FAST-TRACKING THE SH34 BRIDGES OVER THE BIG THOMPSON RIVER

Gary M. Maji, PE, DMJM Harris, Denver, CO
Kirsten Armbruster, **PE**, DMJM Harris, Denver, CO

ABSTRACT

Innovative technologies and fast-track methodologies were used to speed the construction of two bridges over the Big Thompson River, in Loveland, CO. To minimize traffic disruptions and reduce environmental impacts, the project team developed concrete mix designs and procedures, utilized precast construction, and implemented a design-build program for construction within a 14-day bridge closure.

Keywords: Precast, Fast-track Construction, Bridges, Value Engineering, Design-Build, Grouting, Corrosion

INTRODUCTION

In the Fall of 2003, the Colorado Department of Transportation (CDOT) developed contract documents for the replacement of two 70-year old bridges due to their extremely poor conditions and low sufficiency ratings (See Figure 1).

Figure1. One of two existing structures

These new structures are located along State Highway 34 (See Figure 2) just west of Loveland, Colorado near the entrance of the Big Thompson River Canyon, over the Big Thompson River and over environmentally sensitive lands. The documents called for the construction of a 149-ft two span bridge and a 219-ft three span bridge, two temporary detours, stream embankment mitigation and roadway improvements all under a 6-month bridge closure.

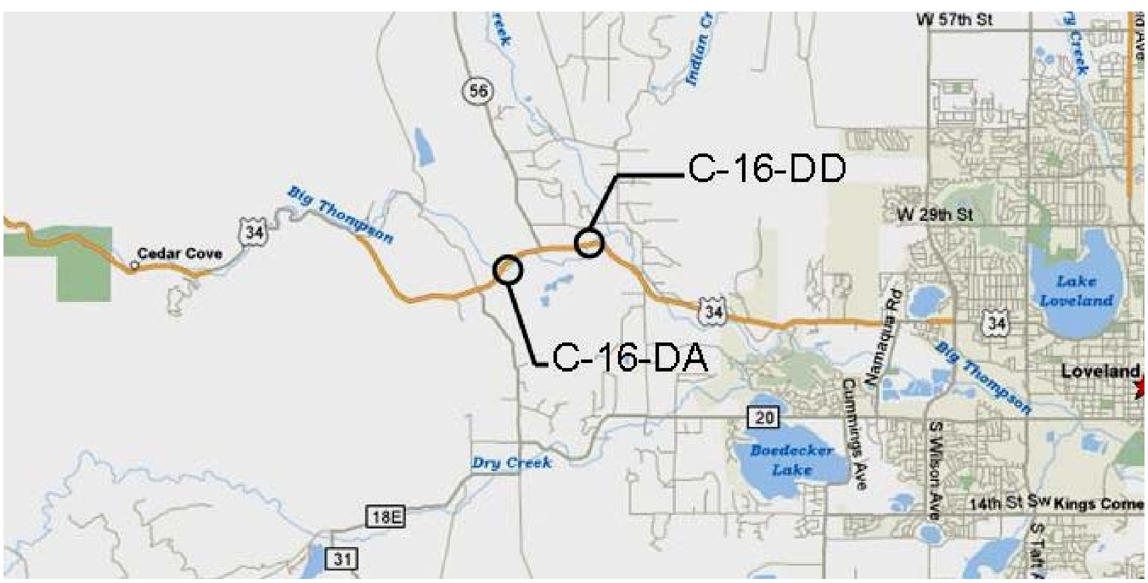

Figure 2. Project Location.

The Contractor utilized a Value Engineer Change Proposal (VECP) to construct these bridges under existing traffic incorporating fast-track construction methods and precast components. This significantly reduced river and environmental impacts associated with the wetlands, trout spawning, tree removal, and river degradation. In addition, traffic impacts were greatly reduced to a 2-week bridge closure in lieu of the originally planned 6-month closure.

