

# Construction of the Hawk Falls Deck Arch

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ABSTRACT: This paper examines the inherent challenges faced during the erection of the 480-foot Hawk Falls Deck Arch Bridge. The decision-making process surrounding the use of falsework towers versus tie-back systems is explored in detail, highlighting the trade-offs in terms of stability and construction efficiency. The paper highlights the unique challenges and complexities posed by the three variable camber arches, which required careful consideration for fit-up during erection.

## INTRODUCTION

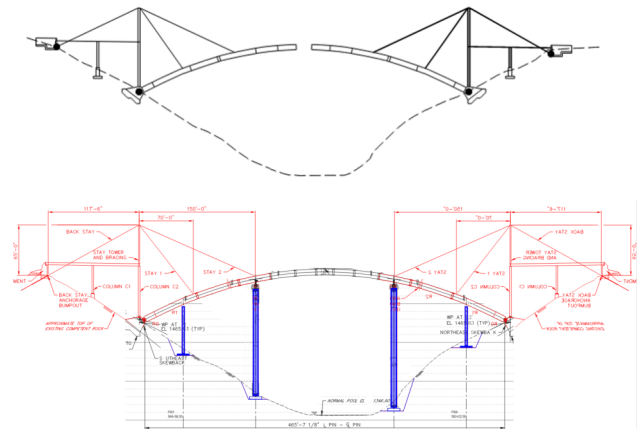
The Pennsylvania Turnpike Commission (PTC) recently undertook the replacement of the 1950s Hawk Falls truss bridge over Mud Run on the Pennsylvania Turnpike Northeast Extension (I-476). The outdated truss bridge is being replaced with a new, visually appealing arch bridge that complements the natural beauty of Hickory Run State Park. This bridge spans a deep gorge, a favorite spot for hikers and anglers in the Pocono Mountains near Albrightsville, Pennsylvania.

The new bridge is a 720-foot-long steel structure featuring a 480-foot deck arch span, flanked by four 60-foot deck plate girder spans. It includes three arches, each composed of 11 segments. Each arch measures 465 feet in length with a rise of 61 feet.

Construction of the arches began in the fall of 2023 and was completed by the summer of 2024.

## GENERAL CONSTRUCTION METHODS

As is the case with many complex bridge structures, the contract plans included theoretical erection sequence of the 480-ft arch structure. The designer's erection sequence used tiebacks to support the arch segments cantilevering out into the valley.



The project team moved away from the conceptual tie-back system of arch erection to the use of falsework towers once the determination was made that adequate access roads could be installed to facilitate construction of the necessary falsework foundation locations. Additionally, the

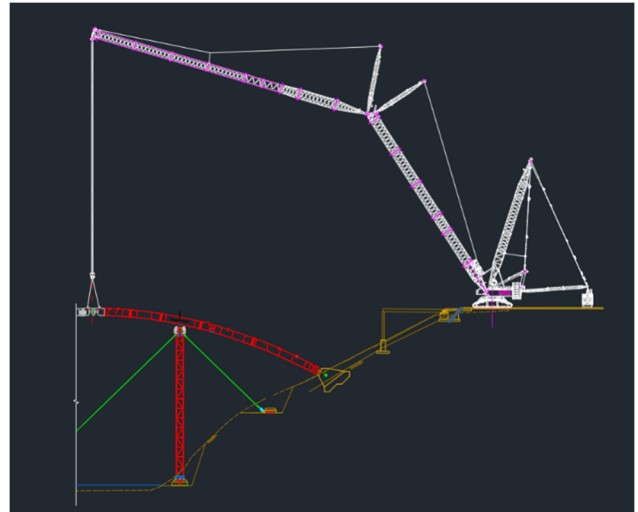
contractor had enough in-house falsework towers to facilitate the project and only minor modification to the tower sections and header beams would be required.

