Aesthetic Solutions Using Spliced Girder Technology: Dayton Fifth Street over the Great Miami River

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ABSTRACT

The Dayton Fifth Street Bridge over the Great Miami River is a five-span, 623-foot long precast concrete bridge that was constructed using a combination of spliced girder techniques and conventional prestressed concrete construction methods. This aesthetically enhanced structure was designed to resemble the closed spandrel-filled arch bridge that it replaced. Half-span girder segments were spliced together to create deeply haunched fascia girders. Conventional, constant depth prestressed concrete I-beams were used for the interior beam lines.

Keywords: Aesthetics, Post-Tensioning, Spliced Girder

PROJECT DESCRIPTION

The Fifth Street Bridge over the Great Miami River connects downtown Dayton, Ohio with the historic Wright Dunbar Village area. This bridge is a vital and highly visible transportation link for the city, carrying nearly 15,000 vehicles per day, as well as significant pedestrian traffic from the adjacent community college campus.

The existing Fifth Street Bridge was an earth-filled, closed spandrel arch structure that was constructed in 1916. This bridge consisted of seven spans and was approximately 620 feet in length. A study conducted by the Ohio Department of Transportation (ODOT) showed that the existing bridge was deteriorating structurally and that its width was inadequate to meet the city's growing traffic demands. Preliminary design of a replacement structure began in 2000.

The existing bridge was one of a number of historic earth-filled arch structures that cross the Great Miami River near downtown Dayton. The majority of these structures were built in the aftermath of a large flood that occurred in 1913, when many of Dayton's bridges were destroyed. Community leaders, through a workshop process administered by ODOT, requested that the new bridge be designed to resemble the existing spandrel arch it would replace.

Funding for architectural enhancement of the replacement structure was limited, so the designer proposed an innovative design to achieve the aesthetic requirements of the project at a low overall cost. The replacement structure would be constructed using a conventional concrete I-beam superstructure with deeply haunched fascia girders to mimic the appearance of the existing bridge.

Fig. 1 Existing Dayton Fifth Street Bridge

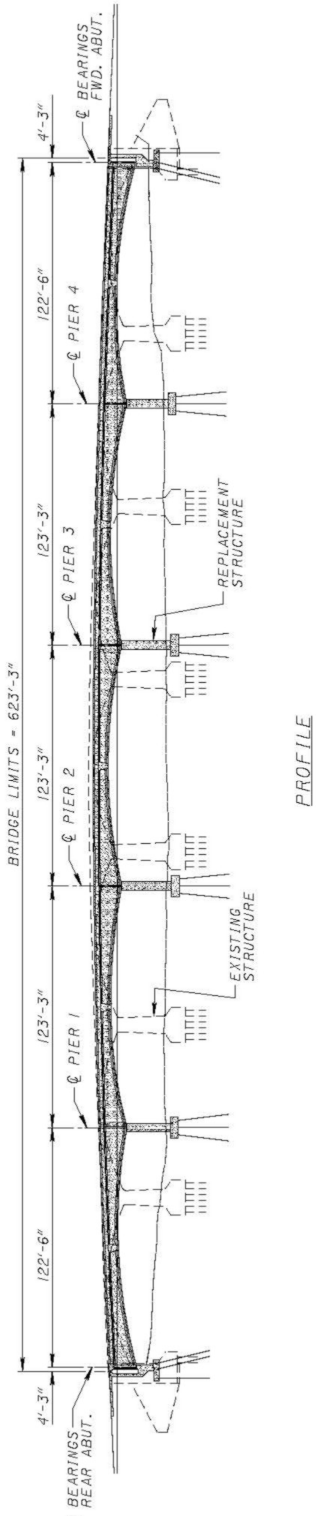

Fig. 2 New Dayton Fifth Street Bridge

REPLACEMENT STRUCTURE

The new Fifth Street Bridge is a five-span, 623-foot long structure built using a combination of conventional prestressed concrete I-beams and spliced, post-tensioned concrete girders. The bridge is 89.5 feet wide measured from edge to edge of deck, and it is supported by nine interior beam lines and two fascia girders. Fig. 2 shows a profile drawing and photographs of the replacement structure.