VALUE-ENGINEERED CHANGE PROPOSAL

In accordance with CDOT's guidelines, the VECP was submitted. Design and construction details contained within the VECP identified the use of staged construction techniques to build cast-in-place and precast concrete bridge components under traffic. Partial construction of the abutment structures was accomplished by the use of open trench boxes, prefabricated reinforcement cages, and one-lane roadway closures. Both cast-in-place and precast straddle pier caps were used for the intermediate supports. These caps were supported by pier columns located beyond the limits of the existing structure edge of deck. Precast side-by-side box girders laterally post-tensioned and a 3-inch asphalt and waterproofing membrane topping would allow for quick superstructure construction. To minimize the work in the river, precast concrete block and cable scour mitigation blankets were proposed. These blankets provided the necessary hydraulic and embankment protection along the river.

CRITICAL EXECUTION OF THE VECP

Project meetings were quickly established to discuss the VECP and address any concerns from CDOT. These meetings played a pivotal role in the successful execution of the project by establishing project delivery and construction constraints, defining durability and maintenance requirements, and providing fast-track construction details that incorporated precast components. To expedite the VECP approval process, preliminary calculations of some of the proposed VECP details were provided to CDOT to demonstrate the general concept behind the design and to confirm that the calculations would support the work.

A design-build delivery method was used to meet project schedule and construction requirements. This method allowed for the design and construction process to occur simultaneously. Upon CDOT's approval of each Release For Construction (RFC) package, the Contractor was able to start construction for that particular portion of work. The construction of the pier caissons within the river had first priority. Concerns of rising river elevations normally associated with the spring thaw mandated that these caissons be completed by early spring during low-water river flow elevations. While pier design and construction progressed, the designers prepared construction sketches and design details for upcoming construction. These submittals, to both Contractor and CDOT, allowed the project team to openly discuss proposed design solutions, identify critical issues, and expedite the design approval process for the subsequent construction phases.

Durability and maintenance concerns of the proposed structures were discussed throughout the implementation of the VECP. Design and construction details needed to provide for a 75-year performance against corrosion. To address this requirement, the project team included a nationally recognized corrosion expert. As a result, the designers were better able to develop concrete mix design parameters (i.e. lower w/c ratios, use of superplastizers and flyash, air entrainment, and smaller aggregate sizes) to enhance durability at precast component connections; specify full-scale testing of the key grouting materials and operations; and provide additional corrosion protection measures of the reinforcement at critical locations.

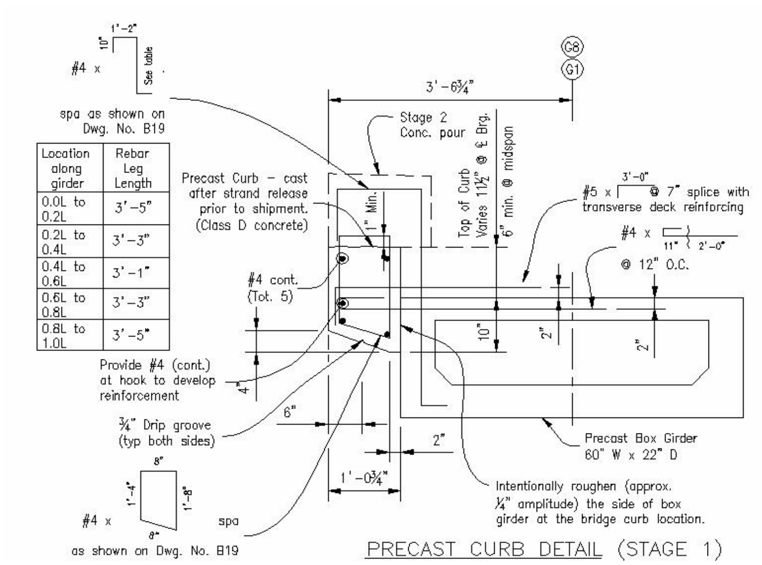

Figure 3. Precast Curb Details

Concerns of the ability of the deck protection system to provide the 75-year durability resulted in the team's decision to provide a 6-inch cast-in-place concrete deck on the box girders with a 3-inch asphalt and membrane topping in lieu of the laterally post-tensioned box girders and a 3-inch asphalt and waterproofing topping. The excessive structure skews and the potential differential deflection between the laterally post-tensioned girders also led the team to the cast-in-place deck option. However, with the proposed 10-day closure and a 5-day minimum concrete deck-curing requirement for each structure, the Contractor proposed precast bridge rail curbs (See Figure 3) on the exterior box girders to eliminate the need for deck edge formwork. Screed rails would be placed directly on the rail curbs and the deck concrete was cast against the curbing saving considerable time associated with the construction of the edge formwork.

