BACK IN ACTION

At one of Northern Virginia's most complex and notoriously congested intersections, the superstructure of a critical highway overpass was demolished, removed, and replaced in a single weekend. The design's accelerated bridge construction techniques included three composite units that were prefabricated off-site and a customized very early strength latex concrete mix for the deck closure that provided the cure time, strength, and durability necessary to get the job done on time.

BY KELLY A. GUILD, P.E., M.ASCE, POOYA AZAR, AND JOHN MICHELS, P.E.

THE EASTBOUND (EB) Wilson Boulevard Bridge, in the Northern Virginia city of Falls Church, is part of an interchange known locally as Seven Corners, which brings together five roadways, each incredibly busy in its own right. Four of the roads cross over Route 50 (Arlington Boulevard), a major thoroughfare leading in and out of Washington, D.C. The average daily traffic volume on Route 50 is 50,000 vehicles, making Seven Corners one of the busiest intersections in Northern Virginia. Furthermore, its design—developed progressively over decades—makes it one of the most complex choke points for daily commuters to and from the nation's capital.

PHOTOGRAPH COURTESY OF MARTINS CONSTRUCTION CORP.

To maximize the number of concurrent activities, the existing bridge was cut into manageable T sections that were then lowered and cut into smaller pieces that could fit on standard trailers.

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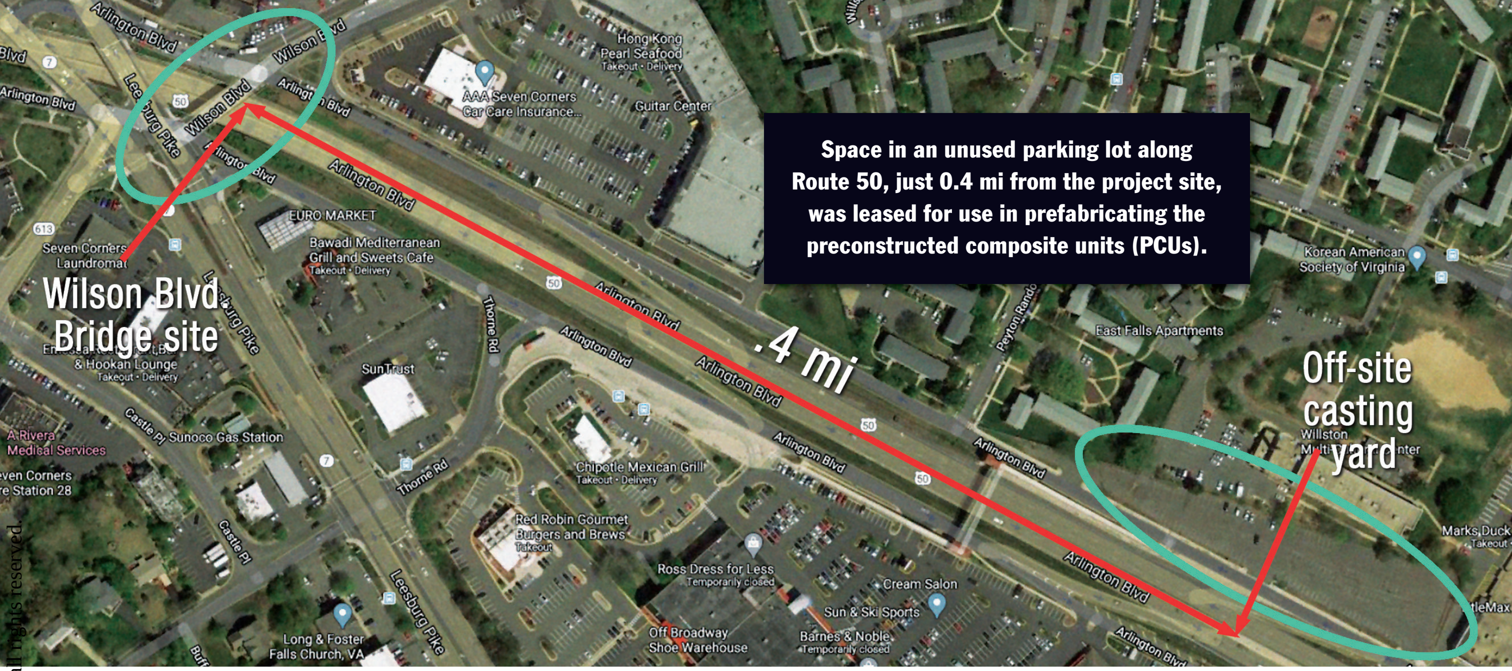

MAP COURTESY OF GOOGLE MAPS, ADAPTED BY WSP; PHOTOGRAPH COURTESY OF MARTINS CONSTRUCTION CORP.

