The Dulles Corridor Metrorail Project

Connecting the Nation's Capital with its International Airport

by Shea Daugherty
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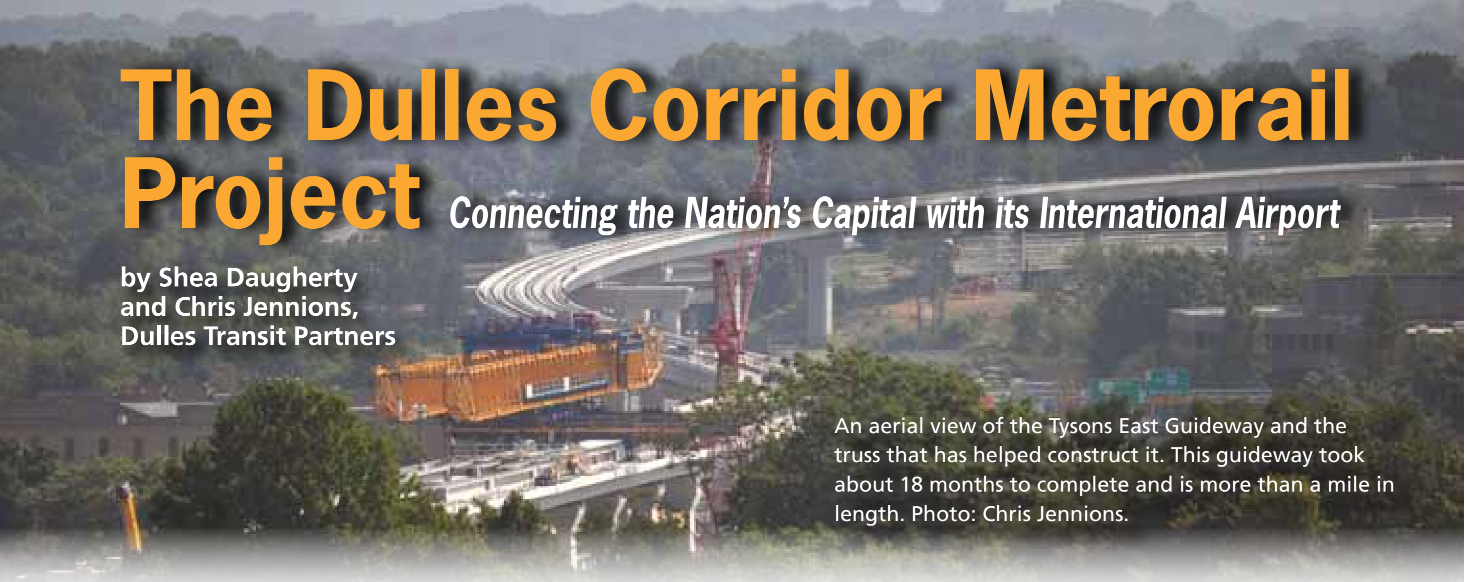

An aerial view of the Tysons East Guideway and the truss that has helped construct it. This guideway took about 18 months to complete and is more than a mile in length. Photo: Chris Jennions.

The Dulles Corridor Metrorail Project, a two-phase, 23-mile extension of the existing 106-mile Metro rail system, will connect the nation's capital, Tysons Corner, and Washington Dulles International Airport. Construction of Phase 1, the first 11.6 miles, is nearly 50% complete. It will include five stations and multiple auxiliary power facilities and environmental controls.

One of the project's biggest challenges has been working in and around this heavily congested area. Work sites are limited and narrow, mostly in the medians of the area's most traveled thoroughfares where traffic moves just feet away. "The safety of the traveling public and our employees is the top priority of this project," said George Morschauser, executive director for the project's design-build contractor.

Project Orientation

Phase 1 features nearly 3 miles of aerial guideway. The rest of the alignment will run at-grade except for a 2400-ft-long tunnel between two of the stations. There are three guideway sections in this new alignment: "O-1," "Tysons East," and "Tysons West."

The O-1 begins at the eastern end of the project, where the new line will split from the existing Metro Orange Line. It features two parallel, 1600-ft-long guideways that fly over I-66, a major interstate highway.

The other two guideways, Tysons East and Tysons West, are precast segmental concrete box girder bridges constructed using highly-visible trusses—massive machines that are unlike anything most of the area's traveling public has ever seen.