The fabrication of the precast curb required the precast manufacturer to utilize wood side forms that could allow drilled holes for the projecting horizontal reinforcement. A roughened form-liner was placed along the inside face of the formwork to create the intentionally roughened surface.

The use of precast components in the pier caps, abutment diaphragms, retaining walls, box girders, and precast block scour blankets helped to facilitate many of the fast-track construction techniques employed on this project. The proposed grades at the abutment locations prevented the Contractor from completely casting the abutment backwall in place while the existing structure was in operation. As a result, only the abutment caisson cap was cast while the remaining abutment backwall section was precast onto the end of the box girders.

The design development of the precast pier cap and the cap-to-column connections allowed the project team considerable timesavings during construction. Concrete mix designs for the grouting operations at the keyway connections were specified to facilitate placement and consolidation of the mix around the confined reinforcement. The shape of the keyway connections within the precast cap eliminated the possibility of entrapped air at reentrant corners (See Figure 4 and 5). Two 6-inch diameter ducts were specified at the top of the precast cap to cast-in-place column connection to accommodate the connection pouring operations. Reinforcement within the keyway was designed to transfer the horizontal and vertical forces from the precast pier cap into the cast-in-place column.

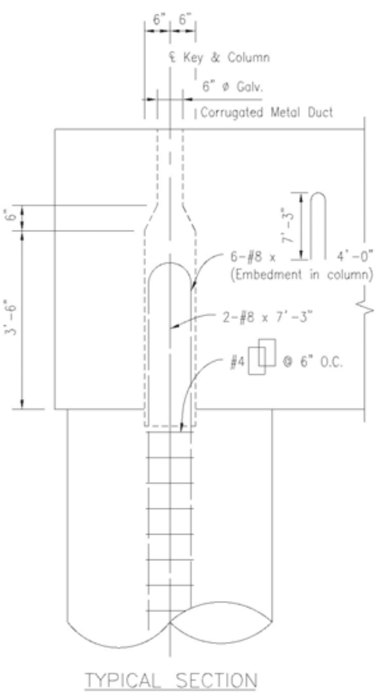

Figure 4. Side Section through keyway

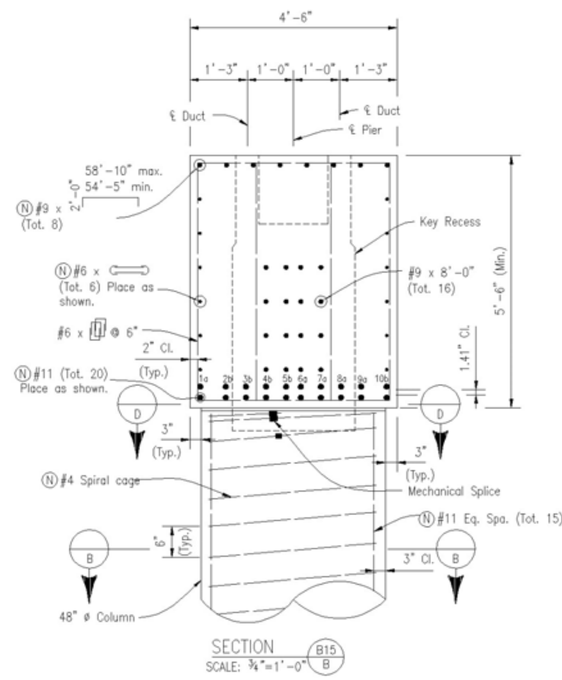

Figure 5. End Section through keyway

To ensure complete consolidation of the keyway concrete placement, the designers specified a full-scale set-up and demonstration placement requirement of the keyway shape. Wood dowels were specified within the set-up to simulate the presence of the horizontal reinforcement. After completion, the formwork was removed from the keyway (See Figure 6) and the concrete shape was checked for honeycombed voids at the keyway surfaces.