The fascia girders are parabolically haunched to resemble the shape of the existing arch structure. The depth of these girders vary from 5 feet at midspan to 11 feet at the piers. The fascia girders were precast in half-span segments and spliced at midspan and at the piers in order to reduce the size and weight of the segments for transportation and handling. The girders were continuously post-tensioned over the entire length of the structure. Details of a fascia girder segment are shown in Figure 3.

The interior beam lines of the replacement structure consist of constant-depth AASHTO type 4 modified prestressed concrete I-beams. The interior beams are constructed span-by-span and carry non-composite dead load as simple spans. Continuity for live load is achieved through a composite concrete deck.

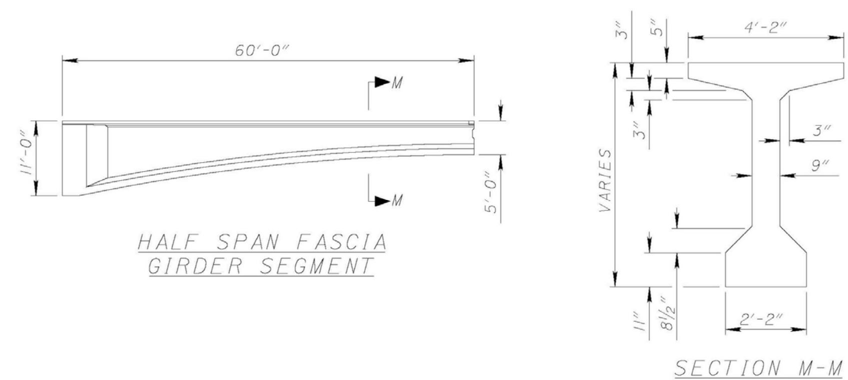

Fig. 3 Fascia girder segment details

Fig. 4 Transportation of fascia girder segments

Fig. 5 Temporary shoring supporting fascia girder segments

The interior beams and fascia girders are tied together by steel crossframes at the span quarter-points and by cast-in-place diaphragms at the piers and substructures. Both the interior and exterior girders are fully embedded in the pier and abutment diaphragms, and the diaphragms are supported by a single line of bearings at each substructure.

The bridge railing consists of cast-in-place panels and pylons and a galvanized steel handrail. An architectural relief was formed into both the inside and outside face of the railing panels. A photograph of the bridge railing is shown in Fig. 7.

Piers and abutments include architectural pylons that extend outside of the fascia girders on each side of the bridge. The pylons serve both to enhance the appearance of the substructures and to hide the elastomeric bearings and the cast-in-place splice in the fascia girder located at each pier. A photograph of a typical pier pylon is shown in Fig. 8.

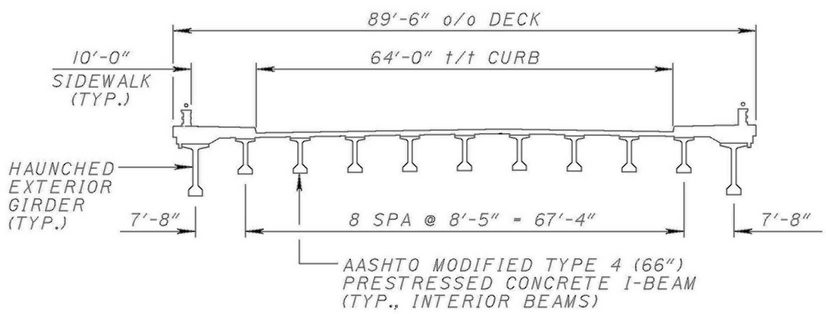

Fig. 6 Superstructure cross section

Fig. 7 Railing

Fig. 8 Pier pylon

DESIGN CONSIDERATIONS

A three dimensional analysis of the structure was conducted in order to account for the effects of differential stiffness between the interior beams and fascia girders. The analysis was conducted using a finite element model that considered member conditions at the various construction stages and under final loading. Time-dependent effects due to shrinkage and creep were incorporated into the model.

