PROJECT

Middlebury Bridge and Rail Project

by Aaron Guyette, VHB; Jeb Pittsinger, Mott MacDonald; and Jon Griffin, Vermont Agency of Transportation

Increasing the vertical clearance for the railroad by more than 3 ft required substantial excavation and shoring. All Photos and Figures: VHB.

Nestled in the heart of the Green Mountains, Middlebury, Vt., is a quaint New England village. It is the shire town (county seat) of Addison County, the home of Middlebury College, and the heart of the region's culture, arts, restaurants, and commercial economy. Winding through the heart of downtown Middlebury runs the former Rutland Railway, now operated by Vermont Railway. Originally constructed in the 1840s, the railroad split the downtown area in half and had two bridges that spanned the 20-ft-deep rail corridor running through the town green. The bridges were replaced in the 1920s but had since deteriorated to the point where their structural integrity was threatening the safety of vehicle drivers, bicyclists, and pedestrians above and the operation of the railroad below.

The Middlebury Bridge and Rail Project was initiated in response to the deteriorating condition of the two almost 100-year-old bridges carrying Main Street and Merchants Row over the Vermont Railway. In addition to the crumbling bridges, the railroad corridor had been plagued by drainage issues, poor track conditions, and vertical and horizonal clearance restrictions. Poor track conditions contributed to a 2007 train derailment, highlighting the critical need for improvements throughout the corridor.

Shared Sacrifice

Solutions had to address both the project location in downtown Middlebury as well as technical requirements for the roadways and railroad. Infrastructure improvements would need to meet not only technical code requirements but also construction requirements dictated by mobility needs, time restrictions, impacts on public spaces, and potential irreparable harm to the historic Middlebury downtown commercial district. The extensive needs of all stakeholders led the project team to pitch a shared sacrifice model. With this approach, the Vermont Agency of Transportation (VTrans) agreed to structure its construction contract for an accelerated bridge construction (ABC) period to reduce the overall construction impact, the operating railroad agreed to allow a 10-week extended track closure, and the Town of Middlebury agreed to a 10-week full closure of its downtown streets—which would essentially cut the downtown community in half.

CMGC Project Approach

The project was structured as construction manager/general contractor (CMGC), where the construction manager was a key member of the design process. Using the CMGC approach enabled the project team to develop a constructable concept that provided certainty in the schedule and helped define impacts to project stakeholders and the general public well in advance of actual construction. Backed with this information straight from the contractor, the project team engaged in a robust public outreach plan to establish local relationships and build credibility in the community. The open communication led to a great working relationship with local government officials and project stakeholders.

The overall general scope of the project called for replacing the bridges and maintaining the existing roadway profiles along municipal streets while increasing the overall vertical clearance for the railroad by more than 3 ft. With no way to build upward, the project team would excavate downward to accommodate the vertical clearance, which resulted in adjustment to the railroad profile for approximately 3500 ft. The project team still needed to identify solutions for railroad drainage, permanent retaining walls, and an ABC approach.

A Precast Concrete Solution

As the project team evaluated structure types, it became clear that a precast concrete box structure was an ideal solution for many design parameters. A concrete box provided a durable, long-term solution that could be quickly assembled as part of the ABC approach. It would permanently retain surrounding soils and support the existing roadways, and it provided a sealed structure that would keep groundwater out and help collect and convey stormwater from the tunnel approaches. As an added

