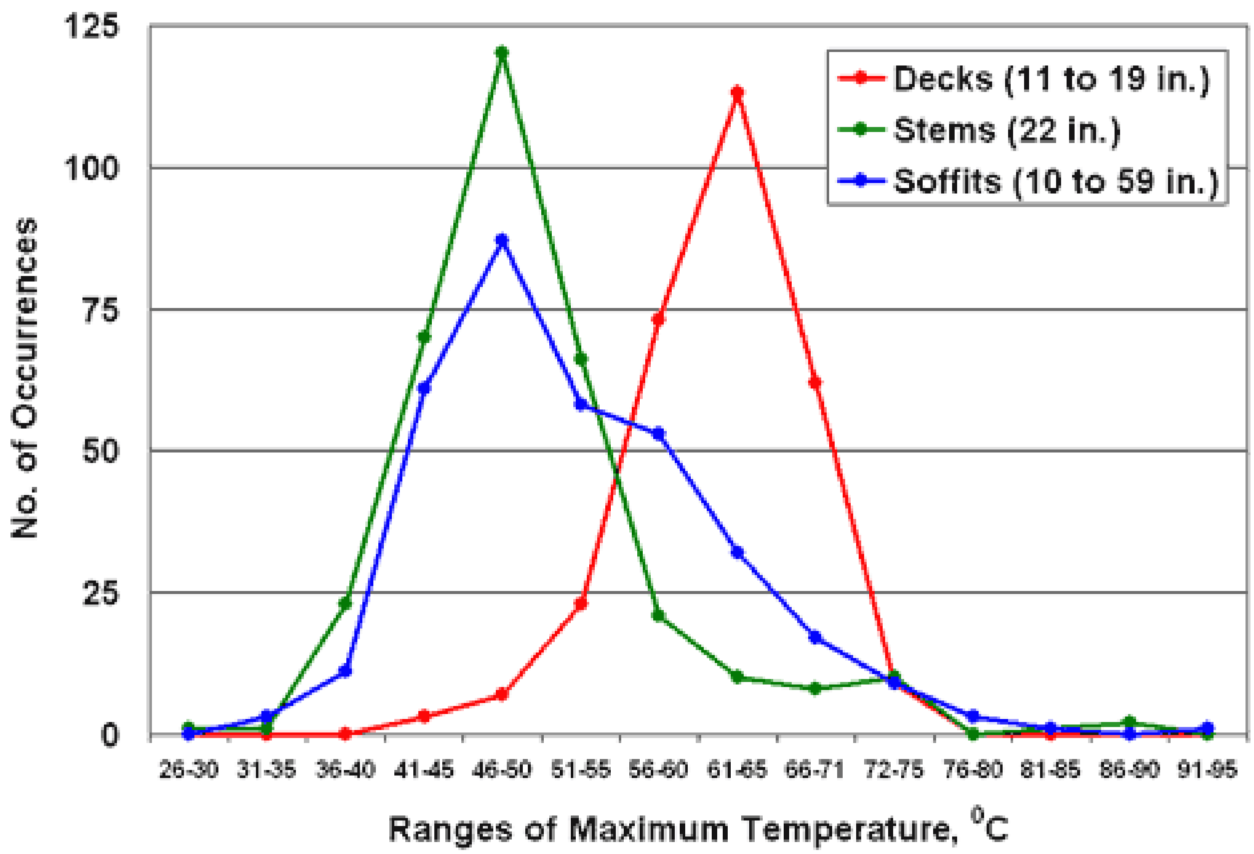


Fig. 2. Frequency of peak temperatures.

Thermal Issues in High Performance Concrete

John Gajda, CTLGroup

High performance concrete (HPC) is routinely used in all elements of bridge construction from the foundations to the wearing surface. HPC is utilized for various reasons, including the need for high early strength, low permeability, and ease of placement. In most cases, the cementitious materials content in HPC mixes is high. This can result in thermal issues in relatively thin sections, including excessively high internal temperatures and thermal cracking. These are the same issues that are commonly found in mass concrete placements.