Figure 6. Completed keyway

VECP CONSTRUCTION

The construction of these two bridges (See Figures 13, 14 and 15) along SH34 and across environmentally sensitive lands required strategic planning and extensive agency coordination. Both traffic and environmental impacts required clearance before the construction of these structures could commence. In order to minimize traffic impacts during the roadway closure, the designers performed detailed traffic analysis in the initial stages of the VECP to assure both state and local agency concurrence of the detour plan. FHWA, CDOT, and local agency personnel were notified of the proposed environmental mitigation to expedite the required clearances.

Construction project scheduling was critical to the success throughout the project duration. The Contractor directed the designers to focus on bridge design elements that could be constructed under the existing bridge footprint, thus various substructure components (pier caissons, columns and abutments) were designed and constructed from the onset. Drilled caissons and columns for the piers were constructed just beyond the existing structure edge of deck (See Figure 7). Due to the revised profile grades at Structure C-16-DA, a cast-in-place pier could be constructed beneath the existing structure. At the abutments, drilled caissons were installed through the existing deck between the steel stringers or behind the existing abutments through the roadway pavement. Construction phasing and temporary one-lane traffic closures were required to facilitate the abutment caisson and substructure construction. Cast-in-place abutments and wingwalls with pre-assembled reinforcement cages and attached formwork were installed within trench boxes beneath the highway. After the phased caisson construction, the existing deck was patched using a high-early strength mix with spliced reinforcement to provide continuity across the new deck surface.


Figure 7. Pier caisson construction


Figure 8. Fabricating the pier caps

With the cast-in-place substructure components under construction, the designers focused their attention to the prestressed box girder and precast pier cap design. The box girders were fabricated at the plant and later shipped to the jobsite. Some of these box girders incorporated the precast rail curb and/or abutment diaphragm details developed and approved during the VECP execution phase. These additional components required extensive coordination with the plant inspection personnel to assure that the design details were implemented. The precast pier caps were fabricated at the project site (See Figure 8). These caps were approximately 225 kips each and transporting them from the fabrication plant (approximately 75 miles away) was cost prohibitive. Extensive planning and coordination efforts were required by the project team for the precast pier cap pours to assure that favorable placement and curing operations would occur.

VECP BRIDGE CLOSURE

Preparations of the upcoming closure for the bridge construction had the project team members providing public notices for the planned closure, procuring additional labor and materials, and finalizing RFC packages for the remaining superstructure components. The original 10-day closure required construction crews and on-site engineers 24/7. The first few days of the closure were critical to the success of the proposed construction. CDOT's mandate for a 5-day cure of the concrete bridge decks required the project team to quickly complete the precast construction.

Figure 9. Precast pier cap installation

The removal and demolition of the existing bridges, completion of the remaining abutment portions, and setting of the precast pier caps (See Figure 9) helped to set the stage for project completion. The precast pier caps were placed on the cast-in-place pier columns and the concrete mixture was poured into the keyway connection and allowed to cure for a minimum 24 hour period prior to girder placement on the pier caps. Concrete mixes for these connections were specifically designed to meet these project schedule constraints.

The precast block and cable scour mitigation blankets were placed prior to the girder placement. These units were delivered and installed in segments within a 4-hour window for both bridges. They were placed directly underneath the end spans, adjacent to the river. The use of this system helped the Contractor save time normally spent on placing bed coarse material and rock riprap along the river embankments.

Following the placement of the precast scour blankets (See Figure 10), the Contractor started girder erection operations (See Figure 11). Girder placement occurred for both structures throughout the night and into the following day to prepare the structures for the concrete deck placement.

Figure 10. Precast block scour blankets

Figure 11. Girder erection

This placement started immediately after the deck screed was set so the specified curing requirements could be met. The Contractor saved considerable time during this portion of work. The use of the precast rail curbs at the exterior box girders eliminated the work normally associated with the construction of the edge decking forms. However, during construction the Contractor discovered that the excessive skews of these precast box girders caused a plumbness issue at along portions of the precast rail curb. In addition, some of these skewed precast box girders had twisted causing the girders not to sit squarely on the abutment caps. To allow the girders to set properly on the abutment caps the contractor installed shims at the pier caps beneath these girders. Since the pier diaphragm on top of the pier cap is cast with the deck, shimming of the girders would not affect the structure performance. These issues along with softened subgrade soils brought about by recent rains delayed the project approximately four (4) additional days. Thus the original 10-day roadway closure was extended to 14-days.

