The access solutions developed for the 264m-long rail viaduct featured a combination of rotating suspension assemblies, monorails and swing stages

Platforms provided access to the walkway above and the arch below

Swing stages were suspended from monorails beneath the platforms

PLATFORM OF INNOVATION

The rehabilitation of Romania's Caracău Viaduct has seen the delivery of industry-first access solutions, writes Jerry Dolly

Few bridge structures combine beauty, form and function as naturally as a reinforced concrete arch. The Caracău Viaduct, which has a length of 264m and an arch that is 100m wide and rises 64m above a valley floor, is a prime example. Inaugurated in 1897, the original structure was part of a railway connecting Transylvania and Moldova, two of Romania's historical regions. Damaged during World War I and destroyed during World War II, the current structure was built in 1946 and is owned by Căile Ferate Române (CFR), the state organisation responsible for national rail infrastructure.

After the fall of communism in Eastern Europe in 1989, Romania was left with one of the largest, most frequently used, but also ageing, railway networks in Europe. CFR is currently improving its infrastructure, frequently working with Romanian bridge specialist SCCF Mures, which completed work on the Caracău Viaduct in October.

Featuring multiple access challenges, the viaduct served as proving grounds for several innovations, including a patented rotating suspension point assembly and the industry's first use of the Quikdeck rigid multi-point suspended work platform, combined with steel monorails and swing stages.

"Our solution created X-, Y- and Z-axis motion, which provided access to the entire arch workface, including its underside, without the need to constantly move anchor points," says Mathieu Grumberg, director of product development at Brandsafway. "We see the technologies developed for the Caracău Viaduct being applicable to thousands of other ageing concrete arch bridges around the world."

Located in the commune of Livezi, about 300km north of Bucharest, the Caracău Viaduct lies on a section of railway that connects the cities of Miercurea Ciuc and Ghimeş in the eastern foothills of the Carpathian Mountains. Access to the site is not an issue, and staging areas at the east and west ends of the bridge provided a place to store materials and set up work trailers. While the use of traditional scaffold was an option for the rehabilitation project, it would have been at great expense in terms of material, equipment rental and labour costs, and the work schedule would likely have extended for at least three years.

Caracău Viaduct rehabilitation project

Start date: May 2019
Completion date: October 2019
Customer: CFR (National Railway Company of Romania)
Contractor: SCCF Mures

Having recognised the need for new access solutions, SCCF Mures contacted Hünnebeck, a Brandsafway company, and the respective construction and access teams agreed that using suspended work platforms would enable access to the workface. However, even that solution presented complications because the cantilevered concrete pedestrian walkways, which also needed rehabilitation, extend 3m on either side of the railway track, preventing direct access to the arch face. The walkways also precluded suspending work platforms using the two common methods of looping chain over structural members or using clamps connected to trusses. Fortunately, an alternative solution using a suspension point solution was one Grumberg had been familiar with for a decade.

The concrete anchor system Grumberg engineered for the Caracău Viaduct starts with a 20mm-diameter threaded rod made from galvanised or stainless steel. Hundreds of such rods had been permanently installed by SCCF Mures on top of the walkway in 2018, when the contractor had performed maintenance work requiring a rectangular pattern to match the suspension points of the work platform.

This year, a rope access team from Brandsafway installed rotating suspension point assemblies, which have two key functions. First, the chain-to-wire-rope connector rotates around the bolt, as well as the pivots. This means that regardless of the chain angle, the load pulls in a straight line. Second, a spherical washer makes it possible to bolt the assembly to angled structures, an essential function because the walkways taper as they extend out.

"While a threaded rod made sense in this application because drilling through a quarter metre of concrete is easy, these rotating suspension points can also be secured from the bottom side of thick sections with concrete wedge anchors," says Grumberg. He adds that where standard anchor plates for concrete require four bolts, the rotating assembly needs just one, overcoming the need to drill parallel holes. Each assembly holds 4,000kg, which created a 4:1 safety factor for the final viaduct access structure.

The base platform for accessing the arch consisted of suspending the Quikdeck platform beneath the concrete walkways on either side of the viaduct. This rigid platform uses 2.3m-long trusses that connect to central nodes via a pin-and-retainer-clip system. Once pinned, the trusses pivot outward to form squares or triangles when connected to the next node. Workers then secure sections of structural-grade plywood to provide a flat, stable and sturdy work surface with a load rating of up to 366kg/m². Grade 100 chain running through the central nodes connect to the rotating suspension assemblies. Once a starter platform has been erected, Quikdeck's modular design allows a leapfrog-style assembly process to build out the work surface in any direction, without ground access.

The rigid work platform provided access to the underside of the walkway and the top of the arch. It could also support several levels of conventional tube and clamp scaffold, so the platforms could have been suspended in tiers to reach the entire arch. The access teams evaluated this solution but discarded it due to high material rental and labour costs.

Instead, the engineering team decided to access the arch by using swing stages – or powered suspended scaffold. Depending on capacity and length, a swing stage can support up to 680kg, generally enough for two people and associated equipment and materials. Swing stages are typically suspended from fixed anchor points, such as hooks or davit cranes. After completing work in one section, the swing stage is lowered to the ground, moved laterally and reattached to a new set of points.

Using the typical solution, unfortunately, would have meant clearing trees from the valley floor and added delays every time a lateral shift was required. As a more efficient and environmentally sensitive alternative, Brandsafway designed moving suspension points from monorails created by clamping sections of W10 (200mm by 100mm and 15kg per metre) steel I-beams to Quikdeck trusses. By mounting power trolleys on the monorail, the engineering team created a work platform that restoration workers could move laterally and vertically using two pendant controls.

Each Quikdeck platform had two monorails running parallel to the viaduct. One of these was next to the arch and the other on the outside edge of the platform. The inside monorail provided suspension points for a 7m-wide swing stage, and there was one swing stage on either side of the viaduct. These swing stages slid parallel to the arch sides.

The outside monorails provided a suspension point on either side of the viaduct for a single 12m-wide swing stage. Perpendicular to the railway tracks, this swing stage enabled workers to move along the inside curve of the arch without any repositioning delays.

Site work began in June 2019 and was organised into three stages. Using 425m² of Quikdeck on each side of the viaduct and the three swing stages, work started on the west side of the viaduct, moved to the east and finished in the centre.

"The combined access solutions used a minimum amount of materials and labour power while optimising concrete repair work," says Grumberg. "Jobsite efficiency, safety and work quality are a direct result of higher-quality access." The suspension points were removed after the project and returned to rental stock, but the threaded rods will remain in place for future projects ■

Jerry Dolly is general manager of infrastructure services group at Brandsafway