Rapid Bridge Replacement Lessons Learned

PennDOT's $1.1 billion, 558-bridge replacement program produced many lessons that will help the commonwealth—and other states—on future projects

by Tom Macioce, Pennsylvania Department of Transportation

The Pennsylvania Department of Transportation (PennDOT) has one of the largest and oldest bridge inventories in the country. In summer 2019, Plenary Walsh Keystone Partners (PWKP), the development entity on PennDOT's major Rapid Bridge Replacement (RBR) project, started construction on the project's final bridge. This multiyear, $1.1 billion program allowed PennDOT to fully replace 558 poor-condition structures.

Choosing a Public-Private Partnership

The project was accomplished through a comprehensive public-private partnership (P3) arrangement. The consortium of companies in PWKP included Plenary Group USA Ltd. and Walsh Investors LLC, which are providing financing and long-term management; a joint-venture lead construction team of Walsh Construction Company and Granite Construction Company; HDR Inc., the lead design firm; and Walsh Infrastructure Management, which will provide maintenance on the completed bridges for 25 years.

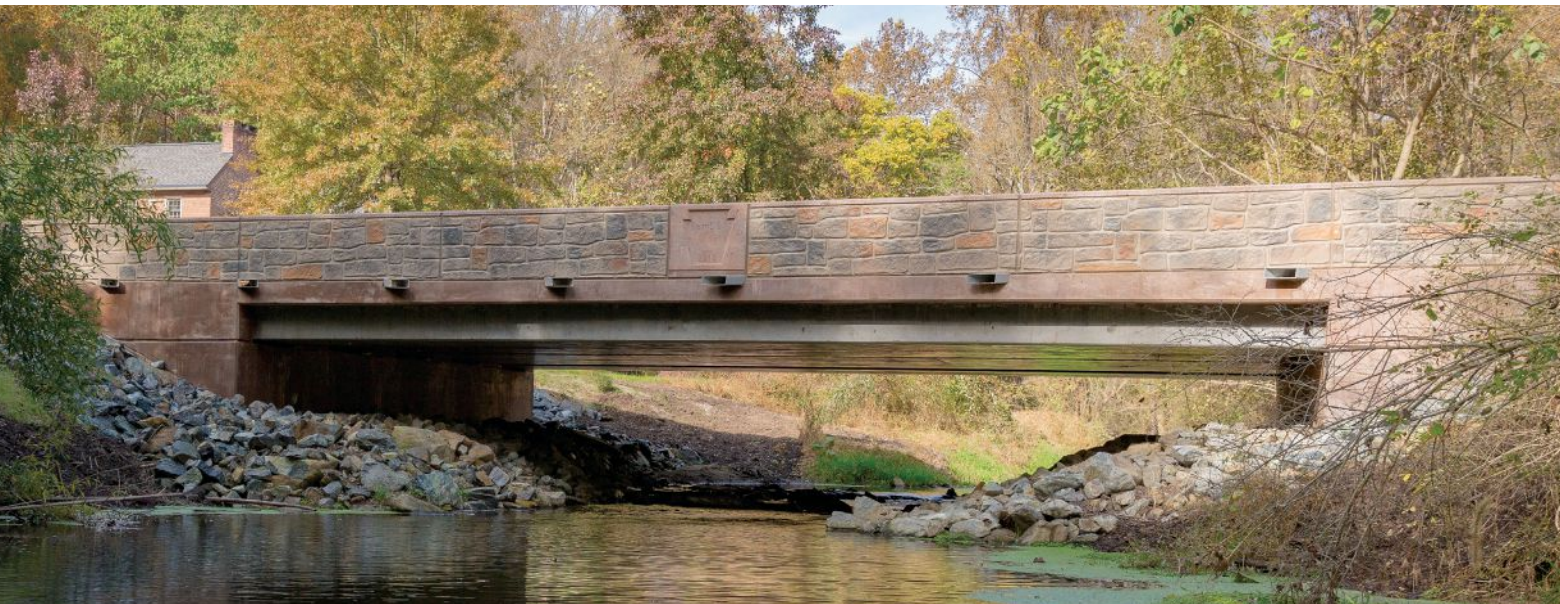
More than 2000 poor-condition PennDOT-owned bridges were screened prior to issuing the request for proposals (RFPs). A host of factors were considered in the screening process, including a bridge's age, length, number of lanes, and average daily traffic, as well as the structure's impact on utilities, railroads, and the environment. Most of the bridges selected were small—mostly single-span, two-lane structures—with similar characteristics.

