

Hybrid Stressed Ribbon Bridge Sets U.S. Record

By Catherine A. Cardno, Ph.D.

The bridge, which spans 210 ft across Interstate 40 in Durham, North Carolina, connects two sides of a rails-to-trails pathway known as the American Tobacco Trail.

August 5, 2014—With the dismantling of rail lines in the United States, there has been a move to transition disused rail beds into pedestrian- and bicycle-friendly pathways. In North Carolina, where the 22 mi long American Tobacco Trail has been created along the right-of-way of a former railroad, engineers have designed a novel way to cross such a trail over a busy highway. Within the next few weeks, a project to carry the pathway over Interstate 40 will be completed as the final elements of the \$5.5-million American Tobacco Trail Bridge—the largest hybrid stressed ribbon bridge in the United States—are installed.

A team that included the New York City and Raleigh, North Carolina offices of global engineering firm Parsons Brinckerhoff and the Berkeley, California-based, bridge architecture firm Steven Grover and Associates conceptualized the bridge. Parsons Brinckerhoff conducted the planning, design, construction management, and construction inspection of the bridge as well as of a section of the trail on either side. Steven Grover and Associates developed the bridge concept, designed the bridge fencing system, and collaborated closely with Parsons Brinckerhoff on the development of the construction documents.

“The City of Durham wanted a signature structure as a gateway to the area,” says Tim Hayes, P.E., a senior project manager in the Raleigh, North Carolina, office of Parsons Brinckerhoff, and the project manager for the bridge. “This is the western entrance to the city of Durham [and] it’s a quickly developing area.” The result is a signature structure that offers access not only to the trail but also to an adjacent shopping mall—the Streets at Southpoint—and its movie theatre and other amenities.

The self-anchored bridge spans 210 ft between its arch supports and is a hybrid because it combines a 268 ft long, 13.5 to 17 ft wide concrete stressed ribbon deck with two 30 in. diameter curved steel arch ribs. The center portion of the deck was made of cast-in-place concrete. To either side of that portion are decks made of precast panels. A total of 12 posttensioning tendons extend across the bridge, from anchorage to anchorage. These tendons made it possible for the deck to measure a mere 9 in. in depth.



The \$5.5-million American Tobacco Trail Bridge—the largest hybrid stressed ribbon bridge in the United States—will be officially completed within the next few weeks. It conducts a bicycle and pedestrian pathway over Interstate 40 in Durham, North Carolina. Courtesy of Parsons Brinckerhoff



The self-anchored bridge spans 210 ft between its arch supports. It combines a 268 ft long, 9 in. thick concrete stressed ribbon deck with two 30 in. diameter curved steel arch ribs. Courtesy of Parsons Brinckerhoff

“We never really intended to build a record span,” says Joseph Tse, P.E., a senior engineering manager in the New York office of Parsons Brinckerhoff and the lead structural engineer for the bridge. “The important thing for us—to make this client successful—was to be sure to stay within the budget that had been set aside while delivering the iconic structure that they wanted.”

The fact that the bridge turned out to be the largest hybrid stressed ribbon span was a product of the terrain at the site at which the bridge crossed the Interstate, the alignment of the trail, and the fact that the design team needed to accommodate a future widening of the interstate on either side of the existing route, according to Tse.

When it came to determining the style of the bridge, the hybrid bridge’s minimalist, streamlined design was seen as advantageous because it would not compete with the natural environment surrounding the edges of the trail, but would be aesthetically pleasing when seen in the context of the tree-lined landscape, according to Tse. Additionally, the design considered the pedestrians and bicyclists who would be using the bridge by giving them only a very slight rise to cross.

“We studied trusses, a cable-stayed bridge with one tower, with two towers—one on each side of the highway—and, of course, the arch bridge,” Tse says. Ultimately, the thin-decked, hybrid was deemed best. “The fine outline of the thin deck that the stress ribbon provides, gives that level of fascination to the observers” from both the highway and the trail, Tse notes.

Civil Engineering

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Aesthetics were not the only consideration in selecting the hybrid design for the bridge, however. "When we made our cost comparison to the stress ribbon hybrid arch against the cable stayed bridge, they are actually quite competitive," he says. However, when the costs of long-term maintenance of the structures were added to the calculations, the hybrid bridge edged out the cable-stayed design as the most cost-effective in the long term, Tse says.

The bridge's funding came partially from the City of Durham, partially from the North Carolina Department of Transportation, and partially from federal sources. Because of the federal funding, the project was under a "buy American" clause, Hayes says. This prompted an unusual solution for the arch ribs. Because pipe of the size that was needed—30 in. diameter with a 1 ½ in. wall thickness—is no longer available in the United States, the team had to find a fabricator who could build the arch tubes out of plate steel, according to Hayes. "They actually started as 1 ½ in. thick plate, and were rolled into a 30 in. diameter cans, and then each can was welded together," Hayes explains. "Once the sections were welded together, another fabricator bent it into the shape of the arch." The weld seams were positioned to the inside and top of the structure, ground smooth, and painted so that they would be less visible, Hayes says. Now, "they are virtually invisible unless you really know where to look," he notes.