After the bridge deck was cast and curing operations started, the contractor's efforts were directed towards the roadway improvement work. Roadway grading and pavement operations were completed on the highway while the remaining portions of the bridge work were completed. Temporary precast concrete barriers were placed along the structure until the bridge guardrail was assembled. These barriers allowed CDOT to open the roadway to traffic, remove the temporary detour, and complete the remaining project tasks including the embankment mitigation, guardrail installation, and drainage improvements. The final asphalt topping was installed in the Spring of 2005.

TIME-LINE COMPARISONS

To better understand the project scheduling and design sequencing of the VECP operations, we have developed a project timeline to compare against the originally proposed project schedule. This time-line (See Figure 12) provides a brief idea as to the timing of events which were required to facilitate the VECP project schedule.

During the initial stages of the VECP process, CDOT and the contractor developed a design and construction schedule for the remainder of the project. Firstly, designs for the pier substructures were required so that construction of these elements could occur at low-water river elevations. Construction of the CIP pier cap for Structure C-16-DA and partial abutment construction also occurred in Spring 2004. Construction at the site temporarily stopped during Summer 2004 while the superstructure design was completed.

The contractor completed the casting operations associated with the keyway set-up demonstration, fabrication of the precast pier caps, and prestressed box girders during the Summer of 2004. This allowed the project team to finalize the remaining details associated with the proposed 14-day closure.

Early November was chosen for the 14-day closure. After SH34 was closed and the detour was in place, the contractor quickly demolished portions of the existing bridges leaving some existing structures in place that would not be affected by the new construction. The precast pier cap was set on the cast-in-place pier caissons at Structure C-16-DD and the keyway connection was filled with concrete. Installation of the precast block and cable scour mitigation blankets along the banks of the Big Thompson River occurred while the keyway concrete cured. Girder placement and deck reinforcement installation quickly followed so the deck concrete could be poured and allowed to cure for a minimum of 5 days. After the 14-day closure, the contractor completed the remaining project work as required.

CDOT's original schedule had proposed a 16 to 18-month construction window that included a 6-month SH34 closure and temporary detour across environmental sensitive lands. It was assumed that most of the bridge construction could occur during the 6-month closure period while the remainder of the work occurred during non closure periods.

