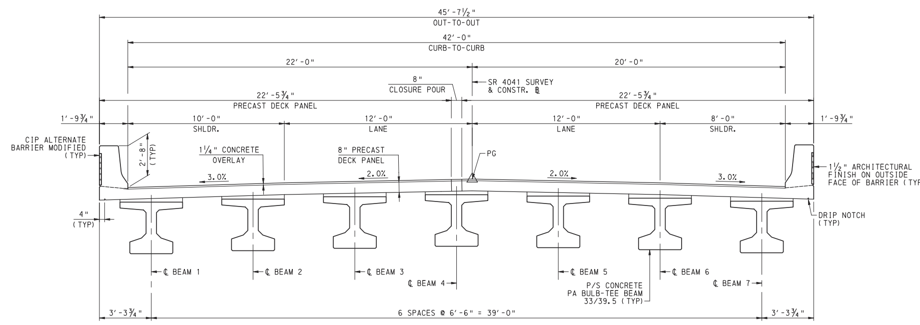
PROJECT

Interstate 78 Bridge Undercleareance Project

by Brian Brawand, Alfred Benesch & Company



State Route 4041 bridge cross section. Figure: Alfred Benesch & Company.

The Pennsylvania Department of Transportation (PennDOT) District 5 recently replaced six overhead bridges located consecutively along an 8-mile stretch of Interstate 78 (I-78) in western Berks County, Pa. This project, which spanned the 2016 and 2017 construction seasons, used accelerated bridge construction (ABC) techniques and featured the first implementation of full-height precast concrete cantilever abutments for PennDOT. The bridges were replaced to increase the minimum vertical clearance over I-78 from approximately 14 ft to 16 ft 6 in. and accommodate the future widening of I-78. As part of the project, approach roadways and ramps were reconstructed to accommodate the roadway profile and width modifications.

All six replacement bridges are single-span precast, prestressed concrete bulb-tee beam bridges that include aesthetic features such as an architectural finish and color scheme. Most of the substructures consist of full-height cantilever abutments supported on spread footings (one structure is supported on pile foundations). The use of ABC techniques under roadway closures reduced the average construction duration for each structure from one year to 45 calendar days. ABC techniques used on the project included time-based bidding techniques and prefabricated bridge elements, such as precast concrete footings, stem pieces, pedestals, back walls, full-depth deck panels, approach slabs, sleeper slabs, and moment slabs. The table provides an overview for each of the six replacement bridges, highlighting the span lengths, widths, skews, number of precast concrete pieces, and number of calendar days for construction and noting if the bridge is located at an interchange.

Time-Based Bidding

After considering available options, the project team elected to apply an *A + Bx* time-based bidding approach for

Overview of the Six Berks County, Pa., Interstate 78 Replacement Bridges

State Route No.	Span Length, ft	Deck Width, ft	Skew, degrees	Located at Interchange?	No. of Precast Concrete Pieces	No. of Calendar Days for Construction
183	121	53	17	Yes	126	40
419	133	50	30	Yes	146	58
4011	111	58	15	Yes	88	40
4041	115	46	0	Yes	86	44
4043	103	32	0	No	54	37
4045	104	32	0	No	40	40

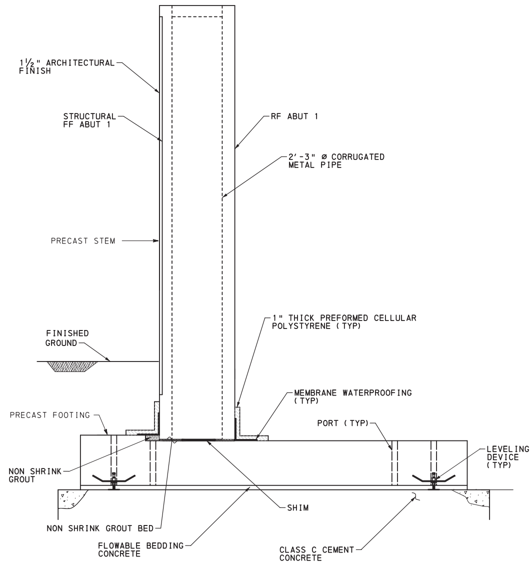
profile

INTERSTATE 78 BRIDGE UNDERCLEARANCE PROJECT / BERKS COUNTY, PENNSYLVANIA

BRIDGE DESIGN ENGINEERS: Alfred Benesch & Company, Allentown, Pa. (engineer of record [EOR] for two bridges); Johnson Mirmiran & Thompson, Allentown, Pa. (EOR for two bridges); Erdman Anthony, Mechanicsburg, Pa. (EOR for one bridge); AECOM, Conshohocken, Pa. (EOR for one bridge)

PRIME CONTRACTOR: HRI Inc., State College, Pa.