The congestion of Tysons Corner was a main reason to use trusses for the majority of the guideway work instead of ground-based cranes. "We're using overhead trusses because they are the most efficient method," said Shawn MacCormack, the project's task manager for aerial structures. "They are ideal in dense urban environments like Tysons Corner because they use a 'top-down' construction method and have little impact on the traveling public."

Traveling from east to west, once over the O-1 guideway, the rail line will descend to grade level for about 2 miles in the median of the Dulles Connector Road (Route 267). Then, the Tysons East guideway begins, crossing over into Tysons Corner, and into the first of the four Tysons Corner stations. From there, the rail will continue at an elevated level, ascend to its highest point—approximately 55 ft—over the eight-lane I-495 Capital Beltway and then descend into the second station where the rail line briefly goes underground.

The alignment resurfaces in the median of Route 7 at the third station, which is partially underground. From there, the Tysons West guideway begins, running for about a mile and through the fourth station. One final flyover takes the guideway westward into the median of the airport access highway, descending to grade for the rest of the alignment. The fifth station is located approximately 4 miles west of Tysons Corner.

How They're Built

The Tysons East and West guideways are being constructed using more than 2700 precast concrete segments that are fabricated in an off-site facility on Dulles Airport property. All segments are match cast. The short-line casting method is used for the typical main guideway segments and the shallower station segments use the long-line casting method.

The segmental box is approximately 7 ft 6 in. wide by 8 ft deep, with a top flange approximately 16 ft wide for the

profile

DULLES CORRIDOR METRORAIL PROJECT AERIAL GUIDEWAYS / TYSONS CORNER, VIRGINIA

SUBSTRUCTURE DESIGN ENGINEER: Bechtel, Vienna, Va.

SUPERSTRUCTURE DESIGN ENGINEER: Corven Engineering Inc., Tallahassee, Fla.

CONSTRUCTION ENGINEER AND ERECTION TRUSSES MANUFACTURER: Deal, Pozzuolo del Friuli, Italy

PRIME CONTRACTOR: Dulles Transit Partners, Vienna, Va.—a team of Bechtel and URS

CONCRETE SUPPLIER: DuBROOK Concrete Inc., Chantilly, Va.

PRECASTER: Rizzani de Eccher USA, Bay Harbor Islands, Fla.

A completed span in a span-by-span construction area showing the cross section of the guideway girder. Photo: Chris Jennions.

typical guideway sections. The boxes change to 7 ft wide by 5 ft deep with a 16-ft-wide top flange through the stations, where the spans are about 50% shorter. Guideway spans have slightly thinner webs and slabs at 9 in. thick, while station segment webs and slabs are 10 in. thick.

Segments are trucked one-by-one to their locations and hoisted into place by the truss, where their match-cast faces are coated with epoxy, joined together, and aligned. Segments are approximately 10 ft long depending on the radius of the alignment at that location. Span lengths are generally dictated by the availability of ground for locating the cast-in-place concrete piers, but where support is required in a road, straddle bents are constructed to avoid permanent road diversions.

Support piers across the project vary in both footprint and height, ranging from 10 ft tall atop hills in the middle of an intersection cloverleaf to 55 ft tall between two road bridges. In plan, most piers are rectangular with rounded corners. Plan dimensions range from 6 by 7 ft to 7 by 12 ft.

Concrete

Specified concrete compressive strength for the columns and pier caps is 5000 psi. The concrete strength is increased where the substructure pier caps require post-tensioning due to their span lengths; in these cases, the concrete strength requirement is 6000 psi. Column and pier cap concrete includes a calcium nitrite corrosion inhibitor to protect the reinforcement from corrosion from deicing salts from road splash.

Concrete compressive strengths for the precast segments range from 6000 to 8500 psi depending on their location. Both simple spans of roughly 130 ft and station spans have used 6000 psi, while the larger spans and balanced cantilever structures have required 8500 psi. The mixes use ground-granulated blast-furnace slag as a supplemental cementitious material.

Concrete maturity meters were used for the in-place strength of the cast-in-place substructure concrete where post tensioning was not required. This enabled the aerial crews to strip both column and pier cap formwork systems earlier and reuse them elsewhere. The client approved the use of these meters for stripping formwork, but not for verification of strength prior to post-tensioning. Curing compound was used on fresh concrete when the formwork was stripped before 7 days or less than 70% of the design strength was achieved.

The Tysons East Guideway as it curves westward toward Tysons Corner. Photo: Shea Daugherty.