Built in 1958, the EB Wilson Boulevard Bridge has suffered through the decades from continuous exposure to the environment and deicing chemicals, causing the steel reinforcement to corrode and the superstructure concrete to severely deteriorate. The most recent Virginia Department of Transportation (VDOT) inspection of the bridge determined its deck to be structurally deficient and to have a condition rating of 4 out of 9 (poor). The bottom of the deck had numerous areas of concrete spalling and delamination. The rapid deterioration of the underside caused VDOT to install timber debris shields beneath the deck to prevent concrete from falling onto Route 50 traffic below.

The deck required replacement to prolong the life of the bridge. The traditional method of reconstruction would be a staged deck replacement accomplished with lane closures and intermittent traffic stops. Traffic would be significantly slowed for several months, creating a congested environment and long-term inconvenience. In Seven Corners, such a staged construction would cripple the interchange for three to four months, causing serious mobility problems between Virginia's Fairfax County and Washington, D.C., and a significant disruption to community businesses for the project's duration.

Precast deck replacement is often considered for such situations, but the existing EB Wilson Boulevard Bridge had a nonuniform beam layout that would not have readily accommodated this solution. Additionally, the fascia beams supporting the existing sidewalk on one side of the bridge and the curb on the other side were designed only for pedestrian loads and did not have the capacity to support the latest and significantly higher code-required design loads. (See the existing transverse section on page 69.)

In fall 2017, VDOT's Northern Virginia District (VDOT NOVA) tasked WSP USA to provide a design, construction plans, specifications, and construction support for a superstructure replacement that would limit construction time and minimize traffic delays in the area. VDOT determined the project to be an ideal candidate for accelerated bridge construction (ABC). The most feasible option was to replace the superstructure over a single weekend while closing and detouring EB Wilson Boulevard and Route 50. The superstructure replacement would take place during the first weekend in August, when traffic in the region is lightest, avoiding several months of considerable traffic issues and significant disruption to the Seven Corners community.

Rise of the PCUs

The design of the replacement superstructure centered on the prefabrication of three preconstructed composite units (PCUs) built off-site. Each PCU was approximately 87 ft long and included two steel plate girders, each with a 27 in. web depth and an 8 in. deep composite concrete deck slab. The PCUs were each separated by a 3 ft, 7 in. opening that would be cast in place as a closure section and would provide the continuous final bridge deck.

The ability to transport and lift the superstructure into place during a single weekend was the primary design consideration. Limiting dead load enabled the use of a smaller crane, which in turn reduced crane setup time, providing an added buffer to the tight weekend closure schedule.

To accommodate transportation and erection, the widths of the PCUs were set at 10 ft, 0.5 in.; 9 ft, 5 in.; and 11 ft, 6.5 in., respectively, for segments one through three. To reduce dead load, each segment consisted of the deck slab, plate girders, and diaphragms only. This was the minimum necessary to provide a rideable surface by Monday morning. The sidewalks, permanent barriers, pedestrian fences, and deck overlay could then be constructed later, when single-lane closures could be implemented.

To further minimize segment weight, the PCUs were designed using a lightweight concrete deck slab; each unit had a weight of just 116 lb/cu ft. Using lightweight concrete decreased the weight of the heaviest segment, number three, by 14 tons. (See the chart, opposite.)

It was essential to reduce the number of work items that needed to be completed during the critical replacement weekend. The six new girders were therefore located between the seven existing girders, transversely. (See the proposed transverse section on page 69.) This placement allowed construction of the new bearing pedestals between the existing ones before the weekend closure.

