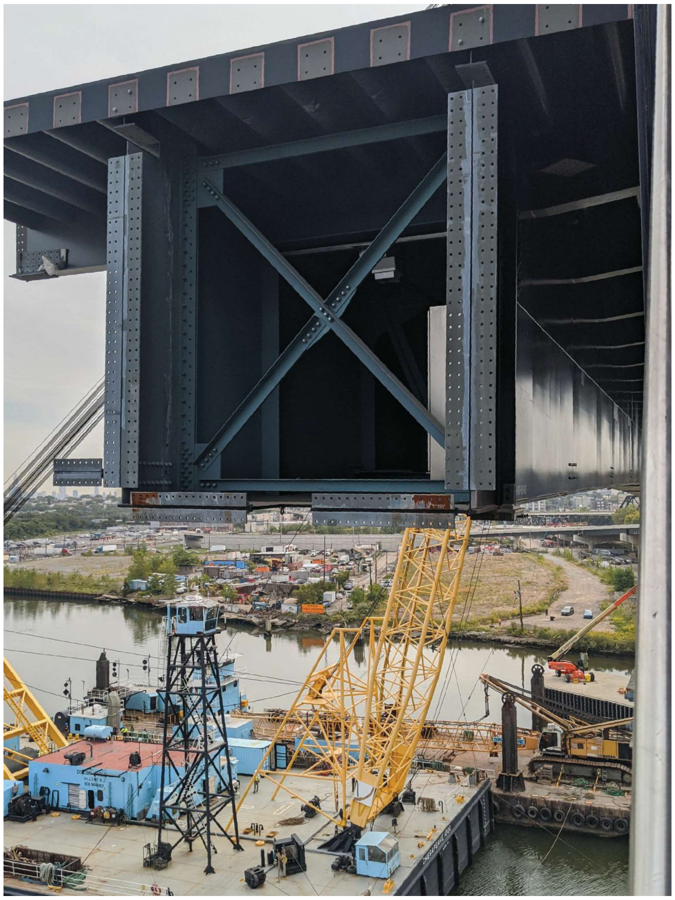
Features

Orthotropic Outlook

Eric M. Helt, PE



Courtesy of CCA Civil »

New Jersey expands its bridge design repertoire by taking advantage of an orthotropic deck solution for a replacement vertical lift bridge.

The new Wittpenn Bridge is New Jersey’s first orthotropic bridge and an integral component of the state’s Portway Corridor project. Courtesy of CCA Civil »

THE WITTPENN BRIDGE is a first for the Garden State.

The new 3,277-ft-long crossing, which carries Route 7 over the Hackensack River between Kearny and Jersey City, is New Jersey’s first orthotropic bridge and an integral component of its Portway Corridor project. It also serves as a symbol of the state’s renewed emphasis on infrastructure redevelopment, especially with the recent passage of the $1 trillion infrastructure bill.

Replacing a deteriorating vertical lift truss bridge built in 1930—which will be demolished and whose four 10-ft travel lanes included no shoulders or any physical separation between opposing traffic—the new vertical lift structure, designed by Jacobs, is wider and safer than the original crossing. In addition to shoulder and median placement, the vertical clearance was doubled from 35 ft to 70 ft in the closed position, reducing the frequency of bridge openings that affect marine and vehicle traffic.