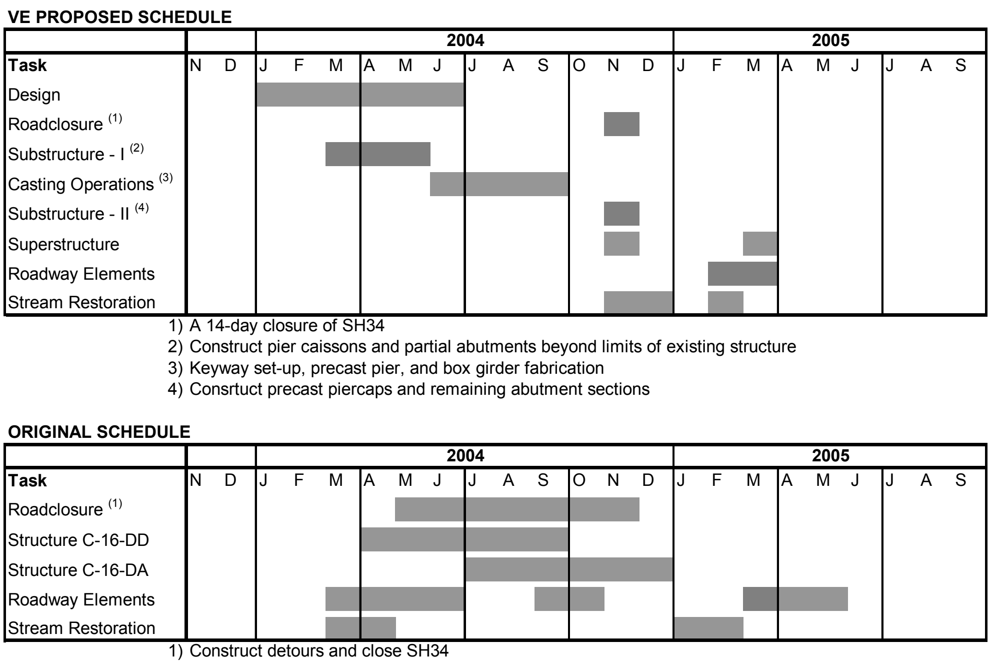

Figure 12. Timeline

CONCLUSION

In this search for excellence, we present an innovative project utilizing fast-track construction methods and precast components. These bridges were replaced with minimal impact on surrounding environmentally sensitive lands that was of paramount importance. Equally significant was the reduction time of the bridge closure from the originally planned 6 months to the actual 2-week closure. Bridge General Layouts and Typical Sections follow this page.

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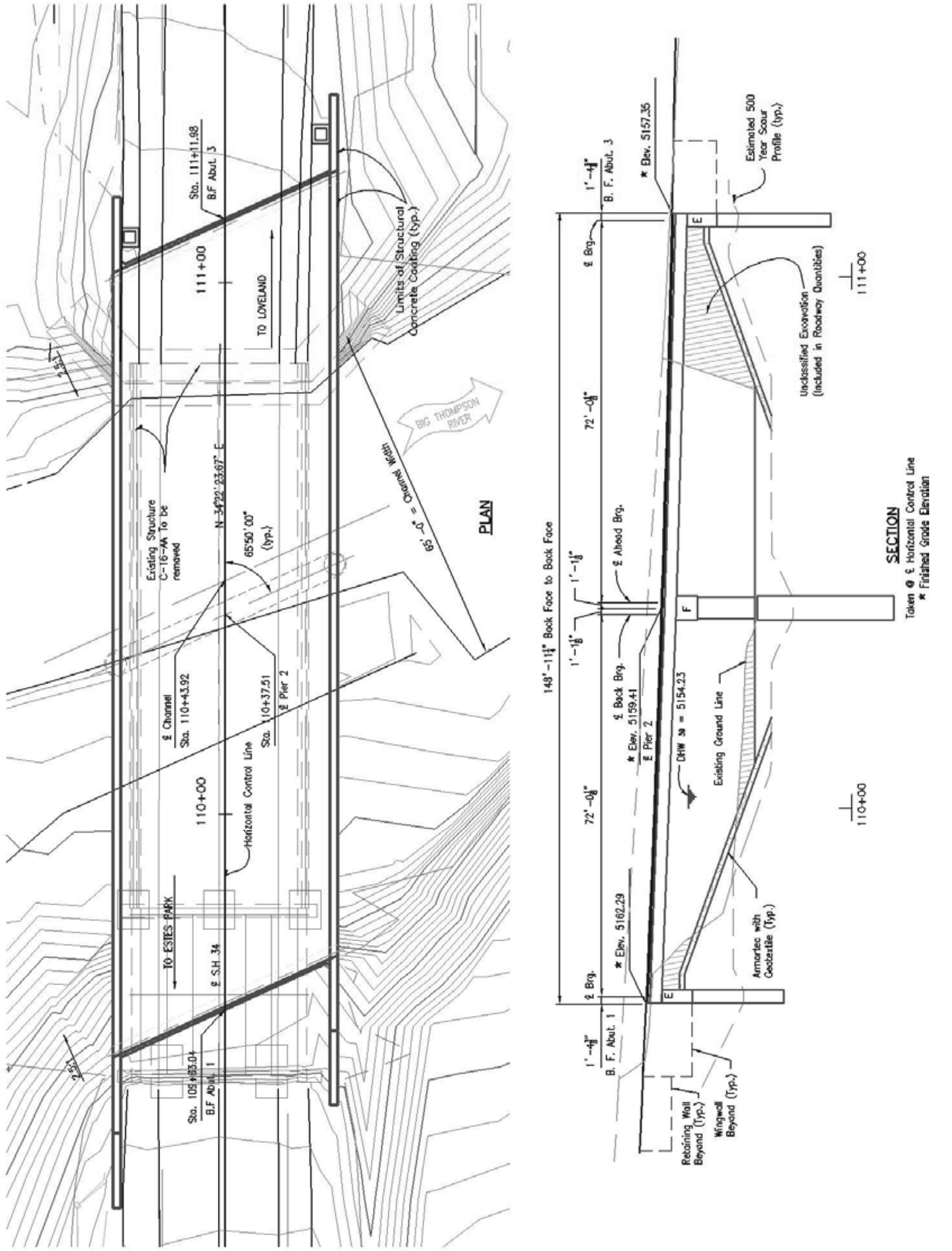