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Estimated Segment Weight, Lightweight Versus Normal-weight Concrete

	Segment 1		Segment 2		Segment 3		Total	
Segment Width	10.04 ft		9.42 ft		11.54 ft		31 ft	
Concrete Unit Weight	150 pcf	116 pcf	150 pcf	116 pcf	150 pcf	116 pcf	150 pcf	116 pcf
Total Weight	72.6 tons	60.0 tons	62.6 tons	52.2 tons	78.8 tons	64.7 tons	209.2 tons	173.3 tons

Extensions and Modifications

To satisfy the VDOT requirement that the project eliminate deck joints, the bridge deck was extended beyond the abutments with deck-slab extensions. These extensions protruded 4 in. beyond the back walls, accommodating bridge expansion and contraction beyond the abutments. The jointless bridge design eliminated the potential for leaking expansion joints and thus reduced future maintenance issues.

The existing abutment back walls required modification to fit the new deck-slab extensions. (See the figures on page 68.) Constructing an accurate interface between the slab extensions and the top of the back wall was essential to fitting the replacement structure. The challenge involved constructing the deck-slab extensions off-site while modifying the back walls on-site with a high degree of precision, a process that had to account for a variable slope because of the roadway crown, cross slope, profile grade, and skew.

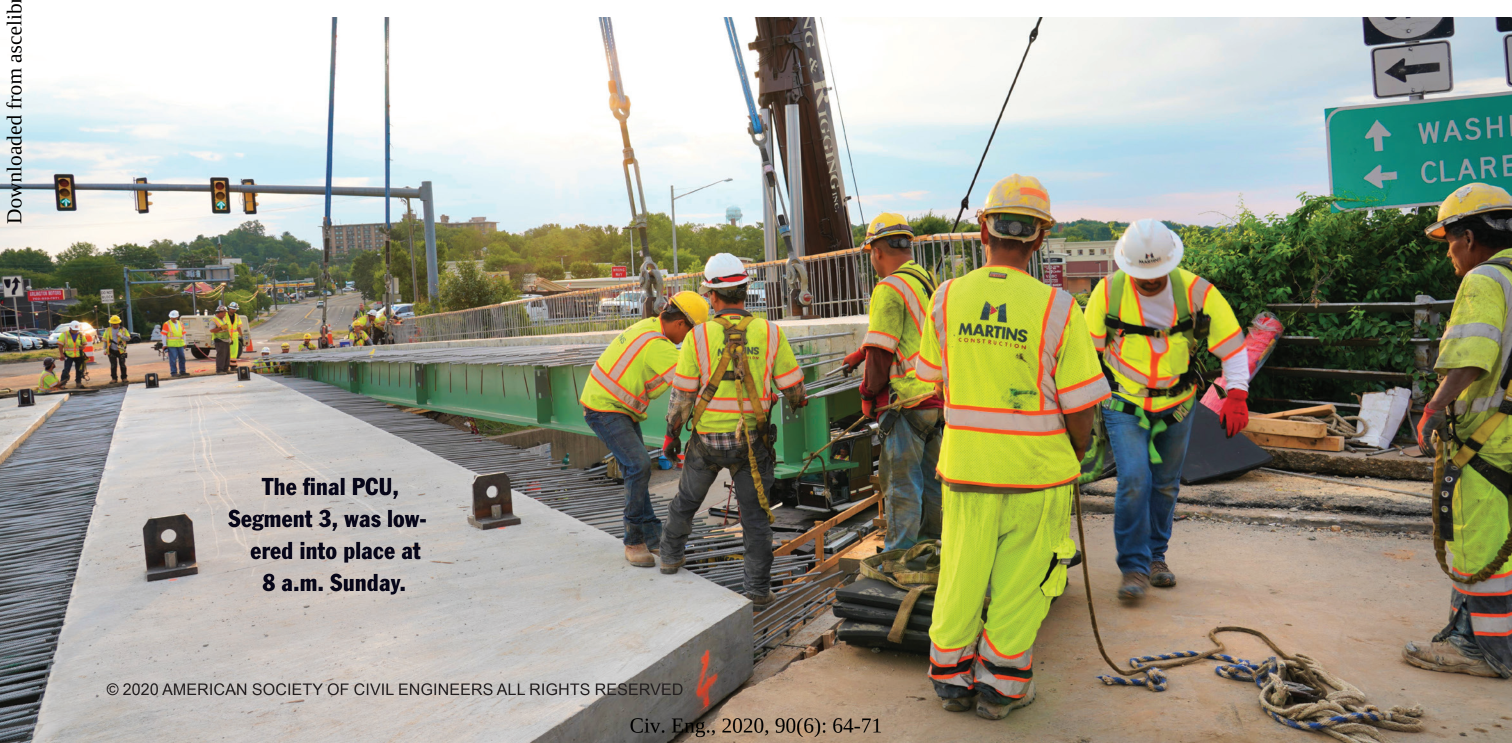
The plan involved demolishing and reconstructing the back walls after the demolition of the existing superstructure and during the weekend closure. Back walls would be formed to accurate elevations—as determined by the design plans and verified by field measurement—before the erection of the segments. The design required a precisely uniform interface between the top of the back walls and the underside of the PCUs along the entire width of each abutment.