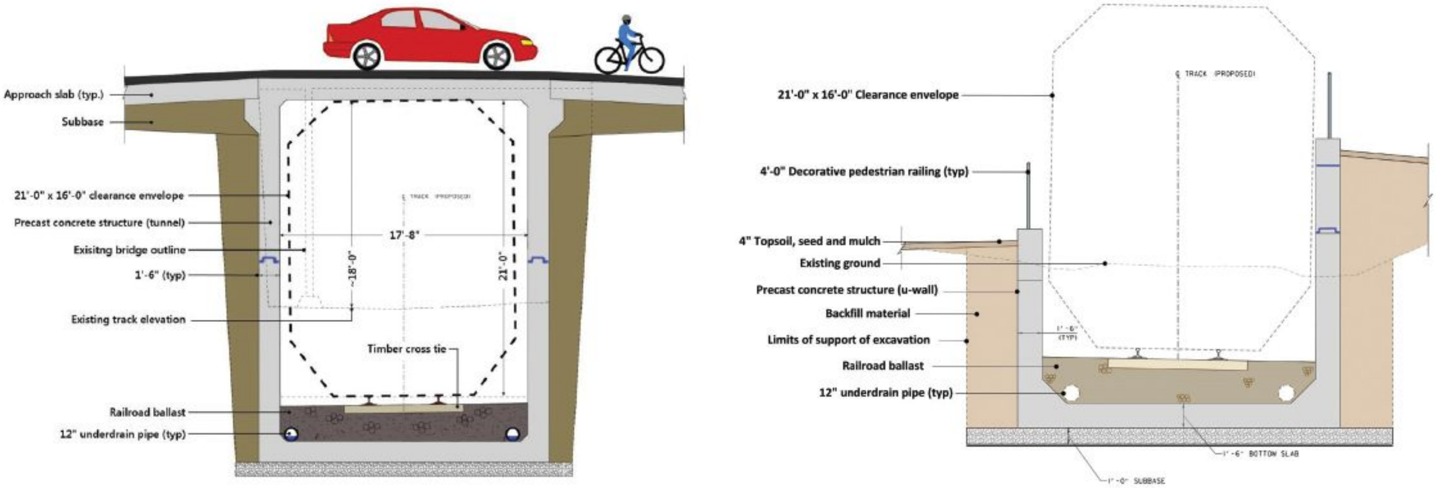
profile

MIDDLEBURY BRIDGE AND RAIL PROJECT / MIDDLEBURY, VERMONT

BRIDGE DESIGN ENGINEER: VHB, South Burlington, Vt.

TUNNEL ENGINEER: Mott MacDonald, Westwood, Mass.

PRIME CONTRACTOR: Kubricky Construction Corporation, Wilton, N.Y.



Cross section of two-piece precast concrete tunnel at highway crossing (left). Cross section of precast concrete U-shaped retaining wall (right).

advantage, the box structure could be extended between the two existing bridge locations to create a tunnel and reconnect the historic town green in downtown Middlebury. As design of the concrete box evolved, a two-piece system emerged as the best option because it provided an appropriately sized structure for the tunnel, with dimensions that could be prefabricated off site and transported by truck to the jobsite. The 345-ft-long concrete box consists of a series of bottom U-shapes and top U-shapes that join together with a keyway to form the 24-ft 4-in.-high × 17-ft 9-in.-wide clear opening inside the tunnel. Each tunnel U-shape was cast monolithically; is 7 ft 6 in. long, 13 ft 8 in. high, and 20 ft 9 in. wide; and weighs more than 30 tons. The keyed joint where the top and bottom of the tunnel fit together was modeled as a pin connection, thereby transferring no moment and simplifying connection requirements in the field. The structural design called for 5000-psi concrete compressive strength, and the design team opted to use galvanized reinforcing steel to help protect against deterioration and provide a 100-year service life for the new structure. The individual pieces were connected longitudinally using galvanized "dog-bone" hardware that could be quickly inserted and tensioned before the next piece was installed. After the precast concrete segments were installed, backfill was placed up to the final grade, with compacted granular material used where the width adjacent to the structure was greater than 3 ft, and controlled-density flowable fill used where the width was less than 3 ft.

Using the two-piece precast concrete box tunnel led to the use of U-shaped retaining walls to retain soils outside of the tunnel portals. The walls stretch 323 ft to the south and 1065 ft to the north. The typical monolithic vertical leg of the U-shaped retaining walls is 11 ft tall. Where taller sections were required to retain the fill, precast concrete panels were post-tensioned to the base to extend the vertical wall by as much as 14 ft. Tops of the U-shaped retaining walls were finished with a cast-in-place concrete cap and decorative pedestrian railing.

In total, the tunnel and U-shaped retaining walls consist of 422 individual pieces of precast concrete, all fabricated in upstate New York, trucked to a marshalling yard about a mile from the project site, and then meticulously

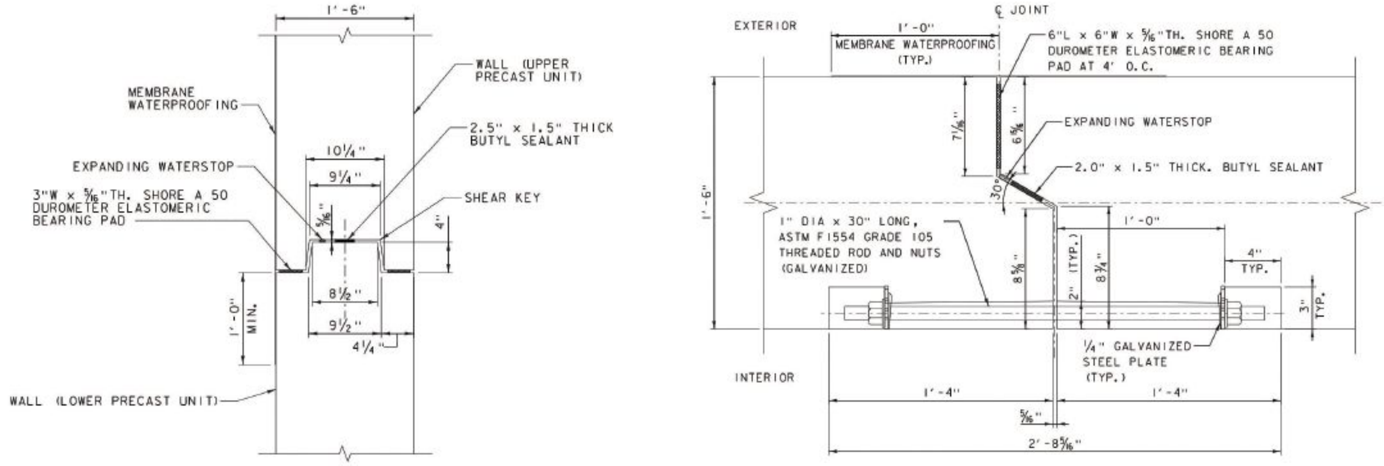
Erection and assembly of precast concrete tunnel pieces. The individual U-shaped tunnel segments and retaining walls were connected longitudinally using galvanized "dog-bone" hardware that could be quickly inserted and tensioned before the next precast concrete piece was installed.

