THE USE OF PRECAST PRESTRESSED BOX BEAMS FOR TEMPORARY BRIDGE CONSTRUCTION

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ABSTRACT

The Connecticut Department of Transportation will be reconstructing the bridge carrying Route 151 over the Salmon River in East Haddam, Connecticut. The project includes a three span temporary bridge carrying two lanes of traffic during construction. The structure is a three span bridge with 80-foot spans, with a total length of 240 feet.

In the early1990's the Connecticut Department of Transportation designed a multi-span temporary bridge for a Connecticut River Crossing using precast prestressed adjacent box beams with precast parapets. The beams allowed for rapid construction, rapid removal and the potential for re-use in the future. The beams have been placed in storage since their removal.

The East Haddam temporary bridge has a skew of 45 degrees, whereas the Connecticut River temporary bridge had no skew. This paper's focus is on the use of precast adjacent box beams for temporary bridge construction and the effect they have on construction speed and subsequent re-use for other temporary bridge projects. The use of square beams for skewed temporary bridge applications will be discussed, thereby making the product applicable to a wide variety of bridge scenarios.

Keywords Precast boxbeam, temporary, rapid construction

INTRODUCTION

In 1983, a portion of the bridge carrying Interstate 95 over the Minus River collapsed. This tragedy precipitated a major bridge rebuilding program by the Connecticut Department of Transportation. During this program hundreds of bridges were either replaced, or rehabilitated. One major bridge that was reconstructed is known as the Bissell Bridge. This structure carries 4 lanes of Interstate 291 over the Connecticut River between Windsor and South Windsor, Connecticut. The Bissell Bridge rehabilitation consisted of a replacement of the superstructure. In order to maintain 4 lanes of traffic during the construction, the State used a temporary bridge adjacent to the existing bridge that was supported on steel pile bents. A decision was made to use precast prestressed adjacent box beams for the temporary bridge for several reasons:

- Adjacent box beam bridges do not require a concrete deck, thereby eliminating the need for forming, casting and curing of a bridge deck
- The construction and subsequent removal of the bridge can be accomplished quickly
- The beams could be re-used for future temporary bridges

The Bissell Bridge project was constructed in the early 1990's. The temporary bridge was designed with multiple 80-foot long spans with zero skew. There were two types of beams cast for the spans. The interior beams were all identical. The fascia beams were cast with preset anchorages for temporary precast parapets. These anchorages required different internal voids in the beams in order to accommodate the parapet anchorages. The precast parapets used on the original bridge were bolted to the box beams with steel brackets. The temporary bridge was in service for several years and functioned well. Upon completion, the bridge was dismantled and the beams were taken to a storage yard in the area.

The beams have now been in storage for over ten years. Figure 1 is a photo of the beams in the storage yard. There has been some camber growth, but overall the beams are in very good condition.

Figure 1: Stockpiles Bridge Beams

REUSE OF THE PRECAST BEAMS

The Connecticut Department of Transportation is currently in the process of replacing the bridge carrying Route 151 over the Salmon River in East Haddam, Connecticut. The existing bridge is a three-span steel through-girder structure with a history of scour problems (see Figure 2). The existing piers and abutments are simple spread footings supported on native soils. The Department has installed grout bags around the piers to prevent scour, and at one time repaired one of the piers due to undermining. The grout bags were only an interim measure, and it was determined that the best course of action would be to replace the bridge with a 250 foot single span structure on pile supported abutments. The two-lane bridge is not wide enough for traffic staging, and the detour route around the site is over 17 miles. These reasons led the Department to decide to build a temporary bridge adjacent to the existing span in order to accommodate two lanes of traffic during construction. The project was listed on the Department's bridge replacement program and was assigned to CME Associates for design plan development.

Figure 2: East Haddam Bridge Site

The Department investigated the use of the Bissell Bridge temporary beams for the site. Since the span lengths matched well with the existing bridge spans in East Haddam, a decision was made to re-use the Bissell Bridge beams. The major problem with the re-use of the beams was the proposed skew of the East Haddam bridge. The Bissell Bridge had zero skew, while the East Haddam bridge was skewed at 45 degrees. The original beams were designed and constructed with typical transverse post tensioning according to the details in the Connecticut Department of Transportation bridge design manual. At that time, the Department was using a single post-tensioning strand tensioned to 30 kips at the beam-ends and at the beam quarter points. The strands were set in precast holes in the beams just below the longitudinal shear keys.

In order to re-use the beams at the East Haddam site, a system of post-tensioning was developed to accommodate the different skew.

DESIGN DEVELOPMENT

The Bissell Bridge beams were fabricated with square ends. In order to accommodate a 45-degree skew, a framing layout was developed with a saw-tooth end pattern (see Figure 3).