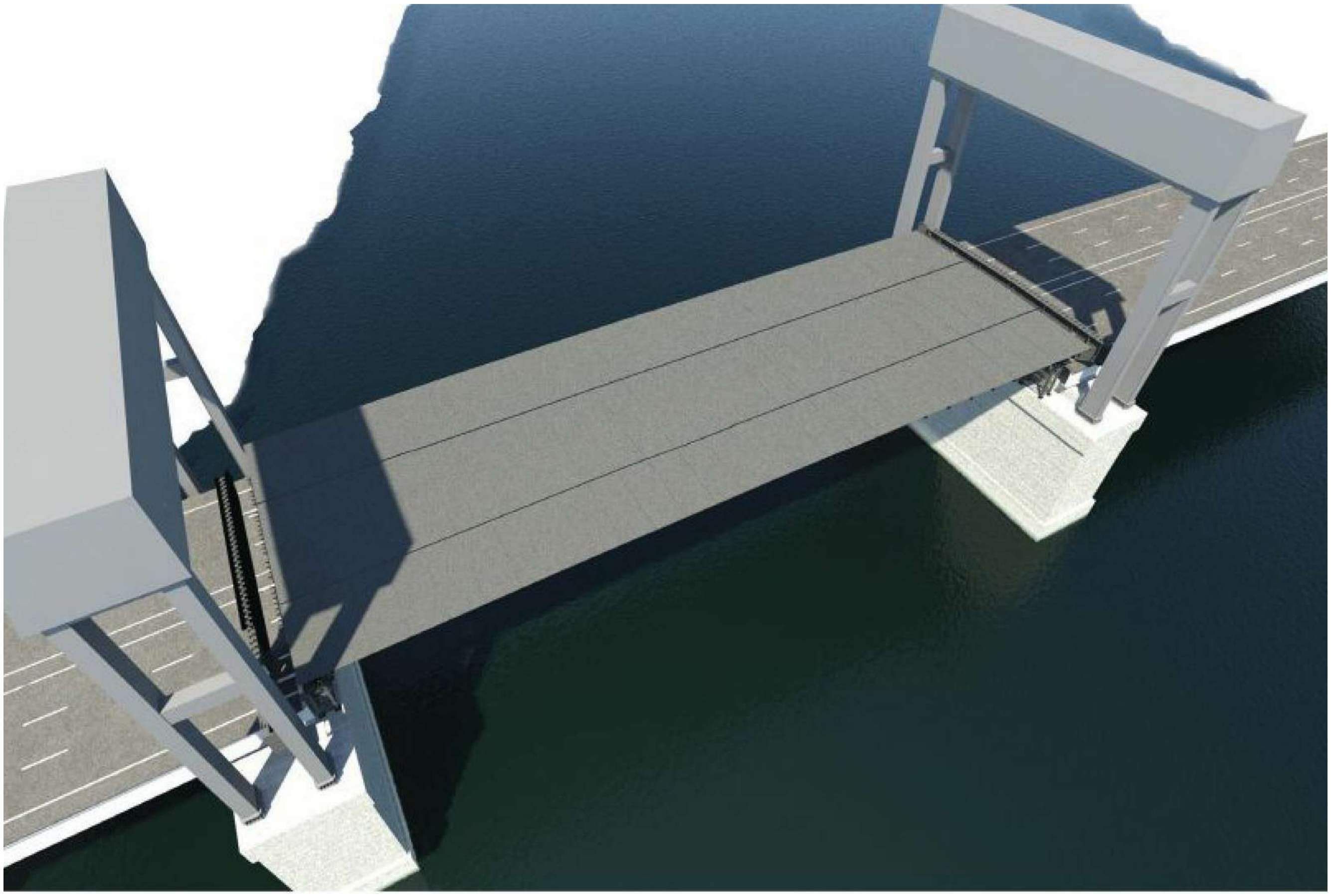
The New Jersey Department of Transportation (NJDOT) divided the project into five separate contracts, allowing work on different portions to take place simultaneously (other phases include connecting exits and demolition of the old bridge and its approach roads). The third contract, awarded to CCA Civil, included the main span vertical lift towers and the main lift span, which is comprised of three steel box girders and a steel orthotropic deck system. The orthotropic approach employs a steel plate deck stiffened either longitudinally with ribs or transversely or in both directions.

Nearly impossible to achieve without the strength of steel, the new bridge's main lift span measures 324 ft long and 110 ft wide and weighs in at nearly 2,500 tons. Fabricated by Vigor, the steel framing scheme features an orthotropic deck system with integrated floor beams and box girders, where the ¾-in.-thick deck serves as the top flange to the U-ribs, transverse floor beams, and primary box girders. This integrated system not only makes the bridge more efficient for such a long span but also allows the deck to directly bear vehicular traffic loads, with only a thin wearing surface for texture. This type of system reduces overall bridge weight, improves construction schedule, and minimizes long-term maintenance.

McLaren Engineering Group's construction team was contracted by CCA Civil to serve as the project's erection engineers and was tasked with helping meet the strict contract tolerances, which included erecting the bridge within a 1⁄16-in. tolerance over 324 ft in the longitudinal deck joints. The challenge required innovative engineering solutions in the development of erection sequences and means and methods, temporary works, crane plans, and custom rigging solutions. All of this was closely coordinated with Vigor, which mimicked the proposed erection sequence in its shop yard—not only to ensure that contract tolerances were met but also to vet the proposed sequence and procedures, work out any kinks, and ensure seamless erection in the field.