During the shop drawing phase, the contractor, Martins Construction Corp. (MCC), of Falls Church, proposed positioning the PCU segments first—before placing the concrete for the back walls. Then the back walls would be cast after the segments were in place by pouring concrete into formwork constructed after the PCU placement, using the gaps between the segments. Given the restricted access and inability to vibrate the concrete to ensure proper consolidation along the entire length of the back wall, the risk of voids forming became central to the concrete selection. To mitigate this concern, latex modified concrete, very early strength (LMC-VE) was chosen. Its high early strength as well as its more flowable nature made it the best choice. The back walls would cure quickly to meet the tight weekend schedule, while the smaller aggregates in the mix would help prevent voids, mimicking results similar to those achieved by self-consolidating concrete mixes.

The request to modify the construction sequence in this way was accepted. Casting the back walls after the segments were in place provided the required perfectly matched interface between the tops of the back walls and the undersides of the deck-slab extensions. The change also saved several precious hours in the construction schedule.

Closing the Gaps

The two longitudinal, concrete closure placements were designed to provide a final continuous deck. Each PCU deck segment was designed with #5 bars spaced 6 in. apart transversely to meet the flexural strength requirements. The transverse bars would extend from each segment by the required lap length and overlap in the closure placement openings. This design also called for LMC-VE, which served two important purposes. The first was to provide a low-permeability concrete. Latex, when added to concrete, can create a more impervious material than traditional concrete mixes. Frequently, LMC is used in bridge deck overlays and joint closures because it reduces the infiltration of water and chloride ions



The final PCU, Segment 3, was lowered into place at 8 a.m. Sunday.

significantly. The concrete deck has a much longer service life, as the reinforcement does not corrode as easily or quickly. However, latex-modified concrete in its pure form still requires several days to gain sufficient strength.

The second and more crucial objective was to use a concrete with an extremely fast cure rate because much of the weekend schedule was already consumed with the demolition and erection of the PCUs. By using LMC-VE for the closure placements, the required 4,000 psi compressive strength was obtained in just four hours, providing a rideable surface that met the critical project deadline.

It's a Go

In March 2019, the construction contract was awarded to MCC. While the contract allowed a choice of three weekends for the full closure of the bridge, MCC elected from the start to aim for the first allowable weekend in order to achieve the full early completion interim milestone incentive that was part of its contract with VDOT. To achieve this, three primary challenges had to be overcome:

1. Finding ways to perform as much of the work as possible ahead of the closure weekend, which would reduce the amount of work performed during the closure hours and increase the time buffer for unforeseen issues.
2. Ensuring that any deviations in the alignments and elevations of the existing structure versus the theoretical ones assumed in the contract drawings were correctly captured and accounted for in the off-site construction of the PCUs and the on-site reconstruction of bearing pedestals (beam seats).
3. Devising alternative means of construction that could reduce or even eliminate the three- to four-hour wait time for curing and stripping the new back walls. The design originally required this to be accomplished before the new PCUs with the deck-slab extensions could be installed on top.

To address item one, some of the miscellaneous work requirements—such as substructure repairs—were obvious options. But other items—such as constructing the pedestals and demolishing the existing back walls and wing walls ahead of the full closure weekend while keeping the structure safe for use—were more challenging.