The unusual configuration of this structure resulted in a number of noteworthy design details:

Fascia Girder Bearings: Each fascia girder is supported by a single elastomeric bearing at each pier location. A PTFE sliding surface is bonded to each expansion bearing to allow translation to occur during post-tensioning. In order to accommodate the cast-in-place splice at each pier, the half-span segments were temporarily supported until the splice was installed. The gap between the bearing load plate and the bottom of the fascia girder was filled with non-shrink grout. A typical bearing detail is shown in Fig. 9.

Abutment and Pier Diaphragms: At the pier and abutment locations, the fascia girders are 11 feet deep and interior beams are 5.5 feet deep. Bearings for both the interior beams and fascia girders needed to be placed at approximately the same elevation in order to prevent a "wrenching" effect in the deck. For this reason, the interior beams and fascia girders are embedded into a common diaphragm at each substructure, and this diaphragm rests on a single line of elastomeric bearings at its base. The pier and abutment diaphragms are constructed in stages in order to incorporate the interior beams. Details of a typical pier diaphragm are shown in Fig. 10.

Construction Sequence: The unusual combination of girder types and bearing conditions required a relatively complex sequence of construction. This sequence is fully detailed in Fig. 11.

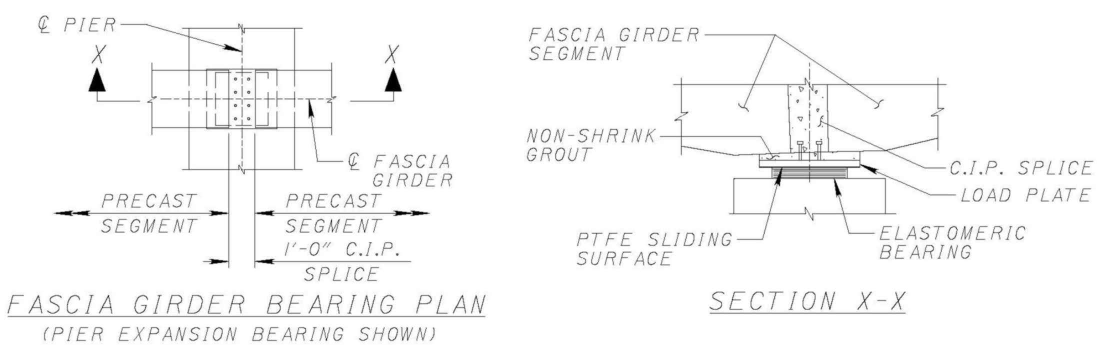

Fig. 9 Bearing details

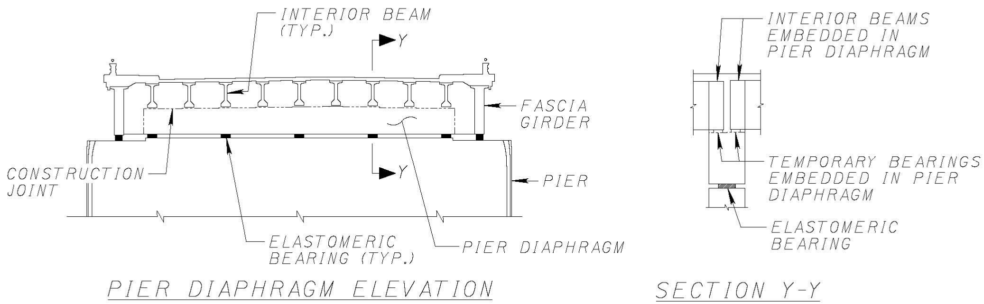

Fig. 10 Diaphragm details

CONSTRUCTION COSTS

Construction of the Dayton Fifth Street Bridge was completed in 2003. The total construction cost for the project was approximately $6.7 million. This cost included the removal of the existing bridge, the construction of the new bridge, and approximately 600 feet of highway construction. The cost of the new bridge alone (not including removal of the existing bridge) was $5.4 million, or $97 per square foot of bridge deck. The cost of the bridge superstructure was $3.0 million, or $54 per square foot of bridge deck.