Consider the segmental cast-in-place superstructure of the recently completed Benicia–Martinez Bridge described in the previous article. The lightweight HPC mix in the superstructure was designed to achieve a rapid strength gain and meet stringent modulus of elasticity and density requirements. The mix contained approximately 980 lb/cu yd (581 kg/cu m) of cementitious materials. Thermal issues were anticipated in the 40-in. (1.00-m) thick bottom slabs, so these portions were treated as mass concrete and temperatures were measured and tightly controlled. However, after temperatures exceeding 190°F (88°C) were measured in some of the 22-in. (560-mm) thick portions, the entire superstructure was treated as mass concrete. As a result, the concrete was precooled and cooling pipes were installed in portions as thin as about 16-in. to limit the maximum temperature. Temperature differences were also controlled to minimize thermal cracking. While this could be considered an extreme example, it is not all that extreme considering the typical high cementitious materials content of mixes used for high early strengths in segmental construction or for durability in corrosive environments.

Thermal issues result from hydration of the cementitious materials. In most placements, the heat escapes almost as rapidly as it is generated. In thick placements or placements with concrete having a very high cementitious materials content, heat is generated more quickly than it can escape. This results in high internal temperatures within the concrete. The segmental mix used for the Benicia – Martinez Bridge had an adiabatic temperature rise (a measure of the overall heat energy in the concrete) of nearly 150°F (66°C). The temperature rise in the 22-in. (560-mm) thick portions was 117°F (47°C), illustrating how much heat can build up before it escapes.

Maximum Concrete Temperature

Experience has shown that when the internal temperature exceeds 158°F (70°C) during curing, the long-term durability of some concretes can be affected by delayed ettringite formation (DEF). Although DEF is rare and only certain concretes can be affected, it has been identified in bridges and other structures in the United States. When DEF occurs, the concrete paste expands and cracks the concrete with detrimental results. This may not be evident for many years.

Temperature Difference

While the interior of a concrete placement can be quite hot, its surface can be relatively cool. The resulting large temperature difference between the surface and the interior produces large thermal stresses. These stresses add to other stresses such as those from drying shrinkage. Cracking occurs when the stresses exceed the in-place tensile strength of the concrete. This can occur if inadequate measures are used to control the temperature difference, or when these measures are discontinued too soon—before the interior concrete has adequately cooled. Historically, limiting the temperature difference between the interior and surface to less than 35°F (19°C) has been found to prevent or minimize thermal cracking. Certain concretes are more tolerant of thermal cracking than others, and can withstand a higher temperature difference without thermally cracking.

In extreme cases, thermal cracking can be a structural concern; however, in most cases, thermal cracking is a durability issue. When HPC is used for durability, thermal cracking “short circuits” the benefits of the low permeability concrete by providing convenient paths for corrosive agents to readily reach the reinforcing steel.

Recommendations

To minimize or reduce thermal issues, the following guidelines are recommended:

1. Use a reduced-heat concrete mix, with as low a total cementitious materials content as reasonably practical.
   - If low permeability is desired, increase the percentage of fly ash, silica fume, metakaolin, slag cement, or other supplementary cementitious material.
   - If high early strength is required, consider the use of an accelerator to achieve the high early strength. This will help achieve early strength without greatly exceeding the design strength requirement. Consider the use of silica fume or metakaolin to increase the early age strength. Also, consider the use of maturity or temperature-matched curing to accurately determine the in-place strength. In placements that get hot, the in-place strength develops more rapidly than that of cylinders cured at lower temperatures.
2. Limit the maximum temperature in the concrete to 158°F (70°C) by using a reduced-heat concrete mix design (the preferred approach), precooling the concrete, and/or using internal cooling pipes.
3. Limit the temperature difference to prevent thermal cracking through the use of insulation. Curing methods that artificially cool the concrete should be avoided. The temperature difference must be controlled until the concrete adequately cools to prevent thermal shock. The cooling time depends on the concrete mix and member thickness, and may extend well beyond the normal curing period.

In summary, thermal issues are a concern for HPC placements. If not properly managed during construction, thermal issues can reduce the service life of the concrete. Management of thermal issues can impact construction costs and schedules. These impacts can be minimized or even eliminated with proper planning and the use of an appropriate HPC mix. Consideration of thermal issues is the first step in this process.

More Information

For more information about mass concrete, see PCA Publication EB 547 titled "Mass Concrete for Buildings and Bridges."

Mass Concrete Provisions in Texas

Kevin R. Pruski and Ralph Browne, Texas Department of Transportation

Over the past 30 years, the Texas Department of Transportation (TxDOT) has transitioned from building bridges supported by multi-column piers to using single column piers for many bridges built in urban locations. This minimizes site restrictions, enhances aesthetics, and improves the hydraulic function. Thus, the use of more massive concrete members, required to accommodate the single pier approach, became mainstream. With this trend, construction practices required modification to ensure quality concrete construction.