This was especially true in the case of the pedestals, where a lack of line of sight for proper surveying exacerbated the difficulties associated with having to perform the work under daily closures. Additionally, conveying the rapid-setting concrete to the top of the 15 ft high abutments for placement before it hardened would be difficult.

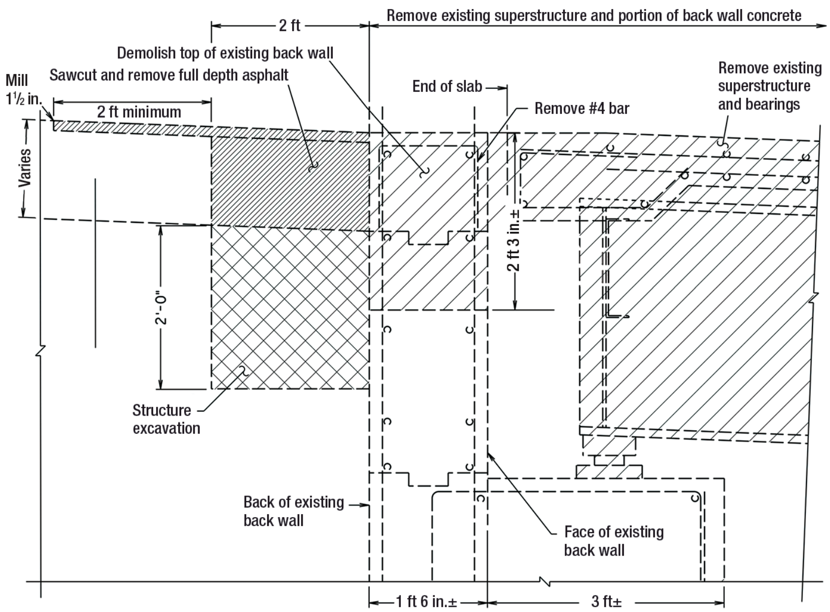
The work-around for the surveying was to drill holes on the existing deck at the location of each proposed bearing seat to enable a survey to be conducted from the top during both the layout and verification stages.

To convey the concrete, the team proposed using openings above parts of the back walls that had originally been designed as the block-outs for the CIP closure pours. The sequence of construction was then revised so that during the full weekend closure the formwork for the back wall could be erected before the PCU installation but also so that the concrete could still be placed after the PCUs were in place. This order would eliminate the wait for the back walls to cure, allowing the forming of the closure placements, installation of rebar, and other miscellaneous tasks to be performed in concurrence with curing.

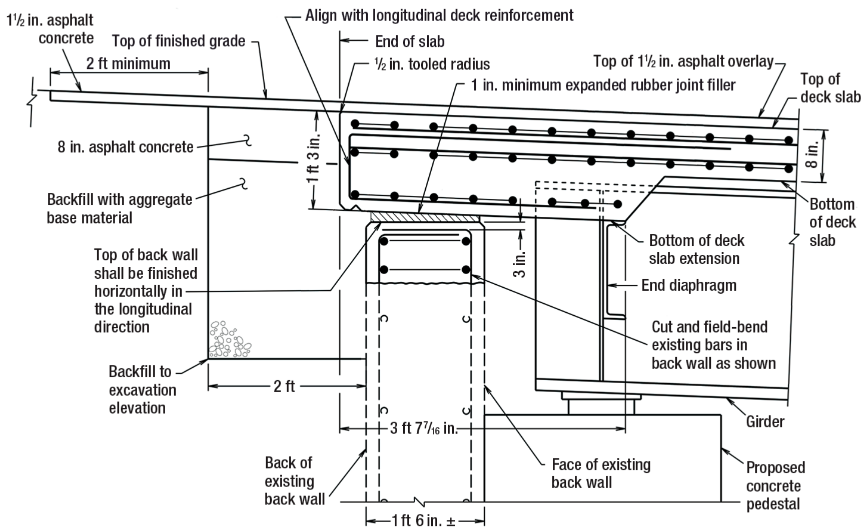
Make It and Take It

To ease the transportation constraints, especially the 8-ton weight restrictions on