ACKNOLWDGEMENTS

The owner of the Dayton Fifth Street Bridge is the Ohio Department of Transportation. The bridge was designed by Burgess & Niple, Inc. and built by Kokosing Construction Company. Precast beams and girder segments were fabricated by Prestress Services, Inc.

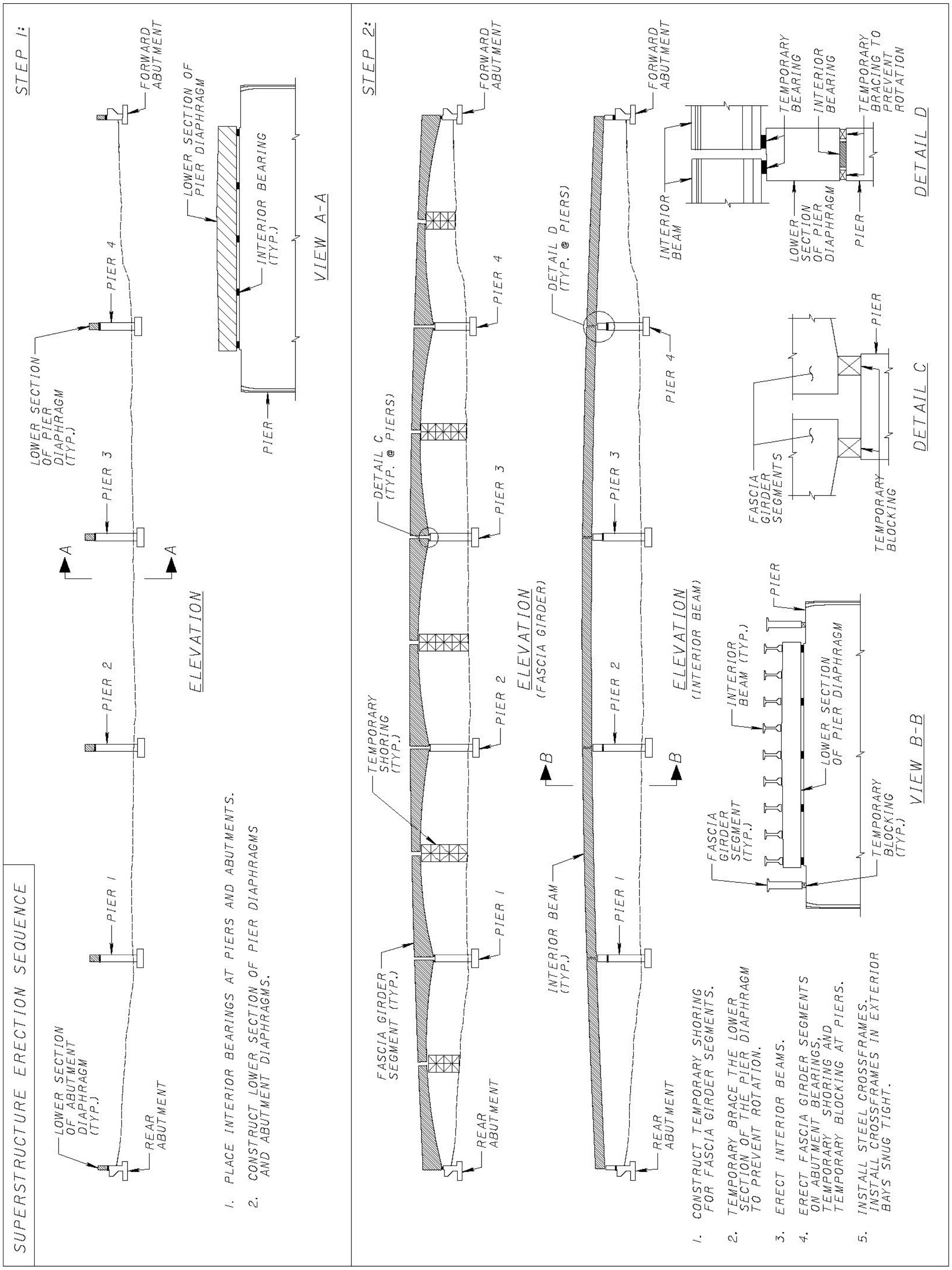

Fig. 11 Superstructure Erection Sequence (Sheet 1/3)