THREE MILES OF AERIAL GUIDEWAY THAT INCORPORATES FOUR DIFFERENT TYPES OF BRIDGE CONSTRUCTION / METROPOLITAN WASHINGTON AIRPORTS AUTHORITY, OWNER

POST-TENSIONING MATERIALS: VSL, Hanover, Md.

FORMWORK SUPPLIER: Symons of Dayton Superior, Des Plaines, Ill.

EXPANSION JOINT SUPPLIER: D.S. Brown, North Baltimore, Ohio

BEARING SUPPLIER: R.J. Watson, Amherst, N.Y.

GUIDEWAY DESCRIPTION: AASHTO precast, prestressed concrete box beams and steel plate girders, all with cast-in-place concrete decks; segmental concrete box girders erected using both span-by-span and balanced cantilever methods built on cast-in-place concrete substructures

BRIDGE CONSTRUCTION COST: Approximately $170 million

Upon completing a span, the truss prepares to launch to the next pier on the Tysons East Guideway. Photo: Igor Scherbakov.

Guideways by the Numbers

O-1 Guideway

- Two parallel, 1600-ft-long guideways in the median of Interstate 66 and the Dulles Connector Road (Route 267)
- 23, 88-ft-long spans with 48-in. by 48-in. AASHTO box beams
- 16 spans with steel plate girders
- All decks are 9-in.-thick cast-in-place concrete

Tysons East Guideway

- Two aerial stations
- 6178 lin. ft of segmental guideway along the northern shoulder of Route 123, a major roadway in Northern Virginia
- 75 spans, including five balanced cantilever spans and three precast, prestressed AASHTO box beam spans with cast-in-place concrete decks
- 1333 lin. ft of station guideway
- Three segmental erection trusses operating concurrently
- Typical span-by-span length of 130 ft with balanced cantilever spans up to 174 ft. Station spans 66 ft long

Tysons West Guideway

- One aerial station
- 5715 lin. ft of segmental guideway along the median of Route 7, a major Northern Virginia highway
- 55 spans, including three balanced cantilever
- 600 lin. ft of station guideway
- Two segmental operations working concurrently

Post-Tensioning

Post-tensioning is used throughout the project. In the stations, it is used in the substructure pier caps, straddle bents, and precast concrete mezzanine beams. The precast concrete box beams in the O-1 guideway use 1¼-in.-diameter lateral post-tensioning bars at six locations in each span. The standard design of the segmental concrete box girders for locations both inside and outside the stations contains six tendons per span. With minor exceptions, these comprise four 19-strand tendons at 750 kips each, and two 15-strand tendons at 600 kips each—totaling 4200 kips of post-tensioning in each span. Tendons in the longest cast-in-place concrete straddle bents use up to 31 strands. All post-tensioning strands are 0.6 in. diameter.

Grout for the post-tensioning ducts is produced from one of two dedicated mobile grout trailers. Each trailer contains a storage area for the grout and water, and the colloidal mixer, and a shelter area for the workers. Grouting operations are done in accordance with standard American Segmental Bridge Institute practices.

The steepest grade is 4% at the I-495 crossing, and almost none of the guideways is perfectly level, with the exception of the stations. The decks and segments do not have any superelevation because the concrete rail plinth, which is cast on the deck after erection, provides this slope.

For safety reasons, bridge construction is not allowed over active roadways, so a large amount of the work is being done overnight. This time constraint on the aerial team required intense planning and coordination with the project's maintenance of traffic team, as well as the Virginia Department of Transportation (VDOT) and the project owner.

Phase 1 construction has about a year and a half to completion. The aerial guideways are scheduled for completion by May 2012. Once the system is turned over to Metro, approximately 6 months of pre-revenue testing and integration with the existing system will occur, with the first new riders boarding by the end of 2013.

A completed span has been post-tensioned together before being placed in its final position in the Tysons East Guideway alignment. Photo: Chris Jennions.

Shea Daugherty is construction communications manager and Chris Jennions is aerial lead field engineer, both with Dulles Transit Partners in Vienna, Va.

For additional photographs or information on this or other projects, visit www.aspirebridge.org and open Current Issue.

In a typical sequence, segments are lifted into place, aligned and post-tensioned on the Tysons West Guideway. Photo: Shea Daugherty.

Ironworkers are shown installing the reinforcement inside a straddle bent form. Photo: Chuck Mills.

A rendering of the Tysons West Guideway in the median of Route 7 in northern Virginia. Rendering: Dulles Corridor Metrorail Project.