Abutment Demolition



New Construction, Back Wall Modification, and Deck-Slab Extension



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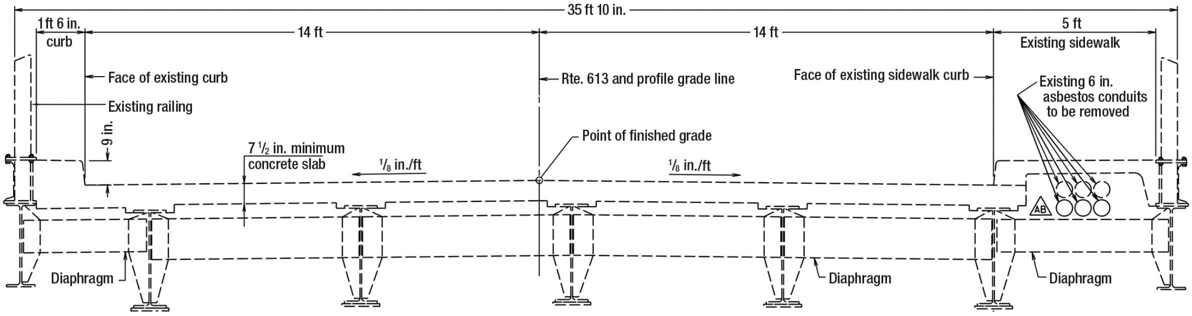
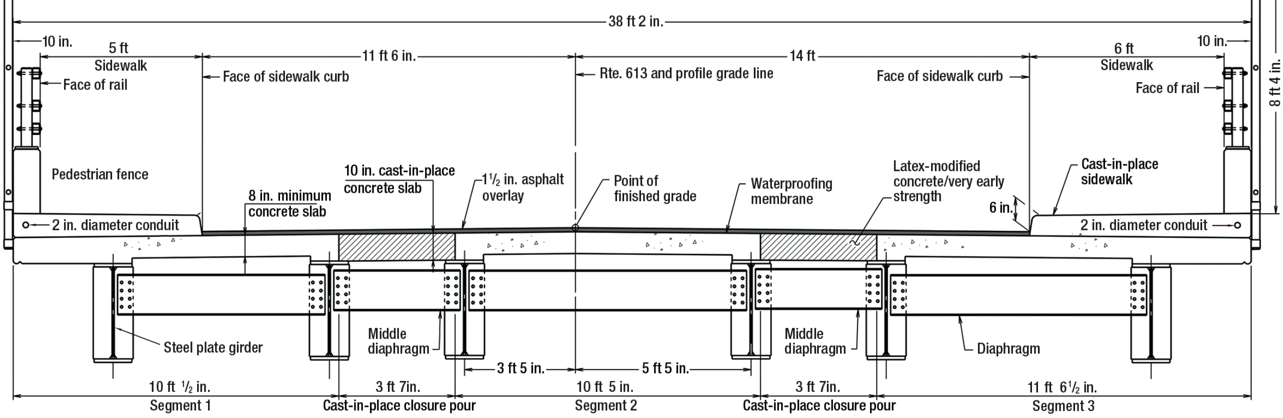
Existing Transverse Section



Proposed Transverse Section



Route 50, and accommodate the extensive need for repeated survey verification of the remaining substructure elements and the new superstructure components, a casting yard near the project site was needed. On VDOT's suggestion, space in an unused parking lot along Route 50, just 0.4 mi from the bridge, was leased.

Given that the plate girders for the PCUs required staging at the same profile grade, cross slope, and skew as the bridge site, the need to minimize deflections during construction prompted the selection of a portion of the parking lot with a favorable slope. This location would accommodate the near 4.5 ft elevation difference between the two abutments. Additionally, to ensure that the PCUs would not be subject to unwanted twists and deflections, specialized stretchable trailers with self-adjusting hydraulic axles were hired and fitted with custom-fabricated pedestals. Large turnbuckles were also incorporated into the rigging design to accomplish the same during the lifting process. In this way, not only were the PCUs constructed in the same vertical and horizontal alignment as their final resting position, but they were also lifted and transported in the same manner.

To reduce dead load, each of the three precast deck segments consisted of the deck slab, plate girders, and diaphragms only. This, coupled with the use of lightweight concrete, made it easier to transport the segments from the casting site to the project site and to lift them into place.