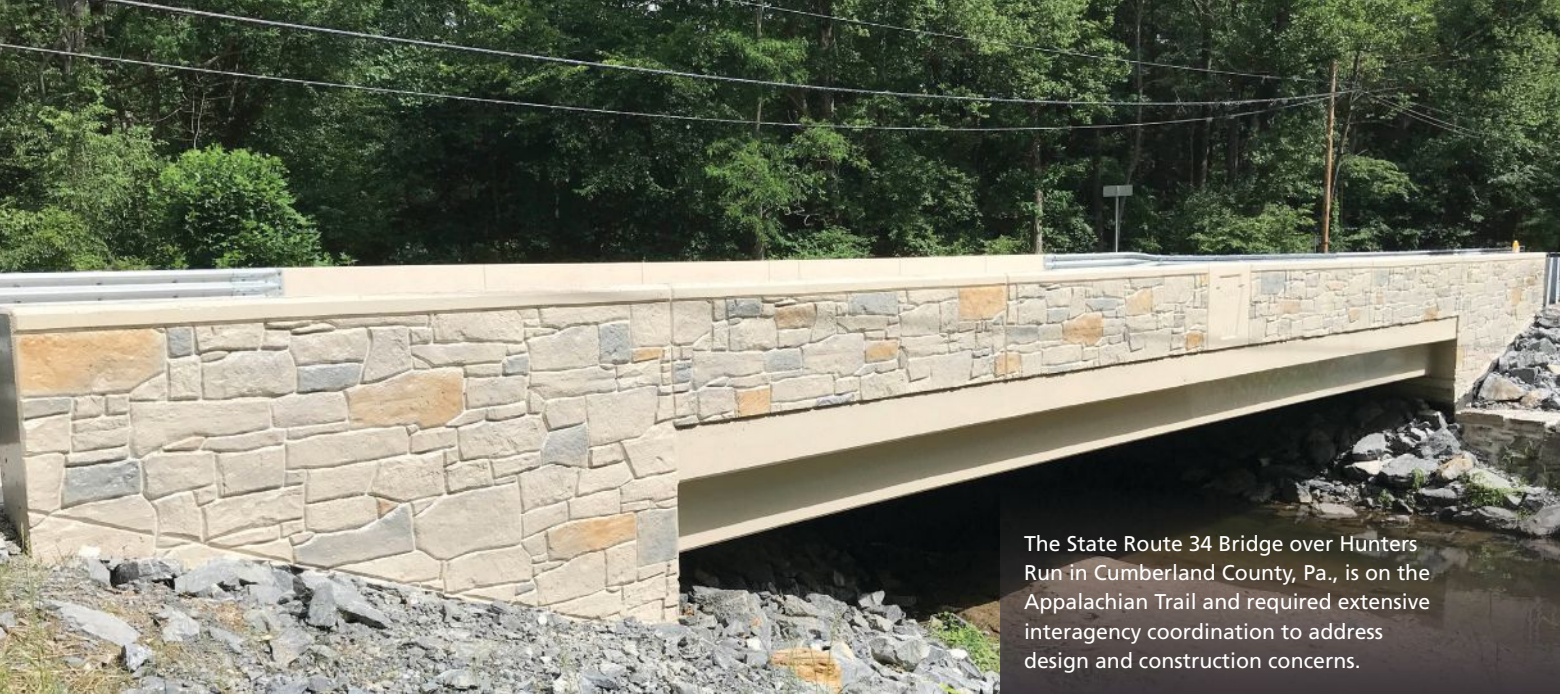
Developing the P3 required significant effort involving requests for information, RFPs, the actual contract, and the development of the technical provisions. More than 1000 documents were saved in 29,000 files, requiring 37 gigabytes of memory.

Four teams were invited to submit final proposals, and the PWKP team was ultimately chosen based on scoring that considered cost as well as the team's financial capability, background, experience in managing comparable projects, understanding of the work involved, and technical approach.

Construction began in 2015. PennDOT's RBR project was the first in the nation to bundle the full replacement of hundreds of bridges in a single P3 agreement.

The bridge carrying Kirks Mill Road (Route 2002) over Reynolds Run in Little Britain Township, Lancaster County, Pa., was replaced in August 2018. Located near the Kirks Mills Historic District, this project required extra coordination and monitoring efforts. All Photos: Pennsylvania Department of Transportation.