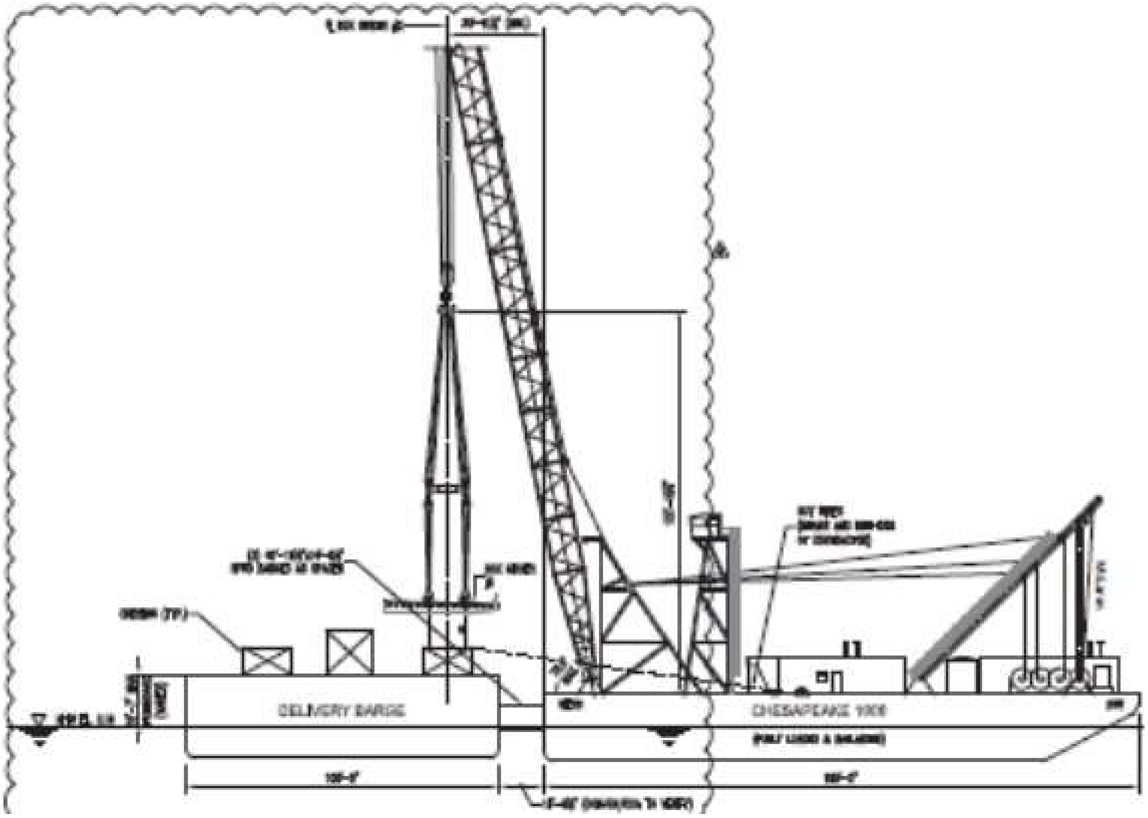
Given the massive weight and scale of the three box girders—which were 12 ft wide and 15 ft deep—with integrated orthotropic steel deck, the project team used a Donjon Chesapeake 1000 crane, one of the largest heavy-lift cranes on the East Coast, and took advantage of its 1,000-ton lifting capacity and 231- ft boom length, to perform the erection work. The crane was located on a barge in the Hackensack River, which was maneuvered by tugboats.