The tie-back to tower concept change required additional upfront engineering to understand any modifications required of the permanent structure. The EOR designed in the construction loads to the tie-back construction method but not the falsework tower method. Ultimately minor modifications to the permanent skewback bearings and reinforcing the anchor bolts in the skewback bearing were required.

Efficiently developing temporary works details and working those details into the steel erection planning process was critical to the success or failure of the project.

### **ARCH ERECTION CRANES**

A 1,200T Liebherr LR11000 Crawler Cranes was positioned behind each abutment to erect the arch rib segments. Each crane consisted of 520ft of boom and 1.5 million pounds of crane counterweight and required a total of 70 truckloads of parts to assemble. Each crane required two weeks of assembly time using a 250T Liebherr LTR1220 assist crane. The segment lifts ranged from 200ft to 415ft of radius. Several of the lifts became critical, several exceeding 85% capacity, and required planning and coordination.





## ARCH ERECTION & TEMPORARY WORKS

**ERECTION OVERVIEW** - Each of the three arches consisted of 11 field segments. All but the keystone piece was symmetric about the bridge centerline. Arch segment weights varied from 60 kips to 200 kips. To facilitate erection, the segments became shorter and lighter near the midspan. The permanent arch lateral bracing was a series of moment frames consisting of (2) intermediate struts located near the 1/3 points of the arch and (2) main struts located at the bridge CL in the keystone piece.

The temporary works required for arch erection consisted of temporary wind bracing, 4 falsework tower lines with two unique designs, a temporary frame around the spring line bearings to handle construction forces, and an erection pin at the closure splice.

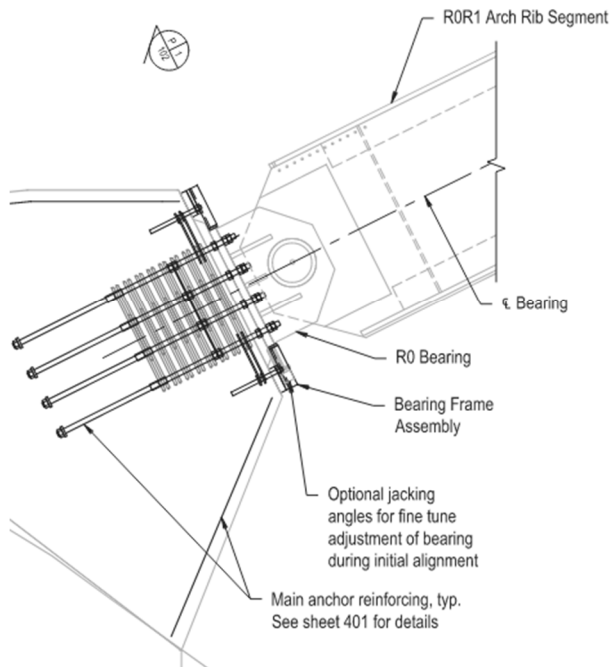
**TEMPORARY WIND BRACING** - The intermediate struts were located at the second arch rib segment. Therefore prior to installation of the second rib and intermediate struts a temporary wind brace system was required. The wind brace consisted of a K-frame with horizontals at the arch ribs located near the shorter falsework towers. The k-frame diagonals

extended from the falsework tower to the spring line bearings. The diagonal was detailed with custom end connections with threaded rods and a tapped end plate to accommodate both length and rotation adjustments during installation. Temporary wind braces provided lateral bracing of the short falsework towers and were particularly critical prior to grouting the spring line bearings.