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The PCUs were formed, cast, and cured in the casting yard while other miscellaneous and preparatory work was carried out at the project site ahead of the weekend closure. Fully cured and stripped, all units were preloaded on the trailers and staged in the parking lot on the Thursday before the weekend closure, ready for transport on Saturday night.

Route 50 closed at 10 p.m. on Friday, August 2, 2019, to allow for the weekend replacement of the EB Wilson Boulevard Bridge superstructure. At the same time, the construction crew began the process of dismantling the existing superstructure. While the 500-ton crane was being assembled on Route 50 below, crews used saws to cut the bridge deck longitudinally between the beams, creating balanced T sections, using the existing diaphragms and anchor bolts for stability. Using Route 50 as a staging area for the dismantled T sections, the concrete decks were then demolished and the girders were cut into smaller pieces so that they could be quickly loaded and transported for disposal using the same trailers that delivered the new PCUs. This provided significant cost savings in contrast to rigging, hauling, and disposing of mixed loads.

In the demolition period, two unexpected issues seriously jeopardized the schedule and caused concerns about the ability to complete the work within the allowable time. Excessive corrosion due to leaking joints over time had caused the bearing plates to seize, adding 45 minutes to one hour to the time allotted for the removal of each girder in four of the seven segments.

Additionally, the existing deck slab and ends of the facia girders were encased in a large quantity of concrete with welded rebar. This required significant hand demolition with small tools to release the segments, adding nearly two hours to the removal of the north fascia beam.

To mitigate some of the impacts, the team resorted to performing certain other works—such as excavation behind the back walls, preparation of beam sets, installation of bearings, and forming new back walls—concurrent with the remaining removal work. These activities were originally scheduled to be performed sequentially, given the considerable lack of available space.

Bringing It All Together

The onset of the PCU assembly began at midnight on Saturday, nearly six hours behind schedule despite all efforts to regain time during the demolition. Additional crews were called to the site to expedite the performance of the remaining work in an effort to regain some of the lost time.

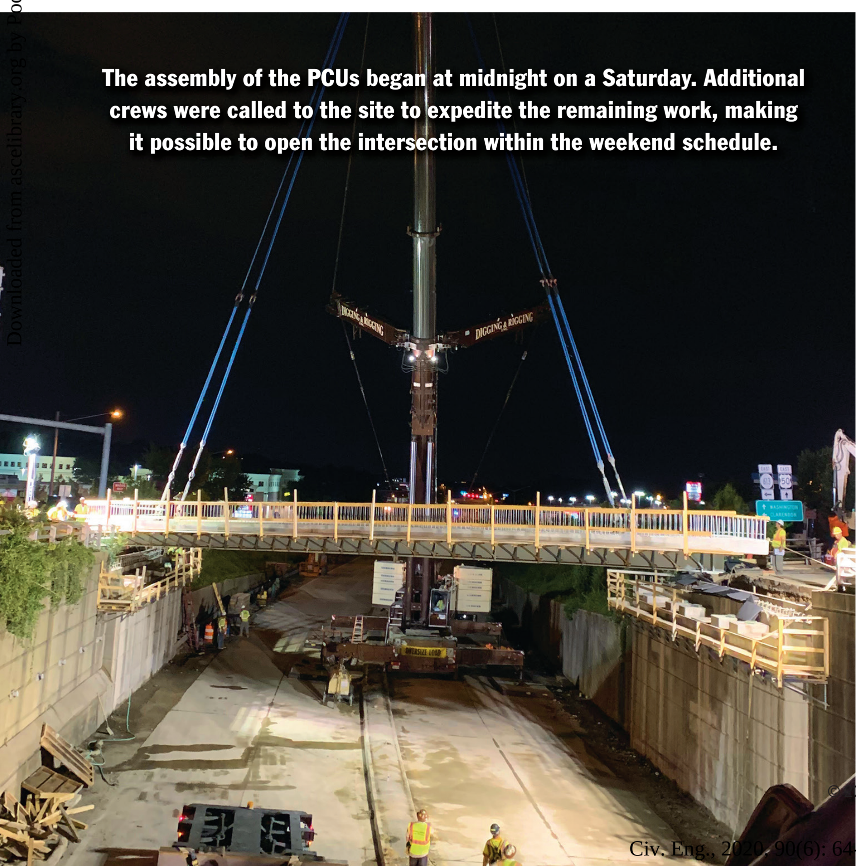
Anticipating conflicts between the reinforcing bars of the adjacent units during the installation, all the end bars along the skew of the bridge were bent in line with the transverse reinforcement. However, it was not until the second PCU was lowered for fit-up that it was discovered that the camber of the first segment, which was already in place, conflicted with the ends of the bars on the second. This was noticed while the second unit was supported by the crane; the bars were preventing the PCU segment from sliding laterally into position. Adjustments to accommodate this differential in camber further slowed the installation process and required additional efforts during the forming process to make up the time.