Figure 13. Structure C-16-DA Plan and Elevation

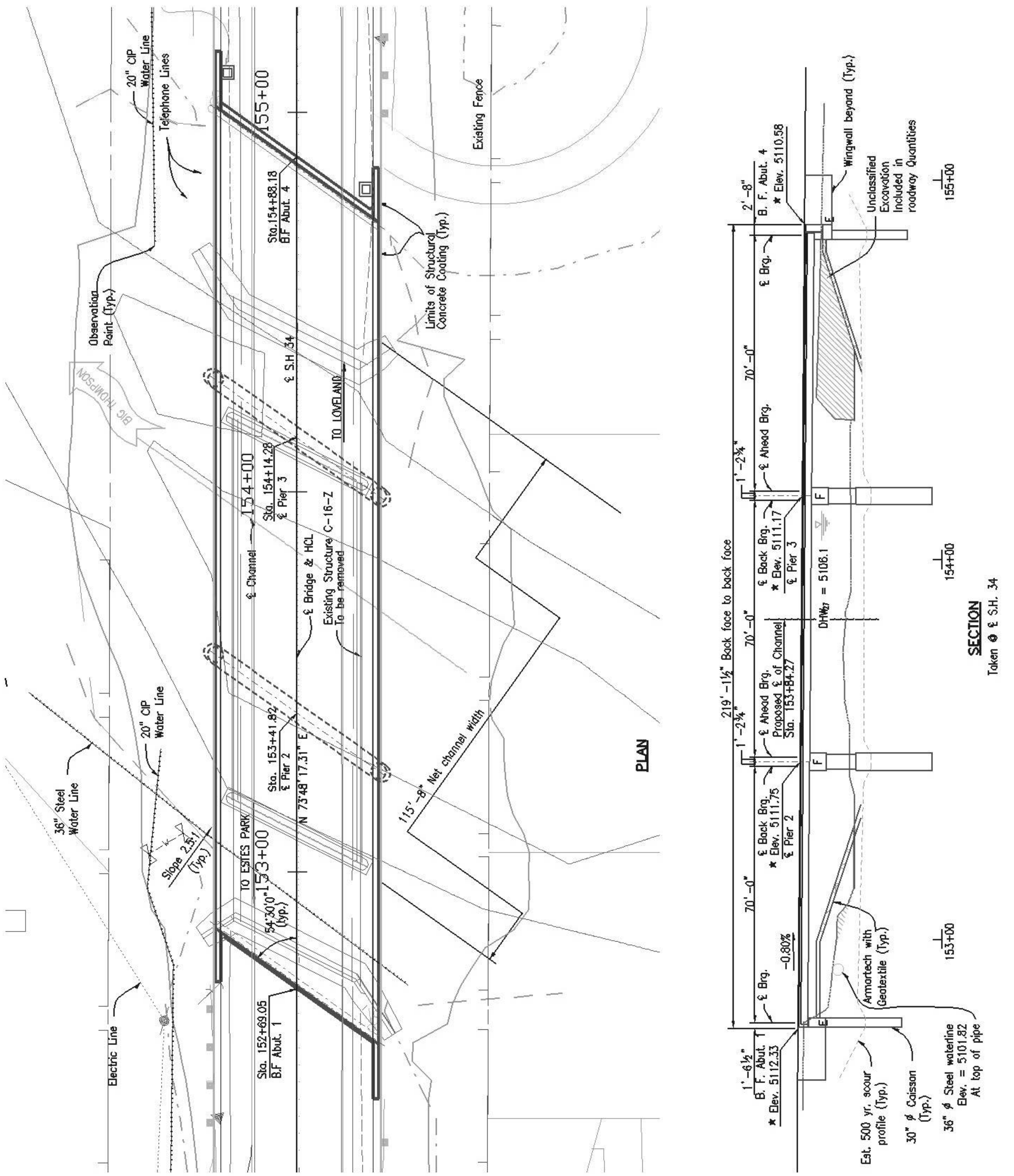

Figure 14. Structure