

# Thin-Skinned

A dilapidated, outdated wooden bridge is slated to be replaced by a three-sided precast concrete culvert bridge featuring a 13 1/2-inch top slab.

By Shari Held

Photos courtesy of Garden State Precast

Originally built in 1945, the R-27 bridge in Keansburg, N.J., crosses Waackaach Creek, a tributary of Raritan Bay. The three-span, continuous nail laminated timber deck structure, supported by a timber pile substructure, was reconstructed in 1966. By 2020, it was structurally deficient and in dire need of repair. In addition, at 24 feet, the bridge's width was substandard.

So, it was no surprise when the owner, Monmouth County, tapped it for demolition and replacement.

The replacement bridge will have a substructure consisting of a concrete foundation poured around concrete-filled pipe piles. The bridge's superstructure will be made up of a precast concrete three-sided culvert and a reinforced concrete cast-in-place riding surface a minimum of 5 inches thick.

So, what's so unusual about this project? The top slab on the three-sided culvert is only 13 1/2 inches thick while the bridge span is 32 feet.

"It's a very thin top slab for that span," said Paul Heidt, vice president of specialty sales for Garden State Precast in Wall Township, N.J. "It's going to be an interesting project."

## PRECAST: THE BEST MATERIAL OPTION

Designer T&M Associates, headquartered in Middletown, N.J., evaluated three potential solutions for the Fourth Street Waackaach Bridge. An alternative analysis included a voided slab box beam bridge, a steel stringer bridge and the precast concrete three-sided culvert bridge. These three solutions were reviewed based on cost, maintenance requirements and suitability for the project, which is on a fast track.

"If we have to close the roadway and propose a detour, we look at what type of structure can minimize that full closure and minimize disturbance to residents in the area," T&M Associates Project Manager Hiral Gaudani, P.E., said.

Other considerations for the new bridge include aesthetics, durability, safety, easy access to materials and impact on the environment. All these factors pointed to the precast concrete three-sided culvert bridge as the best solution.

Precast is one of the preferred materials for Accelerated Bridge Construction because elements can be cast, inspected and ready to install prior to bridge closure, reducing construction time and the impact on the general public. There's no forming, reinforcement assembly or curing that needs to be done on-site.



A culvert section is removed from its formwork and lifted by a crane at Garden State. Production for this project is taking place outdoors due to the size and weight of the culvert sections.

As far as aesthetics, other bridges in Monmouth County – although different in construction – are similar enough that the new bridge design will blend in and provide a uniform look and feel to the area.

“Because precast materials are fabricated in the shop, precast is a better product precision-wise, and you get a better lifespan from it,” Gaudani said.

Ultimately, the precast concrete three-sided culvert won out over the other options.

## WHY GO SO THIN?

The superstructure depth was dictated by the hydraulic design. To prevent bridge overtopping in the event of a 100-year flood, the lowest portion of the bridge superstructure is set above the flood elevation. Since the bridge is located near the intersection of Kennedy Way and Creek Road, the vertical profile is designed so it doesn't impact roadway approaches.

This results in a superstructure that is 18 1/2 inches thick – a 13 1/2-inch precast culvert top slab and a 5-inch riding surface.

At 13 1/2 inches, the top slab of precast concrete may be thinner than most, but it meets all strength and service limit

state criteria of the AASHTO Bridge Design Standards and NJDOT Bridge Design Requirements.

“The higher strength concrete that's now available makes it possible to do that,” Gaudani said. “With today's technologies, we can go with a thinner section.”

While the design is relatively simple, the thin top slab creates several challenges for Garden State Precast, such as the inclusion of shear reinforcement. This bridge project involves a more intricate casting and transportation process.

## MEETING THE CHALLENGE

The project called for eight three-sided precast concrete culverts. The outside dimensions of each element measure 15 feet, 8 inches high by 32 feet, 9 inches wide with an interior measurement of 14 1/2 feet high by 29 feet, 9 inches wide. The legs are 18 inches thick. Six of the elements are 66 inches in length. The two at either end measure 72 inches to accommodate the bridge rails. The weight of each element ranges from 64,000-75,000 pounds.

The design calls for a high steel-to-concrete ratio. According to Heidt, typically 250-300 pounds of concrete per cubic yard of



Garden State is using all-steel forms for the project while incorporating some wooden components to assist with placement of lifting inserts. The precast concrete culvert sections will comply with Monmouth County's recently revised tolerance scheme, which cut the previous alignment tolerances in half.

concrete produces a balanced structure for precast. But once a project gets in the 350-400 pounds of reinforcement per cubic yard of concrete range, the precast concrete is not as forgiving.

"In the culvert world, a higher steel ratio per yard means it's going to be more difficult to produce and handle," Heidt said.

Although this wasn't a mega-million-dollar project, the planning process for Garden State was extensive. The 13 1/2-inch top slab could be susceptible to cracking, necessitating special consideration for lifting, handling and rigging the elements.

"We did a lot of drafting and concept sketches, and we printed 3-D models of it to make sure it would all go together right," Heidt said.

## THE FABRICATION PROCESS

Garden State used NJDOT- Class P concrete with a compressive strength of 5,000 psi for the project. Weighing 3.4 pounds per foot, 1 1/8-inch-diameter (No. 9) steel reinforcement bars are positioned every 6 inches in the culvert elements. Ensuring they are all placed within tolerance was crucial for the precast's thin top slab. Additionally, one hundred and twenty six pieces of stirrup reinforcement was placed per section to increase shear capacity.

Garden State rented materials from EFCO Formwork, headquartered in Des Moines, Iowa, to create an all-steel form for the project. The form needed to adhere to Monmouth County's new tolerance requirements, which cut the tolerances for the vertical and horizontal alignment in half, from 2 inches to 1 inch. The county also introduced staining as a cause for rejection. Concrete elements can become discolored from form oil or the steel form itself. If necessary, Garden State will use formliners during the fabrication process.

The pouring plan was carefully choreographed during the planning process to ensure the elements were all poured so they aligned in one direction, right-leg-to-right-leg and left-leg-to-left-leg. An "L" or "R" was cast on the end of each element so construction workers could identify the left and right legs and place them correctly. That process kept everything within tolerance.

Each element contains an embedded lifting pin system with 12 pick points for ease of rotation – eight on the roof and four on the legs.

Garden State began production of the elements in May 2021 and planned to ship the elements to the jobsite in late June.





The precast concrete culverts are reinforced with 1 1/8-inch diameter (No. 9) steel reinforcing bars spaced every 6 inches. The design also uses stirrup reinforcement to increase the culvert sections' shear capacity.

## THE EASE OF PRECAST INSTALLATION

Installation of the new bridge is anticipated to go quickly and without a hitch.

“When we have segmental construction using precast structures, it minimizes errors because it’s very easy to put it together in the field,” Gaudani said. “No specialized labor is required.”

The only hiccup might come from work limitations imposed by the New Jersey Department of Environmental Protection. During the time when the fish spawn, workers won’t be allowed in the waterway.

Completion of the new Fourth Street bridge over Waackaach Creek is slated for August 2021. **PS**

*Shari Held is an Indianapolis-based freelance writer who has covered the construction industry for more than 10 years.*



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