Mass Concrete Challenge

The push for accelerated construction combined with large members brought new challenges. Because of specification changes, Type I or Type I/II cement began to behave more like Type III cement with respect to rate of strength gain, set time, and heat of hydration. Also, contractors began providing higher strength concrete to reduce formwork cycling times and to ensure that specified strengths were exceeded. The faster strength gain and the higher strength concrete placed in large members resulted in higher heat of hydration leading to higher concrete temperatures. This resulted in observed thermal cracking. At least one structure showed signs of possible delayed ettringite formation distress.

Specifications

It became clear to TxDOT that mass concrete placement controls were practically ineffective and needed modification. Prior to the current TxDOT standard specification, mass concrete members were not specifically identified on the plans or differentiated from other similar structural concrete that did not meet the mass concrete parameters. Now, TxDOT specifically identifies members requiring mass concrete temperature controls in the plans as well as differentiates the mass concrete as a separate bid item to allow the contractor to capture the costs.

The specifications require any concrete member with a least dimension of 5 ft (1.5 m) or more to comply with the mass concrete requirements. A plan must be submitted showing that the temperature differential between the core and the surface will not exceed 35°F (19°C) and the maximum core temperature will not exceed 160°F (71°C). In addition, the concrete temperature at start of a placement must not exceed 75°F (24°C) and all formwork must remain in place for a minimum of 4 days.

Field instrumentation, consisting of two recording temperature probes, is required for all designated mass concrete members to verify that the proposed plan adequately complies with the temperature limits. Also, understrength concrete penalties were adjusted to a less punitive, more logical assessment of actual damage and financial impact to TxDOT. The intention was to eliminate the industry practice of adding an extra quantity of cement to avoid the potential penalties.

Implementation

Calculating thermal rise and temperature differentials in concrete members is not a simple matter. It was soon discovered that the method outlined in ACI 207 overwhelmed the construction personnel. TxDOT worked with the University of Texas in Austin to develop a computer-based method that would simplify this issue substantially. The endeavor resulted in a computer program named ConcreteWorks, which may be downloaded from www.texasconcreteworks.com. The simplicity and versatility of this program allows for rapid analyses to be performed on typical bridge elements based on current field conditions. This facilitates construction operation scheduling more suitably than the traditional approach and also promotes better owner and contractor cooperation. The program allows for detailed material property input or the user may select the default values for a variety of the usual concrete constituents. A significant amount of field verification testing was done showing the program accurately predicts heat generation. In addition, verification testing continues as results from field instrumentation are compared with the analysis results.

Practice

Twenty percent of the total pier concrete let in the past year had the mass concrete designation. There was no substantial difference in the price bid for the mass concrete compared to other concrete. Though not shown in the bids, there is a cost associated with meeting the mass concrete provisions. The most significant expense is providing the concrete with a temperature not exceeding 75°F (24°C) at placement compared with 95°F (35°C) allowed for normal pier concrete. Replacing mix water with ice is the most common method for cooling but there has also been a trend for producers supplying concrete for large construction projects to use liquid nitrogen.

The other cost is associated with instrumentation and data collection for the mass concrete members, which is approximately $200/member. The most common method of instrumentation uses concrete maturity sensors that are self-contained time and temperature collectors. After the critical heat generation period is complete, a handheld device retrieves the data, which is then transferred to a computer.

One particular situation revealed that the standard concrete mix design provisions limiting the amount of fly ash in the concrete made it necessary to pursue more substantial measures to keep the maximum core temperature from exceeding 160°F (71°C). It was decided that the maximum limit of 35 percent Class F fly ash should be increased to 45 percent for mass concrete members. The high volume fly ash mixture was tested and used and the temperature provisions were satisfied. The specifications for concrete mix design have been updated to now allow up to 45 percent Class F fly ash for all mass concrete placements.

Future

TxDOT believes the implementation of ConcreteWorks for mix design development will significantly improve the concrete used for mass concrete placements and possibly other concrete as well. One feature that shows great promise is mix design optimization. The user can clearly see the benefits of using supplementary cementitious materials and uniformly graded aggregates to reduce the cement requirement, which subsequently reduces heat generation. With the aim to more carefully control concrete temperatures, TxDOT likely is getting more durable concrete as well.