PRECASTER: PennStress, Roaring Spring, Pa.—a PCI-certified producer



Typical section of State Route 183 precast concrete stem piece at abutment. The 2-ft 3-in.-diameter corrugated metal pipe was used in stem pieces of two bridges to keep the piece weight within the 50-ton limit. Figure: Alfred Benesch & Company.

this project. The *A* component was the dollar amount proposed by the bidder for construction of a structure. The *Bx* component was the number of days for roadway closure proposed by the bidder multiplied by a road-user liquidated damages (RULD) value calculated by the project team for a given location. The RULD value was based on the average daily traffic at each structure and the associated detour length. There were six separate *A* + *Bx* bidding items as part of the project, one for each bridge. The time-based bidding approach placed significant value on the time component of the bid and helped determine the sequential order in which the bridges would be constructed.

Prefabricated Elements

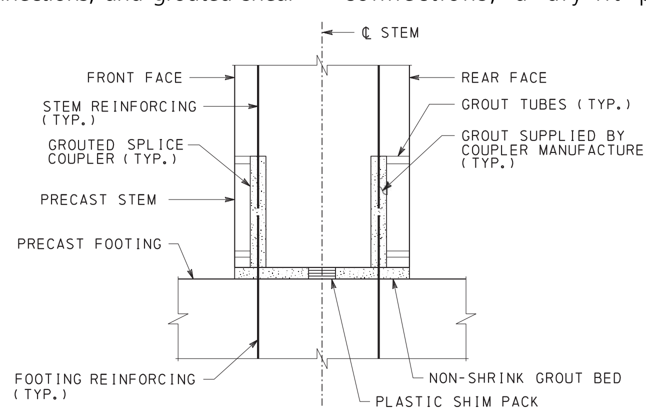
The project used more than 500 prefabricated bridge elements. The precast concrete footing and stem components were the largest prefabricated bridge elements in the project. The precast concrete footing pieces were up to 2 ft 9 in. thick, 18 ft 6 in. long, and 14 ft 6 in. wide. The precast concrete stem components were up to 3 ft 6 in. thick, 30 ft tall, and 12 ft wide. The weight of all precast concrete pieces was limited to 50 tons. On two of the bridges, corrugated metal pipes were used to form voids within the stem pieces to reduce the piece weight and meet the 50-ton requirement. After erection, concrete was used to fill the voids. Some of the prefabricated element connections or concepts for the substructure included overlapping or staggering of the precast concrete stem and footing joints, grouted splice couplers for the precast concrete footing to stem connections, and grouted shear keys between adjacent precast concrete footing and stem pieces.

The full-depth precast concrete deck panel pieces were typically 8 in. thick and less than 14 ft wide to facilitate shipping. The six bridges had significantly different bridge widths; therefore, some bridges used precast concrete deck panel components that extended across the full bridge width while others used two or three precast concrete deck panel components to extend across the full bridge width.

Blockouts in the deck panels, protruding bars from the bulb-tee beams, and ultra-high-performance concrete (UHPC) in the beam pockets were used for the panel-to-beam connections; additionally, longitudinal closure pours with UHPC, transverse joints with shear keys, and longitudinal post-tensioning of the precast concrete deck panels were also used in the construction of the superstructure.

Dry-Fit Procedure

Fabrication of the prefabricated concrete bridge elements required tight tolerances to avoid fit-up issues on site. Given the accelerated nature of the project and minimal tolerances permitted by some of the prefabricated bridge element connections, a dry-fit procedure



Grouted splice-coupler connection detail between precast concrete footing and precast concrete stem. Figure: Alfred Benesch & Company and Johnson, Mirmiran & Thompson.

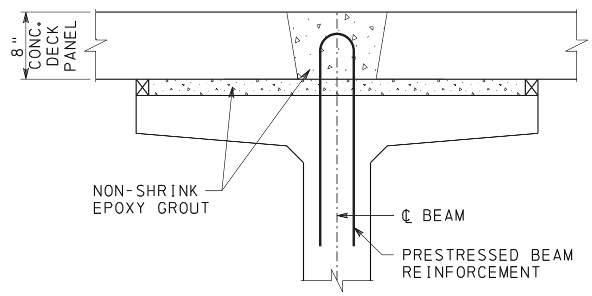
PENNSYLVANIA DEPARTMENT OF TRANSPORTATION DISTRICT 5, OWNER

BRIDGE DESCRIPTIONS: Six single-span precast, prestressed concrete bulb-tee beam bridges that used prefabricated concrete bridge elements for both the substructure and superstructure, including full-height cantilever abutments typically supported on spread footings

STRUCTURAL COMPONENTS: 104 precast concrete footing components, 182 precast concrete stem components, 41 precast, prestressed concrete bulb-tee beams, and 122 precast concrete full-depth deck panel components with bonded post-tensioning tendons

BRIDGE CONSTRUCTION COST: $44.5 million (project cost)

AWARD: 2018 American Society of Highway Engineers East Penn Section Project of the Year (over $20 million in construction costs)



Precast concrete deck panel–to–beam connection detail. Figure: Alfred Benesch & Company and Johnson, Mirmiran & Thompson.


State Route 183 precast concrete footing being erected on site. Photo: Alfred Benesch & Company.

completed at the fabricator's storage yard was required for the project. These connections included the grouted splice-coupler connections between the precast concrete footing and stem pieces and the connection between the precast concrete beams and deck panels.

