LIGHTWEIGHT HPC ON ROUTE 106 BRIDGE IN VIRGINIA

H. Celik Ozyildirim, Virginia Transportation Research Council

High performance concrete (HPC) bridges in Virginia have shown initial cost savings mainly due to the reduced number of beams per span, use of smaller cross-sections, and the ability to span longer distances. More benefits can be realized by reducing the dead load of the structures. The improved durability of HPC is also expected to lead to more savings over the life of the structure. Thus, the use of lightweight HPC (LWHPC) for the beams and deck for a bridge on Route 106 over the Chickahominy River, east of Richmond, Virginia, was proposed for the FHWA Innovative Bridge Research and Construction Program. The bridge, constructed in 2001, has three spans of 85 ft (25.9 m) and a width of 43.3 ft (13.2 m). The 7.9-in. (200-mm) thick deck is continuous over the two intermediate piers. Each span has five AASHTO Type IV beams spaced at 10 ft (3.05 m) centers.

Implementation of the LWHPC beams and deck was accomplished in three phases. In the first phase, a test program focused on fabricating and testing Type II and Type IV beams. In the second phase, the Type IV bridge beams were fabricated and erected. In the third phase, the concrete bridge deck was constructed. A portion of the deck over one of the piers contained synthetic fibers in the concrete for crack control. Condition surveys were performed after the placement of the deck and 2 years later.

The specified 28-day compressive strength and 28-day permeability were 8000 psi (55 MPa) and 1500 coulombs, respectively, for the beams and 4000 psi (28 MPa) and 2500 coulombs, respectively, for the deck. The specified concrete strength for detensioning the bridge beams was 4500 psi (31 MPa). The target density for the LWHPC for the beams and deck was 120 lb/cu ft (1.92 Mg/cu m). The concrete mixture proportions, which included both lightweight and normal weight aggregates, are given in Table 1. Grade 270 low-relaxation 0.5-in. (12.7-mm) diameter prestressing strands were used.

Workable concretes were obtained. The bridge beams had a concrete density about the same as that specified. Before pumping, the deck concrete had a density less than the specified value. However, samples taken after pumping had a higher density and lower air content. During sampling of the pumped concrete, there was a longer vertical drop than during the deck placement and flow of concrete was not continuous. This could have contributed to a large loss of air in the test samples, which would increase their density.

For the tests on hardened concrete, the beam samples were steam cured and the deck samples moist-cured. The measured compressive strength, flexural strength, permeability, and modulus of elasticity values are given in Table 2. The strength of the concrete with fibers was considerably lower than the strength of the concrete without fibers. This strength reduction is attributed to the addition of extra water to compensate for reduced workability due to fibers. To improve workability without adverse effect on strength, water-reducers should be used.

Table 1 Concrete Mix Proportions

Material	Quantities per yd³	
	Beams	Deck[1]
Portland Cement[2]	451 lb	489 lb
Slag	301 lb	—
Pozzolan Class N	—	163 lb
Fine Aggregate NW	541 lb	1228 lb
Fine Aggregate LW	390 lb	—
Coarse Aggregate NW	605 lb	—
Coarse Aggregate LW	696 lb	900 lb
Water	255 lb	292 lb
Water Reducer/Retarder	22 fl oz	20 fl oz
HRWR	56 fl oz	33 fl oz
Calcium Nitrite	3 gal/yd³	—
Air Entrainment	5.5 + 1.5%	6.5 + 1.5%
w/cm ratio	0.34	0.45

[1] Without fibers. Fibers were added at 9 lb/yd³ to the deck concrete used over one pier
[2] Type II
NW = normal weight, LW = lightweight

Table 2 Properties of LWHPC

Property	Age	Beams	Deck Control	Deck Fiber
Compressive Strength, psi	1 day	4720	4740	3275
	28 days	8100	7225	4940
	1 year	7890	8915	6570
Flexural Strength, psi	28 days	640	780	740
Permeability, coulombs	(1)	917	832	1372
Modulus of Elasticity, ksi	28 days	2980	2750	2790

(1) For the bridge beams, permeability measured at 1 year after initial steam curing and subsequent drying. For deck concrete, permeability measured at 28 days after 1 week moist curing at room temperature and 3 weeks at 100°F.

The results indicate that LWHPC can be produced such that the material is workable, strong, volumetrically stable, and resistant to cycles of freezing and thawing, thus leading to a long service life with minimal maintenance. Testing of prisms showed that the fibers provide residual strength expected to mitigate deck cracking. A condition survey after 2 years of exposure indicated only limited cracking including two transverse cracks above the piers in the sections with and without fibers. Based on the experience, more structures with LWHPC for beams and deck are expected to be built in the future. A 1.01-mile (1.63-km) long bridge with LWHPC beams and deck is currently under design in Virginia.

Further Information

For further information, contact the author at celik@virginia.edu or 434-293-1977.