C-16-DD Plan and Elevation

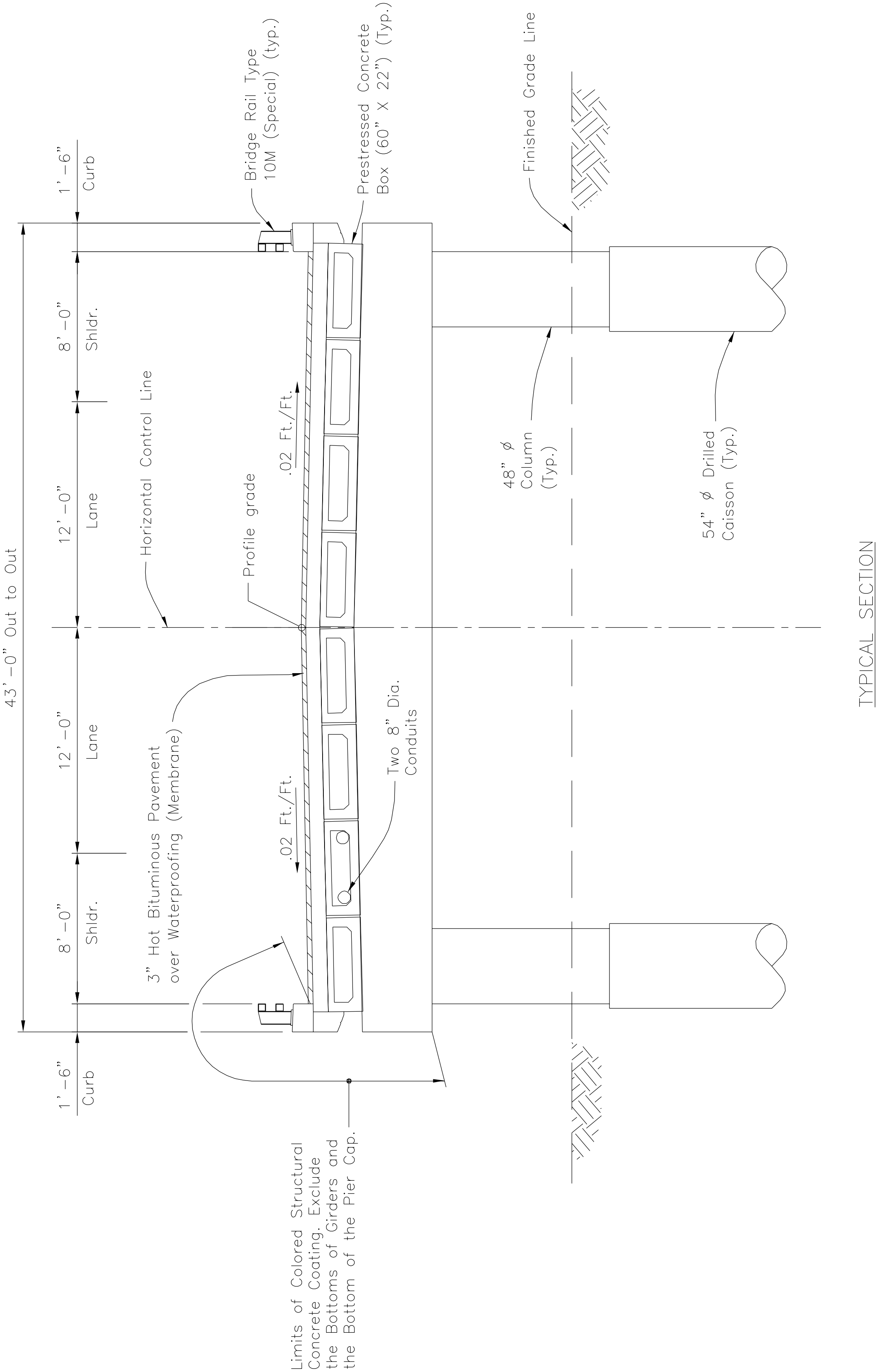

Figure 15. Bridge Typical Section