Three longitudinally split, approximately 700- ton deck spans were lifted into place, one per day. Courtesy of CCA Civil »

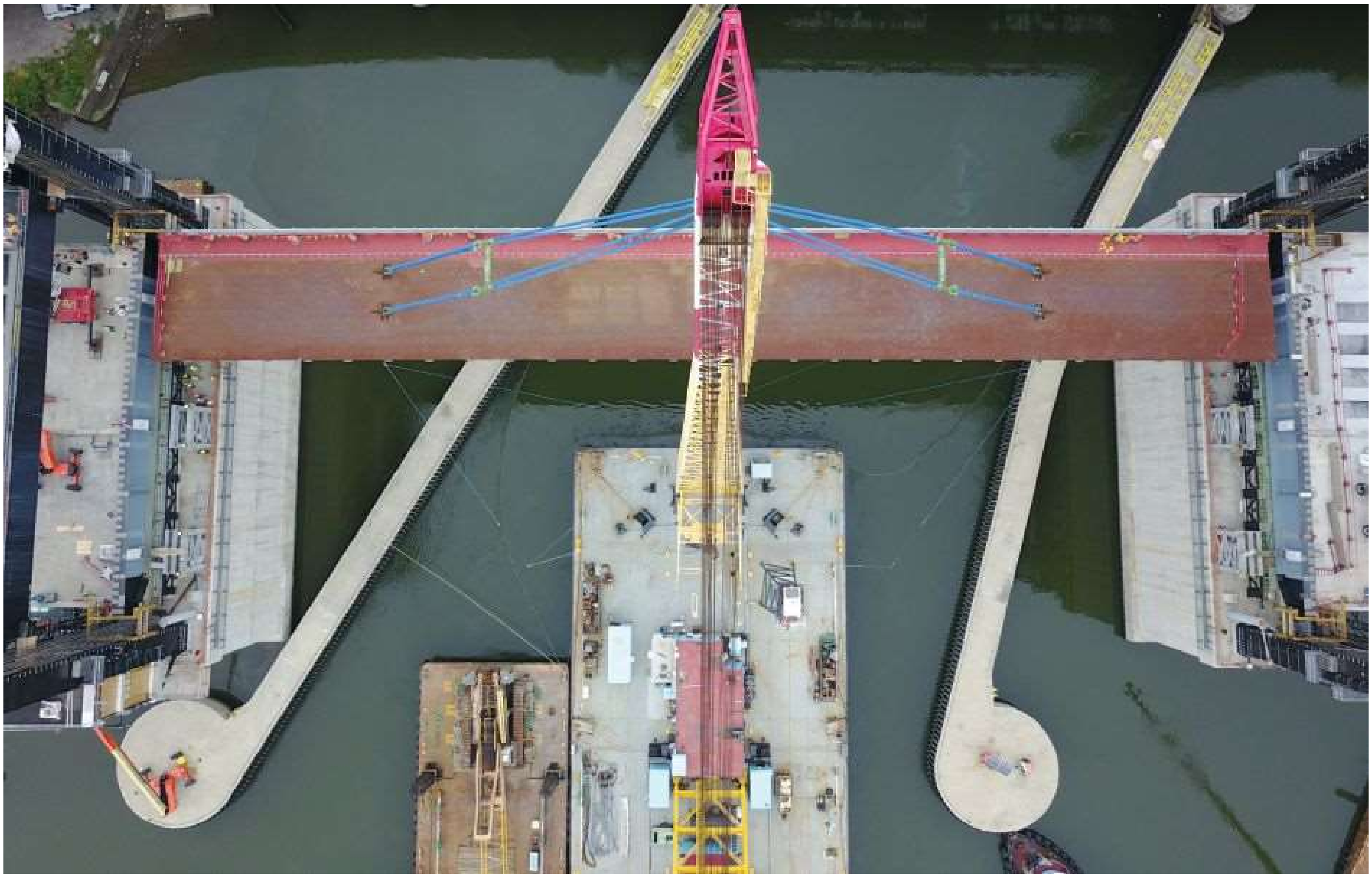


A rendering of the lift bridge with all three deck spans in place. McLaren »

Three longitudinally split, approximately 700-ton deck spans were lifted into place, one per day, and the ¾-in.-thick deck was field-welded together with full-penetration welds (for a total of 644 ft of weld length). Given the overall span geometry, the main span (box girders and end floor beams) would only fit between the approach spans and lift towers once it was fully assembled. With that in mind, McLaren designed temporary shoring towers to raise the bridge's elevation approximately 18 ft during erection and used slide rail systems to support the erection procedures. The bridge was erected on temporary shoring towers, which allowed the end floor beams to be slid back onto the approach span while erecting the three box girder sections. Following the erection of the box girders, the end floor beams were then slid into position, tight to the ends of the box girders, where they were bolted to the end floor beam.