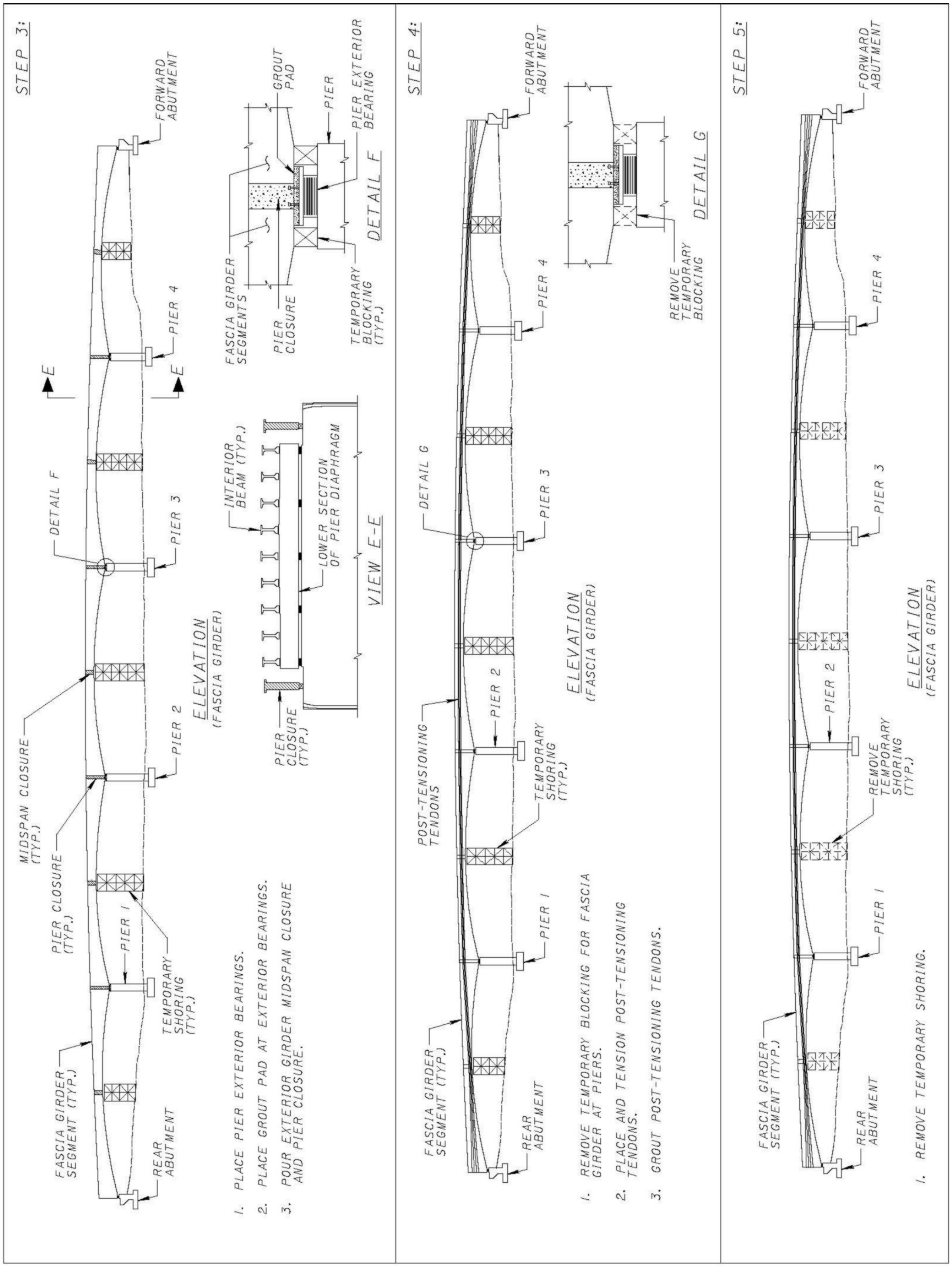

Fig. 11 Superstructure Erection Sequence (Sheet 2/3)

