Eastbound, State Route 18 Over State Route 516, King County

General Description The existing bridge is a two-lane structure carrying eastbound State Route 18 traffic over State Route 516. The HPC bridge is a three-span continuous structure, with a center span of 42 m (137 ft) and side spans of 24 m (80 ft). Pretensioned concrete Washington State Department of Transportation (WSDOT) W74G girders were used. The roadway deck is 11.6 m (38 ft) wide, carrying two 3.7-m (12-ft) lanes and 1.2-m (4-ft) and 3.0-m (10-ft) shoulders. The bridge is designed for earthquake zone "C" (acceleration coefficient = 0.25 g). The design used the new American Association of State Highway and Transportation Officials (AASHTO) Load and Resistance Factor Design (LRFD) bridge specifications. WSDOT conducted the project in cooperation with the University of Washington.

Outline of HPC Features HPC was used in the girders and in the deck. The durability and strength requirements varied according to the demands of the particular member. The contract originally specified chloride permeability requirements for the deck and girders of less than 1000 coulombs at 56 days. The contract also specified the AASHTO T277 Rapid Chloride Permeability Test as the acceptance test procedure. However, the requirement for chloride permeability was changed to a monitoring measurement for the deck rather than an acceptance criterion. The freeze-thaw durability for the girders was also measured for monitoring purposes only. The strength requirements are shown below:

Element	Compressive Strength
Girders@Transfer	51.0 MPa (7400 psi)
Girders@56 days	68.9 MPa (10,000 psi)
Deck@28 Days	27.6 MPa (4000 psi)

Pretensioned Girders The girders for the bridge used 15.2-mm (0.6-in) strands at 51-mm (2-in) center-to-center spacing. However, prior to production of the project girders, one 6.1-m (20-ft) research girder was made to test fabrication procedures and the instrumentation, and to perform some materials testing. The project girders were WSDOT W74G standard prestressed concrete I-girders that were 1880 mm (74 in) deep and were built with composite decks. No air entrainment agent was used in the girder concrete. The concrete mix proportions for the HPC girders are shown below.

Girder Mix	Per m^3	Per yd^3
Cement (Type III)	432 kg	728 lb
Fly Ash	132 kg	222 lb
Silica Fume	30 kg	50 lb
Fine Aggregate	528 kg	890 lb
Coarse Aggregate	1109 kg	1870 lb
Water	157 kg	265 lb
Water Reducer	1119 mL	29 fl oz
High-Range Water Reducer	8293 mL	215 fl oz

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.

Deck The deck concrete mix was the WSDOT Class 4000D concrete mix that contained fly ash and had a continuous wet cure for 14 days. This was a WSDOT-furnished mix design, but acceptance testing was performed to verify that the project criteria were satisfied. The concrete mix proportions for Washington Class 4000D concrete are shown below:

WS Class 4000D Deck	Per m^3	Per yd^3
Cement	392 kg	660 lb
Fly Ash	44 kg	75 lb
Fine Aggregate	653 kg	1100 lb
Coarse Aggregate	1009 kg	1700 lb
Water	172 kg	290 lb
Air Entrainment	6%	6%
Water Reducer Type A	Yes	Yes
Water/Cementitious Material Ratio	0.39	0.39

Concrete Evaluation The following concrete properties were measured for the project:

- Chloride Permeability
- Compressive Strength
- Coefficient of Thermal Expansion
- Creep
- Shrinkage
- Freeze-Thaw Durability
- Modulus of Elasticity
- Abrasion Resistance

The measured average values for some of these properties were:

	Girder	Deck
Compressive Strength:	74.5 MPa (10,800 psi)	36.5 MPa (5300 psi)
Abrasion Resistance:	Not Measured	4.5%
Chloride Permeability:	1010 Coulombs	2800 Coulombs
Entrained Air:	0%	5.7%
Freeze-Thaw Durability:	100%	N/A

Instrumentation Five of the girders in the bridge were instrumented (three of the girders in the 42-m- (137-ft-) long span and two in a 24-m- (80-ft-) long span). The instrumentation allowed evaluation of internal concrete temperature during curing, end slip of the strands at detensioning, concrete strains, prestress losses, camber, and deflection.

Construction The construction contract was awarded in July 1996. The I-girders for the bridge were fabricated by Central Pre-Mix Prestress Co. of Spokane, WA, who also worked with the University of Washington to produce the research girder. Mowat Construction Company was the general contractor, and the ready-mix concrete supplier was Lone Star Northwest of Seattle, WA. The bridge was completed in January 1998. The bid cost per linear foot of the girder was $153 ($502 per linear meter), compared to the engineer's estimate of $115 per linear foot ($377 per linear meter). The higher cost was attributed to instrumentation. Otherwise, the HPC girder costs about $4 more per linear foot ($13 more per linear meter) than similar girders made of conventional concrete.

Benefits Using high-strength HPC concrete in conjunction with the 15.2-mm (0.6-in) strands, the WSDOT designers were able to use two fewer girders per span than if conventional concrete and strands had been used. In addition, the structure's life will be enhanced because of the durability benefits associated with HPC. ■

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