The project team used a crane with a 1,000-ton lifting capacity and 231-ft boom length to perform the erection work. The crane was located on a barge, which was maneuvered by tugboats, in the Hackensack River. »



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Because the bridge was being erected 18 ft above its final location, the counterweight had to be erected 18 ft below its final contract elevation to maintain contract geometry. McLaren designed temporary link bar extensions to suspend the counterweight so that the relative distance from the partially elevated bridge, up around the sheaves at the top of the lift towers and back down to the counterweight, remained unchanged.

Properly positioning the pick points was critical to the stability of the bridge. During the pick, stresses in the box girders were reversed, putting portions of the bottom flange and web into compression, yet the bridge was not designed for this condition. As such, it didn't have longitudinal web stiffeners at the bottom of the box girder. McLaren coordinated with Donjon Marine and developed crane pick plans for the Chesapeake 1000, which maximized the reach capacity of the crane and ultimately maximized the spread of the pick points on the box girders. This enabled the reduction of negative flexure in the bridge sections during their pick. A finite element analysis (FEA) of the bridge was developed to check the global stability of the box elements for this temporary condition and to perform a local buckling analysis of the box girder webs, specifically near the pick points. Lifting lugs were designed and integrated into the web of the box girder by upsizing the thickness of the web steel plates in this portion of the box, welding this portion to the adjacent web plates, and allowing it to protrude through the top of the deck to create a continuous portion of the web plate up through the bridge deck. Stiffeners and cheek plates were added to the web extension on the top side of the bridge deck to complete the make-up of each lifting lug. This lug design eliminated the risk of lamellar tearing in the deck plate, which could be a failure mode if the lug was just welded directly to the deck plate.

The individual deck span sections were connected to two end floor beams, each in the neighborhood of 200 kips. However, due to the selfweight of the bridge and camber in those floor beams, the bolt patterns to connect the box girders wouldn't line up in a zero-load condition. To solve this, McLaren worked with Vigor to initiate incremental connection and load transfer procedures.

First, the middle box girder was connected with only 50% of the bolts and then unloaded slightly to release some of the camber in the end floor beams. This allowed more bolt holes to line up and be connected. After erecting the middle box girder, about 80% of the camber was out of the end floor beam, allowing the team to move on to connecting the two exterior box girder sections in a similar fashion. In the final condition, the box girders are supported at the ends as a simple span bridge.

The orthotropic deck was manufactured by Vigor at its facilities in Clackamas, Ore., and Vancouver, Wash. The deck was then transported by a barge, which traveled through the Panama Canal on its way to New Jersey. Courtesy of CCA Civil »

Each of the moment frame permanent vertical lift towers was comprised of four tower legs, two transverse cross beams, and two top sheaves, a total of 16 major picks upwards of 200 kips; all of these major tower components were erected using a Weeks Marine 533 Barge Crane with 360° rotation capability. Due to the eccentricities, the tower sections required custom rigging and pick plans to ensure a level lift that dropped smoothly into place. Additionally, a staged analysis of the towers was performed during erection to ensure stability during temporary conditions. It also helped guarantee that interim de ections encountered during erection would not impact the overall shape of the nal erected tower and that there wouldn't be any issues with steel t-up during erection.

The Wittpenn Bridge replacement project required intensive pre-planning and coordination with the New Jersey Department of Transportation, subcontractors, vendors, and work crews to ensure a safe and coordinated operation. In the end, the team delivered a successful project and completed the erection of the main span.

The bridge opened this past October 1, just 200 ft north of the original structure, and now delivers a safer and less congested crossing over the Hackensack River between Jersey City and Kearny. Not only that, but New Jersey now has one steel orthotropic deck bridge project under its belt, thus clearing the way for other bridge projects to take advantage of this system.