The State Route 34 Bridge over Hunters Run in Cumberland County, Pa., is on the Appalachian Trail and required extensive interagency coordination to address design and construction concerns.

The P3 model promised enticing benefits. In addition to leveraging private investment funds, it was expected to increase efficiency by focusing contracts on bridges of similar size and design, which would allow components to be mass-produced, resulting in time and cost savings.

Unfortunately, actual efficiencies did not match projections due to a variety of reasons. With such a large-value contract and a new delivery method, there were bound to be challenges, unforeseen issues, conflicts to resolve, and nonconformances.

Scheduling Challenges

The requirements for the RBR project were significant, and PWKP essentially assembled a department-of-transportation-like organization within six months to perform preliminary engineering, final design, letting of subcontracts, construction, inspection, and maintenance.

Above all, the project was driven by scheduling, and the partnership hoped to derive key benefits from grouping bridges in a geographic region. However, to advance construction effectively, some bridges were delayed, ending the geographically coordinated effort. PWKP chose to bid many bridges to subcontractors, and this change resulted in many bridges being bid one at a time.

Also, the bridges had varying degrees of complexity, similar to PennDOT's regular program. Some sites were complex and therefore required more extensive planning and additional time to design and/or construct. Complexities included railroads, consideration of historic sites, difficult right-of-way acquisitions, and multiple aerial and subsurface utility relocations.

With "rapid" included as a key metric in the project, PennDOT established limited construction times for projects that contained detours to minimize the impact on the traveling public. Depending on the type of structure, traffic closures were set at 12, 75, or 110 days. If bridges did not meet these schedules, monetary penalties were incurred. In addition, there were incentives, in the form of accelerated availability payments, to complete bridges ahead of schedule.

To allow construction to begin as soon as possible, PennDOT developed conceptual plans and hydrologic and hydraulic reports, and acquired waterway permits and right-of-way for 87 bridges earmarked for early completion. PWKP then developed final design plans and built these bridges. However, PWKP chose to revise roughly half of the conceptual plans, which meant that the waterway permits

Table 1. Existing Bridge Types Replaced with PennDOT's Rapid Bridge Replacement Project

Bridge Superstructure Type	Number of Bridges Replaced	Subtotal (Percentage of Total Bridges)
Cast-in-place concrete T-beams	200	
Cast-in-place concrete slab or frame	55	
Prestressed concrete box beams	39	
Cast-in-place concrete closed spandrel deck arch	19	
Precast concrete channel beams	4	
Prestressed concrete I-beam	1	
Replaced concrete superstructure subtotal		318 (57%)
Steel beams or girders	165	
Concrete encased steel beams	68	
Steel through truss	3	
Steel pipe arch culvert	1	
Replaced steel superstructure subtotal		237 (42%)
Masonry closed spandrel deck arch	3	
Replaced other superstructure subtotal		3 (1%)
TOTAL	**558**	

Source: Table compiled from data at www.dot.state.pa.us/public/Bureaus/Press/P3/P3RBRBridgeList.xlsx.

Table 2. Replacement Bridge Types Constructed under PennDOT's Rapid Bridge Replacement Project

Bridge Superstructure Type	Number of Replacement Bridges	Subtotal (Percentage of Total Bridges)
Prestressed concrete box beams	342	
Precast concrete culvert	177	
Prestressed concrete bulb tee	17	
Constructed concrete superstructure subtotal		536 (96%)
Folded steel plate girder	7	
Steel beam	3	
Constructed steel superstructure subtotal		10 (2%)
Other	12	
Constructed other superstructure subtotal		12 (2%)
TOTAL	**558**	

Source: Table compiled from data received from Walsh-Granite.

required revisions, delaying the start of construction.

Documentation and Informational Challenges

One basic need for the project was a data and document management system. PWKP selected a different system than that used by PennDOT. Had both parties used the same system, construction management probably would have functioned more efficiently.

Another challenge involved the concise definition of the key contractual design information. PennDOT provided the traveled-way geometry (number of lanes, lane widths, shoulder widths, and sidewalks), and the traffic restrictions—namely, whether staged construction or detours would be used, detour duration, road-users liquidated damages, and other restrictions, such as calendar restrictions. However, the concise nature of the contractual design requirements led to mixed results. For example, on smaller bridges, providing one soil test boring per substructure unit produced a successful outcome, but some restrictions were not as clearly defined as intended, eventually resulting in change orders.

