Route 40 Over the Falling River, Lynchburg District

General Description The bridge, located in Brookneal, VA, is a two-lane 13.4-m- (44-ft-) wide structure made up of four equal spans that are 24.4 m (80 ft) long. Each of the simple spans consists of five American Association of State Highway and Transportation Officials (AASHTO) Type IV pretensioned concrete I-beams. The beams are spaced at 3.1 m (10.3 ft) on center. The project was conducted by the Virginia Department of Transportation (VDOT) in cooperation with the Virginia Transportation Research Council.

Outline of HPC Features The HPC members had both compressive strength requirements and chloride permeability requirements based on the particular member's use in the structure. The requirements for all elements measured at 28 days were:

Element	Compressive Strength, MPa (psi)	Chloride Permeability, coulombs
Beams@Transfer	41 (6000)	
Beams	55 (8000)	≤1500
Deck	28 (4000)	≤2500
Substructure	21 (3000)	≤3500

Pretensioned Beams The AASHTO Type IV prestressed concrete I-beams were pretensioned with 15.2-mm- (0.6-in-) diameter strands at 51 mm (2 in) on center. The concrete contained silica fume and had a water-to-cementitious material ratio of 0.32.

I-Beam Mix	per m^3	per yd^3
Type I Cement	446 kg	752 lb
Silica Fume	33 kg	55 lb
Crushed Limestone	994 kg	1675 lb
Fine Aggregate	845 kg	1425 lb
Water	151 kg	255 lb
Superplasticizer	7782 mL	202 fl oz
Retarder	934-1152 mL	24-30 fl oz
Air-Entraining Agent	124-280 mL	3.2-7.3 fl oz

Substructure Although the compressive strength of the substructure HPC was what had been typically specified for substructure concrete in Virginia, there was a permeability requirement added to the performance characteristics.

Deck The deck is 216 mm (8.5 in) thick, which is 13 mm (0.5 in) thicker than the conventional concrete deck design because of the wider beam spacing. The cementitious portion of the concrete was made with equal parts of portland cement and slag. For the actual bridge, the measured deck concrete compressive strength exceeded 55 MPa (8000 psi).

HIGH-PERFORMANCE CONCRETE

Concrete with enhanced durability and strength characteristics. Under the Strategic Highway Research Program (SHRP), more than 40 concrete and structural products were developed. To implement the new technology of using High-Performance Concrete (HPC), the Federal Highway Administration (FHWA) has a program underway to showcase bridges constructed with HPC. The objective is to advance the use of HPC to achieve economy of construction and long-term performance.

Mix Constituent	Deck Mix, per m^3 (per yd^3)	Substructure Mix, per m^3 (per yd^3)
Type II Cement	195 kg (329 lb)	210 kg (353 lb)
Slag	195 kg (329 lb)	139 kg (235 lb)
Arch Marble	1052 kg (1773 lb)	1052 kg (1773 lb)
Natural Sand	696 kg (1173 lb)	744 kg (1254 lb)
Water	156 kg (263 lb)	154 kg (259 lb)
Superplasticizer	508-761 mL (13-20 fl oz)	0-1814 mL (0-47 fl oz)
Air-Entraining Agent	330 mL (8.6 fl oz)	113-181 mL (2.9-4.7 fl oz)
Water Reducer	2538 mL (66 fl oz)	1814-2268 mL (47-59 fl oz)

Concrete Evaluation The following properties were measured for the concrete in the beams, deck, and substructure:

Beams
- 28-day Compressive Strength
- Compressive Strength at Release
- Air Content
- Slump
- Flexural Strength
- Splitting Tensile Strength
- Modulus of Elasticity
- Permeability
- Drying Shrinkage

Deck and Substructure
- 28-day Compressive Strength
- Air Content
- Slump
- Permeability
- Temperature

Construction The contract was awarded in 1994 and construction began in early 1995. The bridge was opened to traffic in May 1996. The general contractor was W.C. English, Inc.; the precast/prestressed concrete fabricator was Ross Prestressed Concrete, Inc.; and the ready-mixed concrete supplier was Felton Brothers Transit Mix, Inc.

Benefits The HPC bridge contained five beams, compared to the seven beams needed if the bridge had been designed as a conventional concrete bridge. This resulted in a net savings of eight beams for the four-span bridge because higher strength HPC beams were used. The bid bridge construction cost was $\$527/m^2$ ($\$49/ft^2$). This may be compared to the 1994 average of $\$624/m^2$ ($\$58/ft^2$) for 34 bridges in the Federal-aid highway system in Virginia. The initial savings over conventional bridge concrete and construction was estimated to be 4 percent. ■

U.S. Department of Transportation
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