Owner

New Jersey Department of Transportation

General Contractor

CCA Civil

Structural Engineer

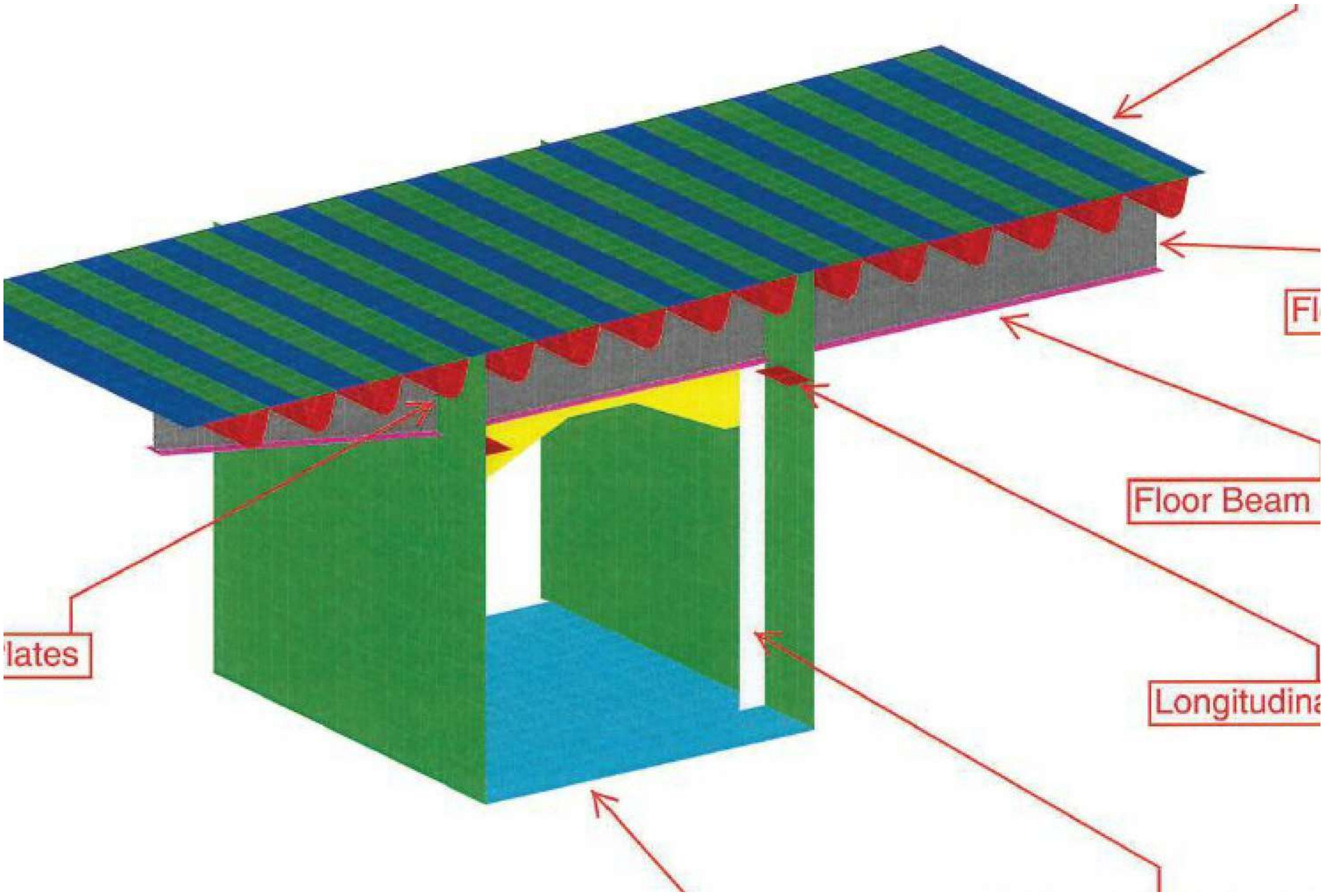
Jacobs Engineering, Morristown, N.J.

Erection Engineer

McLaren Engineering Group, Woodcliff Lake, N.J.

Steel Fabricator

Vigor , Portland, Ore.



A typical section of the superstructure box girder. »

Orthotropic Advantage

Why orthotropic? The New Jersey Department of Transportation, which had never implemented an orthotropic bridge before, looked to this system type for the Wittpenn Bridge based on several advantages, according to its website:

• Shop prefabrication, resulting in faster construction and higher quality control

• Lightness, which is critical for movable bridges

• A high level of redundancy

• Longer allowable span lengths, providing a better riding surface than others since it contains fewer connections

• Good cold weather constructability, since there is not a temperature requirement for concrete to cure

• Excellent corrosion resistance, partially due to the closed ribs

Eric M. Helt »

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