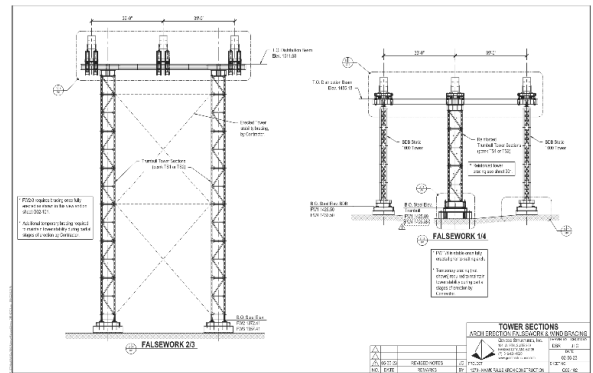
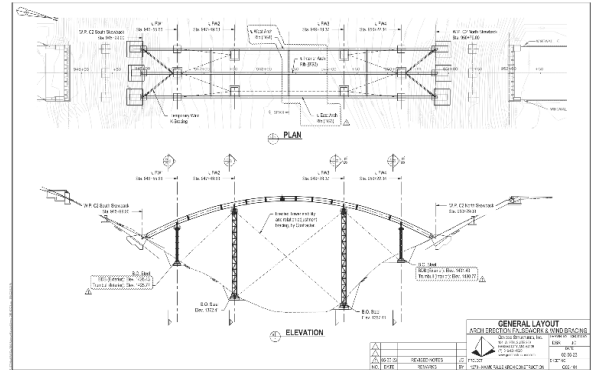
**BEARING FRAMES** - The permanent bridge spring line bearings consisted of (2) 18" diameter pins aligned with the arch rib webs and (16) 1 3/4" diameter anchor bolts. A 4" grout pad was provided between the bearing base plate and the face of the permanent skewback substructure. Prior to grouting the bearings, the exposed anchor bolts were unable to support the temporary

forces anticipated during construction. Therefore, a temporary bearing support frame was designed to provide a load path for vertical and lateral shear forces from the bearing into the skewback. The support frame also provided a convenient "shelf" to hold up the bearing after the first segment was released from the crane.



**FALSEWORK TOWERS** - A total of 4 falsework tower lines were required for arch erection. Only two unique tower designs were required due to the arch symmetry. The tower lines were referred to as FW1/4 (shorter towers) and FW2/3

(taller towers).



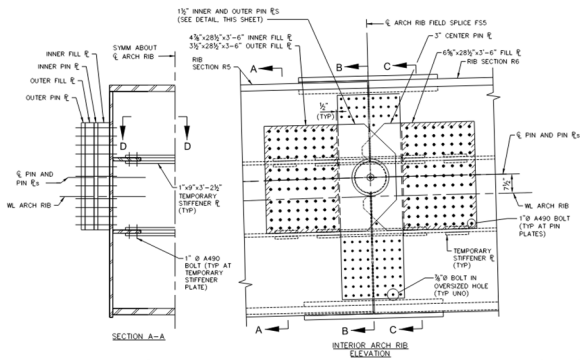
FW1/4 was designed to support the first arch rib segments and remained in the system until FW2/3 was installed. The structural system consisted of one stiffer tower under the center arch and two more flexible towers under the exterior arches. The center tower was the structural "spine" of the system for lateral forces. Any lateral forces from the exterior arches would deliver the load through the header beam to the center tower. All falsework towers were supported by spread concrete footings founded directly on solid rock. The center

tower foundation was anchored to the rock below using grouted high-strength threaded to resist overturning forces. The tower heads were detailed to accommodate adjustment in the vertical and transverse directions. For additional flexibility during the setting of the arch, the tower heads were detailed with a rocker and pintle.

FW2/3 consisted of (2) ~130-ft falsework towers and a robust tower header beam system. Once arch ribs were set on FW2/3, the other tower location, FW1/4, was removed. This was done to simplify geometry control during erection and during the lowering process for arch closure (i.e., only one tower location had to be adjusted during closure). The arch ribs were set high, so the towers only needed to be lowered under the weight of the arch. The tower heads were designed with a vertical adjustable range of +/-3ft. The range was achieved through a plunger system suspended with threaded rods. The threaded rods allowed for fine-tuning adjustments to height. At the time FW2/3 was installed, the arch intermediate braces and the temporary wind braces provided lateral support from wind loads. Due to the extreme tower height and presence of the struts and wind bracing the towers were braced by the arch system. However, prior to supporting the arch ribs, the towers required an intricate bracing system and an engineered installation plan to ensure tower stability. The falsework towers were supported by spread footings founded directly on rock. The size of the spread footings was in part controlled by stability during tower erection. At one tower location, where the footprint of the spread footing was limited, rock anchors had to be implemented in a way that was similar to the center tower at FW1/4.