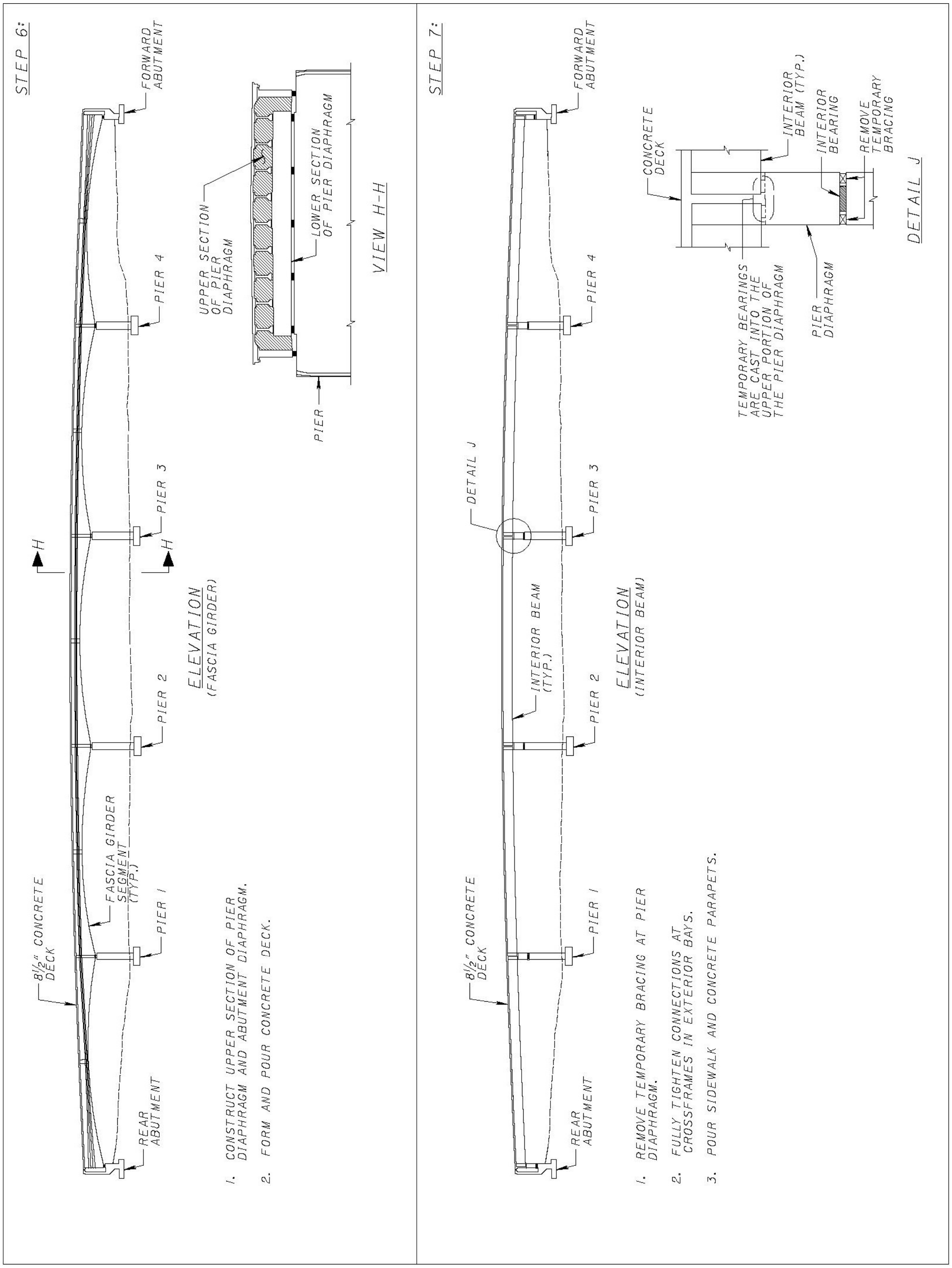

Fig. 11 Superstructure Erection Sequence (Sheet 3/3)