The substructure dry fit was completed by initially placing all of the precast concrete footing pieces for one abutment in place. Each precast concrete stem piece was moved to a sand bed staging area where it was rotated into a vertical position. The precast concrete stem piece was then lifted, brought to the footing area, and lowered into place over the splice couplers to ensure proper fit. The stem piece was removed, and each additional stem piece was subsequently checked for fit. The superstructure dry fit was completed by initially placing all, or a portion of, the precast concrete bulb-tee beams for a structure into place. Precast concrete deck panel pieces were lifted and placed onto the beams to ensure proper fit of deck panel beam pockets and bars protruding from the beams.

Demolition and Construction

Demolition of the existing three-span bridges' end spans and abutments was completed during normal work hours. Demolition of the center span over I-78 was completed at night while the roadway below was protected with timber mats. Traffic on I-78 was maintained, depending on the specific bridge location, with use of a ramp around the construction or a detour route. Piers adjacent to the I-78 shoulders were removed with the use of protective shielding.

The major construction activities required for substructure construction included the following:

Precast concrete footings:

- Placement of subfoundation concrete
- Placement of shims to proper elevation
- Erection of precast concrete footing pieces
- Placement of flowable concrete underneath footing
- Placement of grout in transverse joints between adjacent footing pieces

Precast concrete stems:

- Placement of shims to proper elevation
- Placement of grout on top of footing
- Erection of precast concrete stem pieces
- Installation of temporary bracing
- Injection of grout into splice couplers
- Placement of grout in transverse joints between adjacent stem pieces

State Route 183 precast concrete stem and footing undergoing fit-up procedure at precast concrete plant. Photo: Alfred Benesch & Company.

Erection at the State Route 4045 bridge of the precast concrete stem piece. Note the stone-like architectural finish. Photo: Alfred Benesch & Company.

AESTHETICS **COMMENTARY**

by Frederick Gottemoeller

Overpass bridges on freeways have a very limited time to make an aesthetic impression because their "audience" is typically traveling at 55 to 75 miles per hour. From the point at which the bridge is close enough for its components to be discerned (no more than 1500 ft away) to the point at which the bridge is so close that travelers are looking through and beyond it (perhaps 300 ft away), just 10 to 12 seconds elapse. Only the largest elements can be seen from the traveler's perspective. Therefore, making a memorable impression requires visual simplicity.

When overpass bridges are closely spaced, similarity is also very important. While moving at 70 miles per hour, travelers see the six bridges of the Interstate 78 (I-78) Underclearance Project at a rate of about one every 1 minute and 10 seconds. Imagine the aesthetic effect if the bridges' appearances were all different!

The I-78 bridges make their visual impression with only four significant elements:

- The brown concrete bulb tees
- The rough gray form-liner "stone" of the abutment wing walls
- The smooth, gray horizontal band of concrete at the tops of the wing walls, which follows the roadway slab across the bulb tees and visually ties the whole bridge together
- The same gray rough "stone" on the parapet face

At a more detailed level, the designers took the trouble to make sure that the form-liner stone actually looks like a real stone wall. Each stone is stained a slightly different color, which provides visual texture. Plus, at the corners, the same stones and mortar lines appear on each wall face. As a final effective detail, the deepening of the horizontal band at each beam seat nicely frames the bulb tees. For travelers on I-78, these visually simple, elegantly detailed new bridges must represent a significant visual improvement on their three-span predecessors.

Precast concrete beams and deck panels were erected at night, and I-78 traffic was maintained, depending on the specific bridge location, with the use of a ramp around the construction or temporary 15-minute closures of I-78.

The major construction activities required for precast concrete deck panel construction included the following:

- Erection of the precast concrete full-depth deck panels
- Placement UHPC in the transverse joints
- Tensioning and grouting of longitudinal post-tensioning
- Placement of UHPC in the composite reinforcement blockouts, haunches, post-tensioning anchor blockouts, and longitudinal closure pours

Major construction activities to complete construction of a typical bridge included precast concrete sleeper slab and approach slab construction, cast-in-place concrete parapet construction, deck milling, and placement of the latex-modified concrete overlay.

Conclusion

The I-78 Bridge Underclearance Project was a successful PennDOT District 5 ABC project, featuring the first implementation of precast concrete full-height cantilever abutments for PennDOT. The project replaced six bridges over two construction seasons with an average construction duration of 45 calendar days per bridge. The use of prefabricated concrete bridge elements and a time-based bidding technique were both critical aspects of this PennDOT District 5 ABC project.

Brian Brawand is a project manager in the Structural Group of the Allentown, Pa., office of Alfred Benesch & Company.

At the State Route 183 bridge, ultra-high-performance concrete is placed to fill the beam-to-deck panel connections. Photo: Alfred Benesch & Company.

Elevation view of the State Route 4045 constructed bridge. Exposed concrete surfaces have been stained to enhance the appearance of formed-stone surfaces. Photo: Alfred Benesch & Company.