**ERECTION PIN AT CLOSURE SPLICE-** Closure was achieved with 12" diameter temporary erection pins (2 pins per arch rib). The erection pin was located vertically on the arch to match the bridge camber, which meant that the exterior and interior arch erection pin details varied. The temporary closure pin and connection plates were designed to fit around the permanent splice plates. The concept was developed by the bridge Designer M&M, and the final design was performed by Genesis.



The advantage of the erection pins was it allowed for closure at a range of temperatures. The ends of the ribs could only meet at one common point, the erection pin CL. As the ribs made contact at the erection pins and the towers continued to lower, the weight of the arch was transferred from support by the falsework towers to arch action. The arch action (or axial load in the arch rib and temporary erection pin) force the arch into rotational alignment which allowed for bolt up of the permanent splice connection. The closure splice was detailed with oversized holes in all connection plate and rib interfaces, allowing for more flexibility in the final fit-up.

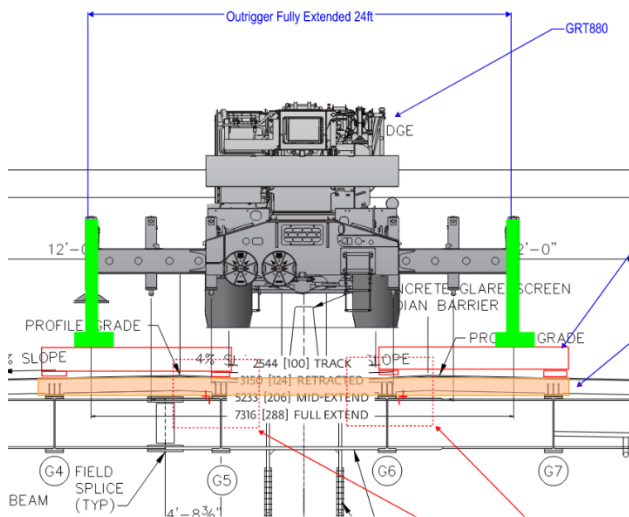


## **SUPERSTRUCTURE CONSTRUCTION WITH CRANES ON BRIDGE**

The large LR11000 crawler cranes were originally considered to complete the erection of the floor system steel following completion of the arch, column & floorbeam erection. The project team moved to the option to use smaller rough terrain cranes on crane mats advancing out from each abutment to finish the steel erection and then support the concrete deck work working from the center of the bridge back towards each abutment.



The crane mat runway provided efficient and safe access for workers to access the leading edge of the work. Use of smaller cranes required a smaller workforce to man equipment and were much more efficient when making smaller picks to support the work.



The span length of 60' and the spacing between the stringers worked well with the selected 12"x4"x30' mixed hardwood crane mats. Outrigger support beams were used to transfer crane loading directly to stringers and angle was used on the underside of the crane mats to retain the mats position between stringers.

## CONCLUSIONS

The construction of the 480-foot Hawk Falls

Deck Arch Bridge presented a series of unique challenges that required meticulous planning and execution.

The project team's decision to go from tie-backs to falseworks towers was not taken lightly. Before changing courses, the project team obtained a detailed understanding of the feasibility of the tower construction, the availability of owned falsework components, and any modifications required to the permanent structure. Collaboration and buy-off of the falsework tower solution were coordinated with the bridge designer before switching construction methods.

The success of the project was a collaborative effort. The bridge designer, contractor advanced planning team, contractors experienced field staff and erection engineering were all pushed and challenged during this project.