Determining Risk Decisions

Deciding which approvals to retain and which to transfer to PWKP was a key risk decision for PennDOT. The contract gave PennDOT approval authority on prefinal design-type submissions to ensure that the bridge and roadway geometries were properly designed, but the final design was completed by PWKP and did not require PennDOT's approval.

The bridge specifications were written to be prescriptive, while other disciplines, such as roadway design, were afforded more flexibility. Limited options for several bridges where design issues arose resulted in difficulty achieving approvals.

Inspection Challenges

Because the design was managed in Pittsburgh, where PWKP is based, and PennDOT is based in Harrisburg, weekly shoulder-to-shoulder meetings were established.

For on-site inspection, an independent quality-acceptance firm hired by PWKP was used. This firm reported to both PWKP and PennDOT; it did not report to the construction joint-venture. The decision to transfer quality-acceptance inspections to a design-build team required careful and comprehensive considerations. While PennDOT would not necessarily preclude the use of design-build team quality-acceptance inspections on future P3 projects, the contract requirements would be modified from the RBR project.

During the first two years of the project, individual quality-acceptance inspectors were responsible for up to three or four bridges, with scheduling based on their presence at key construction activities identified as "hold points." To improve inspection quality, one inspector was assigned per bridge for all bridges constructed after the second year.

Maintenance Phase

For 25 years PWKP will maintain waterway channels 50 ft upstream and downstream of each bridge, and will perform annual cleaning of bridge decks and beam seats on a five-year cycle. A maintenance plan, including maintenance of the guiderail system, pavement, and bridge structure, was developed for each bridge. PWKP will also perform the required National Bridge Inspection Standards biennial bridge inspections.

In the interest of cost-effectiveness, PennDOT kept certain maintenance items in-house. For example, PennDOT crews will plow snow from bridges because they are already clearing roadways.

PennDOT anticipates that on future P3 projects, guiderail and pavement maintenance may be retained in-house because PennDOT believes it can perform this work more efficiently than a contractor could.

As bridges opened to traffic, maintenance phases began. With the 25-year maintenance term, the first bridge will be returned, or "handed back," to PennDOT in 2040. Some features, such as the asphalt approach

Spanglers Mill Road Bridge crosses Yellow Breeches Creek in Cumberland County, Pa., a waterway used recreationally for boating and fishing. The bridge site was the location for the October 2014 press event announcing selection of Plenary Walsh Keystone Partners for the public-private partnership agreement.

pavement, will be returned after five years.

Approximately one year in advance of handing back a bridge, a joint PennDOT-PWKP inspection will be conducted to determine the condition rating of key elements of the bridge. As per the contract terms, 98% of the bridges must have a condition rating of at least 7 for all elements, and 100% of the bridges must have a condition rating of at least 7 for the superstructure.

Payment Structure

During the design and construction terms of the project, PWKP was paid by PennDOT through a mobilization payment, milestone payments, and availability payment made as bridges were constructed and opened to traffic. In addition, PWKP leveraged funds from shareholders in the consortium and from lenders. With these payments, PWKP pays the design and construction joint venture of Walsh-Granite and the maintenance entity, Walsh Infrastructure Management. Then, in the maintenance term, PennDOT will pay availability payments over a 25-year period.

Accelerated Delivery

The RBR project provided an opportunity to accelerate the delivery of replacements for poor-condition bridges. By focusing on bridges of similar size and design (typically, single-span bridges or culverts), PennDOT and PWKP could use similar designs and achieve economies of scale, optimizing the ability to complete the design and construction of individual bridges more quickly. PennDOT estimates that a comparable replacement project using conventional contract procedures would have taken 8 to 12 years, whereas this P3 project compressed the schedule to approximately 5 years.

Lessons Learned

All projects bring with them an opportunity to learn. Given the alternative delivery vehicle used to procure a private partner, as well as the project's size (558 individual locations across the entire state of Pennsylvania), the RBR project provided numerous opportunities for PennDOT to experience new ways of managing and coordinating projects; learn or adapt processes to expedite project development; improve internal and external communications; and gain a better understanding of how performance-based contracting works.

Overall, this project achieved PennDOT's key goals of accelerating construction for the replacement of poor-condition bridges, minimizing impacts on the traveling public, continuing to ensure public safety, and improving system connectivity and mobility for commerce. It provided an approach that could be used again with lessons learned from this project implemented.

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