RDT

Brief

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Research Development and Technology Division

Missouri Department of Transportation

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Missouri High Performance Concrete Update

In 1996, Missouri volunteered to participate as a lead state in the AASHTO Lead State Program for High Performance Concrete. The AASHTO Task Force on SHRP Implementation initiated the lead state program in 1996 in an effort to implement specific "high-payoff" SHRP technologies such as high performance concrete. High performance concrete (HPC) technology utilizes innovative design and construction concepts for improved pavements and bridges. As a result, pavements and bridges are constructed having longer service lives with improved performance and greater economic benefits. As a lead state in HPC technology, Missouri is committed to help further the development and implementation of HPC.

Project Description

On November 3, 1998, two companion bridges on Missouri Route 21 in Jefferson County were opened to traffic. The northbound bridge over Route M was constructed using prestressed I-girders made of HPC with design strength of 10,000 psi (release strength 5,500 psi). The southbound bridge over Route M was constructed using prestressed I-girders made of conventional concrete with design strength of 5,000 psi (release strength 4,000 psi). As a result of the increased concrete strength, the HPC bridge required fewer girders than the conventional bridge. The conventional bridge required 24 MoDOT Type 6 girders, while the HPC required only 20 of the MoDOT Type 6 girders.

HPC Mix Characteristics

The HPC mix was designed by the fabricator to meet the requirements of the special provisions. The required compressive strength was 10,000 psi at 56 days and the chloride permeability was limited to 1000 coulombs or less in accordance with AASHTO T 277. The HPC specifications were written to minimize allowable tolerances during fabrication for improved quality control. The coarse aggregate had to meet Missouri Standard Specifications, Sec. 1005.1 for pavement quality. The fresh air content could be no less than the design air content, nor could it exceed that value by 3.5 percentage points. The slump could not exceed 8 inches and had to be within 2 inches of that specified in the approved mix design. The w/c ratio had to be within 0.020 of that specified in the approved mix design. Table 1 shows the comparison of the actual HPC mix proportions and the conventional mix proportions.

Table 1 – Mix Proportions

	HPC	Conv.
Water (lbs)	219	237
River Type I Cement (lbs)	852	722
W. R. Grace Silica Fume (lbs)	50	N/A
w/c	0.243	0.328
Fine Agg. (lbs)		
Mississippi River Sand	906	1193
Coarse Agg. (lbs) Plattin Limestone	1977	N/A
Coarse Agg. (lbs) Derby Doe Run Dolomite	N/A	1769
Daravair 1400 (oz/sack)	0.5	2.46
Daratard 17 (oz/sack)	2.83	N/A
Daracem 19 (oz/sack)	23.57	N/A
ADVA Cast (oz/sack)	N/A	5.47
Fresh Air (%)	4.8	4.5
Slump (in)	7.75	8.0

Physical Properties

The compressive strength of the HPC and the conventional mix at various ages are shown in Table 2. In both cases, release strength (HPC 5,500 psi, Conv. 4,000 psi) was reached in 1 day and design strength was reached by 3 days.

Table 2
Compressive Strength (psi)

Age	HPC	Conv.
1 day	6,090	5,340
3 days	11,630	5,960
56 days	12,450	6,850
1 year	14,520	*Not Tested*

The chloride permeability of the HPC was very low, while the chloride permeability of the conventional concrete was moderate. Table 3 shows the specified values for compressive strength and chloride permeability of the two mixes and the actual measured values.

Table 3

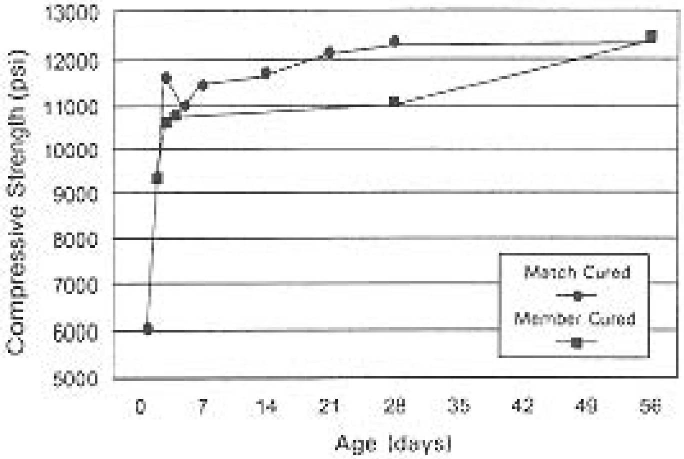
	Compressive Strength (psi)		Chloride Permeability (coulombs)	
	Specification	Actual	Specification	Actual
HPC	10,000 @ 56 days	12,450	<1000	110
Conv.	5,000 @ 56 days	6,850	N/A	3050

Both the HPC and the conventional concrete were subjected to freezing and thawing in accordance with ASTM C666 Procedure B. The freeze-thaw resistance of the conventional concrete was excellent, however the freeze-thaw resistance of the HPC was poor. The poor freeze-thaw performance of the HPC warrants additional investigation. Areas planned for further investigated include: the freeze-thaw durability of the Plattin Limestone; the effect of very impermeable concrete containing silica fume on freeze-thaw performance; and curing procedures that may exaggerate poor freeze-thaw test results. Some researchers feel the continuous wet curing of HPC freeze-thaw specimens amplifies poor test results and have suggested a period of drying time be allowed before the test begins.

Curing Temperature Research

All of the test specimens for MoDOT's research were cured in a "match-cure" environment in an effort to better simulate the actual member curing temperatures. The temperature of test specimens was maintained within three degrees Fahrenheit of the internal girder temperature. A comparison was made of the compressive strength of these "match-cured" cylinders and member-cured cylinders used by the fabricator. As Figure 1 illustrates, the compressive strength at early ages is higher for "match-cured" cylinders than for member-cured cylinders and should be more representative of the actual girder strength.

Figure 1
HPC Compressive Strength
Comparison of Member Cured and Match Cured



Project Costs

Fabrication and placement of the HPC girders per foot of bridge was 16% higher than for the conventional girders. Reduced maintenance and longer life are expected to offset this initial cost.

Conclusions

The high strength and low permeability has shown that HPC is a viable concept in Missouri, although further study into the freeze-thaw durability is needed.

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