VERMONT AGENCY OF TRANSPORTATION, OWNER

PRECASTER: Fort Miller Company, Schuylerville, N.Y.—a PCI-certified producer

PROJECT DESCRIPTION: 345-ft-long precast concrete railroad tunnel and 1388-ft-long U-shaped retaining walls consisting of 422 individual precast concrete pieces

BRIDGE CONSTRUCTION COST: $62.5 million



Two types of joints were used on this project: keyed longitudinal joints in the walls connecting the U-shaped tunnel or wall sections (left), and shiplap joints for the transverse dog-bone connections between tunnel or wall segments (right). The use of shiplap joints was seen as one of the biggest risks associated with construction.

transported to the jobsite and set in place during the 10-week ABC period in 2020.

Although the overall project lent itself to using precast concrete for the tunnel and U-shaped retaining walls, the team faced significant hurdles to accommodate the required horizontal and vertical geometry of the railroad corridor and to develop a watertight joint configuration for the precast concrete pieces. The profile along the railroad corridor consists of shallow vertical grades descending from both the northern and southern limits of the project to a low point on a vertical curve in the tunnel. The bottom slab of the tunnel was designed with a low point for the gravity conveyance and collection of stormwater that flows through the bottom of the slab and into a new stormwater piping network.

The horizontal alignment of the railroad corridor consists of spiral reverse curves, which were accommodated by chorded segments of the precast concrete U-walls and tunnel. Pieces of precast concrete along each chord were of consistent shape and size, and allowed repetitive forming and fabrication; however, each chord was connected by a specialized transition piece fabricated to turn a small angle to the next chord. Using this approach allowed uniformity in the precast concrete fabrication as well as greater predictability in joint width along the length of the project.

The project team spent a significant amount of time designing, detailing, and practicing the transverse joint construction in the field, which was seen as one of the biggest risks associated with construction. Precast concrete erection started with a single "key" piece at the low point of the tunnel and continued by placing additional pieces north and south. Each piece used a transverse shiplap joint in the precast concrete in combination with elastomeric bearing pads, butyl sealant, expanding hydrophilic waterstops, and self-adhesive membrane. The ideal joint width was 5/16 in.; however, the joint width was also designed to be variable up to 3/4 in., allowing for slight adjustments to the horizontal alignment of the precast concrete.

Project Construction

Project construction kicked off in the summer of 2017 with an emergency project to demolish the increasingly dangerous existing bridges and erect temporary bridges at the two crossings. Construction continued in the following years with preparations for the main event during the 2020 construction season. These enabling works included installing support of excavation along the project corridor, constructing a series of gravity drainage tunnels through bedrock, and preparing crane pads for setting the precast concrete U-shaped retaining walls and tunnel pieces.

In July 2020, the 10-week ABC period started. Crews worked around the clock for 70 straight days, completing a massive earth excavation, blasting solid rock, setting the precast concrete pieces, backfilling and reconstructing the municipal roadways, and reconstructing the railroad track through the tunnel and U-wall section. Precast concrete pieces were set over a week-long period in late July, with erection rates averaging one piece per hour, including installation of the joint gasket materials, alignment adjustments, and tensioning of connecting bolts. The ABC period successfully concluded ahead of schedule in early September with a ceremonial passenger train and the resumption of regular vehicular traffic.

Conclusion

The project has one more year of construction to complete new sidewalks, landscaping, final paving, and the construction of new public park space. However, the positive impact on downtown Middlebury is already evident with the reconnection of the town green and Triangle Park for the first time in nearly 180 years. The benefits of this project will be evident for generations to come.

Aaron Guyette is transportation market lead and a project manager at VHB in South Burlington, Vt.; Jeb Pittsinger is a senior project engineer at Mott MacDonald in Westwood, Mass.; and Jon Griffin is a structures project manager at the Vermont Agency of Transportation in Barre, Vt.

Ceremonial first train passing through the tunnel and U-shaped retaining walls.