Among the more challenging tasks during the construction phase of the weekend closure was the simultaneous placement of the two closure sections between the three PCUs. Given that traditionally the rapid-setting LMC-VE is workable for less than 20 minutes, there were concerns that if the two closures were placed consecutively, the truck traversing the deck for the second placement would deflect the deck while the concrete in the first placement had begun to set but had not yet gained sufficient strength. However, given the time constraints, allowing the first placement three hours to cure before starting the second placement was simply not an option.

To address these concerns, MCC worked closely with its concrete supplier (Heartland Concrete, of Petersburg, Virginia) and VDOT's materials department to add retarders and plasticizers to the mix to extend the workability to nearly 40 minutes. With preparations made to have two mobile concrete mixers on the deck, this would allow the crews to simultaneously place and finish the concrete in the two parallel closure placements as the two trucks progressed slowly along the deck at the same time. To reduce the differential deflection between the PCUs as much as possible, additional care was taken to ensure that the two trucks were offset along the length of the deck in proportion to the 33-degree skew angle of the bridge at the start of and during the process.

Providing an appropriately customized concrete mix and strict adherence to placement, finishing, and curing requirements provided by VDOT and the American Association of State Highway and Transportation Officials resulted in a high-quality concrete deck and closures without any shrinkage cracking.

The concentration of businesses and high-traffic volumes in the area increased complications



The assembly of the PCUs began at midnight on a Saturday. Additional crews were called to the site to expedite the remaining work, making it possible to open the intersection within the weekend schedule.

PHOTOGRAPH COURTESY OF WSP

The structurally deficient overpass, which had a sidewalk on one side and a curb on the other, was replaced with a stronger, safer, and longer-lasting version with sidewalks on both sides.

PHOTOGRAPHS COURTESY OF VDOT

in dealing with construction logistics. To address these challenges, coordination meetings with WSP USA, Martins Construction, VDOT NOVA, the City of Falls Church, and Fairfax and Arlington Counties were held to address issues beforehand in a collaborative manner to identify and avoid potential risks. Extensive traffic analysis ensured that the detours included in the transportation management plan could accommodate the traffic variations caused by the extended roadway closures needed for the weekend construction. All these efforts enabled the project to be delivered successfully and on time.

VDOT realized the value of advanced public outreach to the community. The public was notified weeks ahead of time to avoid the area through several media outlets, including local news channels, newspapers, and social media sites like Twitter and Facebook. The true success of the project was measured by the fact that no complaints about the project were registered with VDOT NOVA, something that is very rare for construction projects today.

The EB Wilson Boulevard over Route 50, ABC Weekend Superstructure Replacement Project was the first ABC, full-superstructure replacement using PCUs in VDOT NOVA. Applying this methodology enabled the Seven Corners intersection to remain fully functional throughout the summer months, which minimized disruption to the community and ensured normal traffic mobility. Through advanced planning, close coordination, and well-timed execution, the team delivered the superstructure replacement in just 54 hours—in time for the bridge to open to traffic by 4:30 a.m. on Monday.

The project was a huge success for the Seven Corners community and demonstrated this specific ABC method as an ideal option for superstructure replacement in areas in which traffic congestion is a significant issue. **CE**

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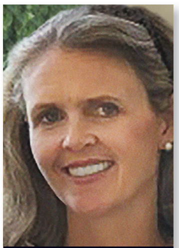
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PROJECT CREDITS **Client** Virginia Department of Transportation's Northern Virginia District **Structural, civil, and traffic engineers** WSP USA, Herndon, Virginia, office **Contractor** Martins Construction Corp., Falls Church, Virginia