A bespoke fencing system—which includes 16 ft long stainless-steel mesh panels attached to painted supports with light fixtures attached—is used for the bridge's sidewalls. "Many times you will see safety fencing that consists of curved chain link fence," Hayes says. "Our fencing system accomplishes the same goal, but it's done in a way that architecturally enhances the appearance of the bridge. It's an aesthetically pleasing fence system that was designed to be somewhat transparent and nonconfining to the pedestrian.

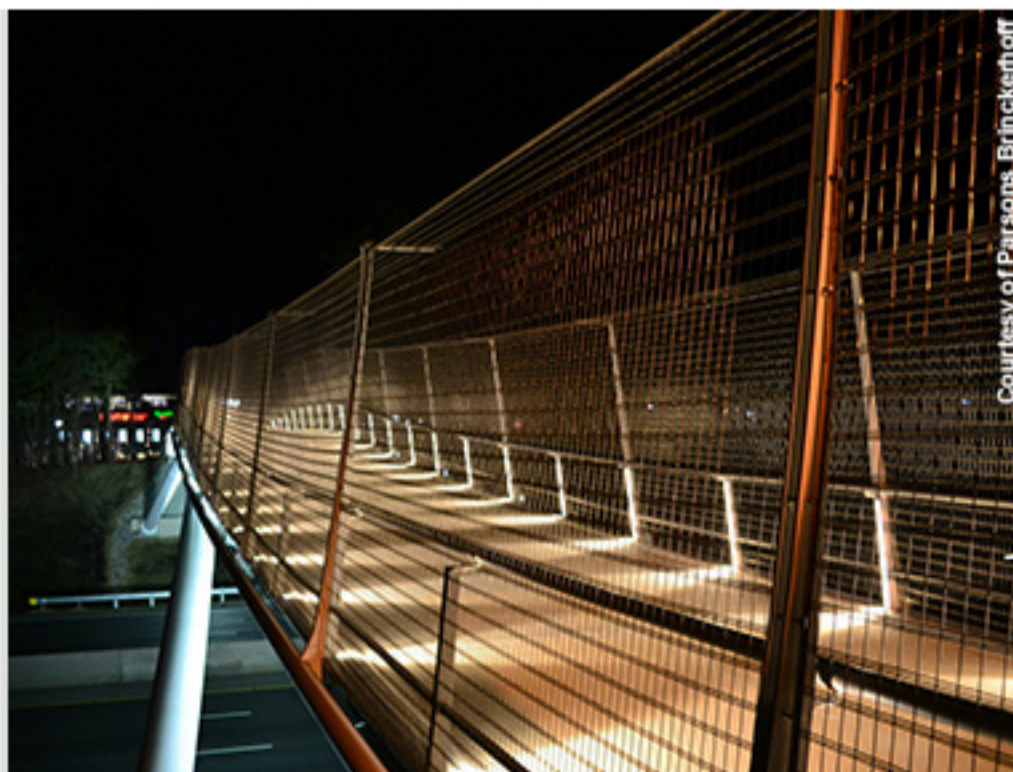
"We didn't want the pedestrian who crossed the structure to feel a tunneling effect," Hayes explains. "We wanted it to be an airy and open feeling, while still providing the necessary safety measures."

The bridge's foundations are cast-in-place reinforced-concrete drilled shafts with the steel arches bolted to mounting pedestals atop grade beams, according to Hayes.



Courtesy of Parsons Brinckerhoff

The arches, made in the United States, are formed from sections of plate steel that have been rolled and welded together, then bent to form the arch. Courtesy of Parsons Brinckerhoff



Courtesy of Parsons Brinckerhoff

Rather than use typical chain-link fencing, a bespoke system was developed for the bridge that uses 16 ft stainless steel mesh panels attached to painted supports that also contain lighting fixtures. Courtesy of Parsons Brinckerhoff

The arch ribs were constructed alongside the interstate and then lifted into place across the highway and bolted into place by Rockingham, North Carolina-based Superior Cranes, Inc., during a seven-hour road closure one night. "The contractor had this lift mapped out pretty much to the minute," Hayes says. "They had milestones throughout the night that had to be hit, and if they didn't, they had to put the bridge back [along the side of the interstate]."

Although the lift was a complex operation, it "functioned like clockwork," Hayes says. "It was well rehearsed. Everybody knew what they were there to do." (A time-lapse video of the closure was released by the City of Durham and can be viewed online.)

Though the bridge has been in use for several months, the entire project is expected to be officially completed within the next few weeks, according to Hayes.