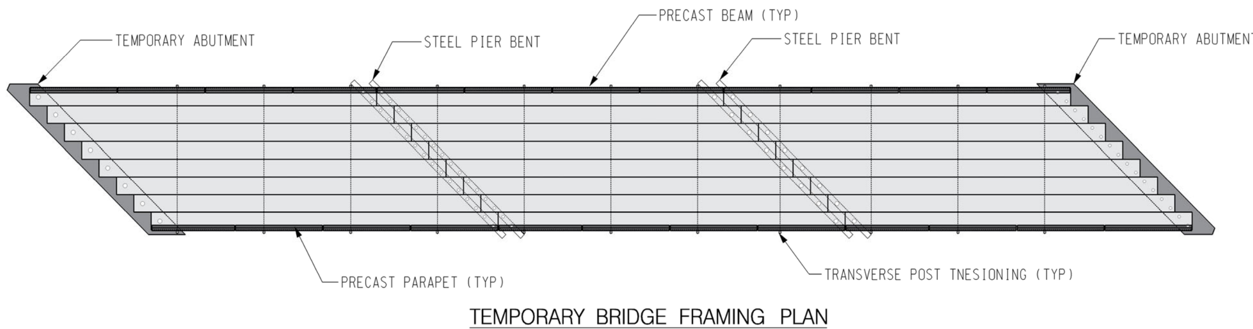


Figure 3

This beam layout necessitated several new design and detailing requirements when compared to the original Bissell Bridge Temporary structure. The holes in the beams for the transverse post-tensioning no longer line up due to the skew (See Figure 4 for the typical hole location at the beam ends). In order to provide a transverse connection between beams, a system of external post-tensioning was developed. The detailing of the abutment backwalls was modified to accept the saw-tooth beam configuration. Details at the piers were straightforward with two lines of beam support. This was required regardless of the skew of the structure.

Figure 4: Existing Beam Details

TRANSVERSE POST-TENSIONING

There is quite a difference of opinion among the State Departments of Transportation regarding the transverse connection of adjacent box beam bridges. Details range from threaded rods to post-tensioning systems. Even the amount of transverse force required to connect the beams varies widely from state to state. Connecticut had been designing

adjacent box beam bridges for years with only 10 kips of transverse force at each transverse tie. Other states design with as much as 100 kips per location. This force is required in order to make use of the live load distribution factors included in the AASHTO codes.
Article 3.23.4 of the AASHTO Standard Specifications for Highway Bridges[1] specifies a transverse connection, but does not specify the level of the force required. Article 4.6.2.2.1 of the AASHTO LRFD Bridge Design Specifications[2] recommends that the transverse post-tensioning force of 250 psi across the beam connection. For a 6" deep shear key, this equates to a transverse force of 30 kips spaced every 20 feet. Current practice in Connecticut is to use 30 kips of force at approximately the beam quarter points.

A system of external transverse post-tensioning was developed to accommodate the required transverse force. Figure 3 shows the layout of the transverse post tensioning, and Figure 5 depicts the typical cross section for the bridge.

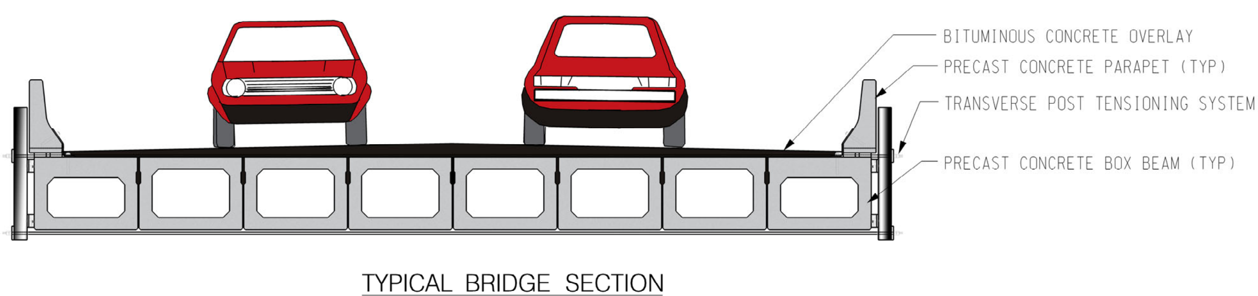


Figure 5

The purpose of this system is to transfer a transverse prestress force at the level of the shear key between the box beams. The system is comprised of high strength threaded post-tensioning rods that run across the width of the bridge. The top rod is placed directly on top of the box beam, and the bottom rod is suspended below the bridge. Different tension in each rod provides a centroid of force at the shear keys. The rod is protected from traffic by a bituminous concrete overlay, which is normally specified on adjacent box beam bridges in Connecticut. This type of system is not recommended for permanent bridge installations where long term corrosion of the rods would be a concern. Most temporary bridges are only in service for one or two years, therefore the corrosion of the rods is not a concern.

Figure 6 and 7 show the details of the end connections. The lateral post-tensioning force is induced into the beam near the centroid of the top and bottom flanges. Normally the post-tensioning force is applied at an intermediate internal diaphragm. The framing layout of the East Haddam bridge necessitated the introduction of this force away from these diaphragms. Application of this force in the beam web could lead to a transverse punching shear failure of the web.

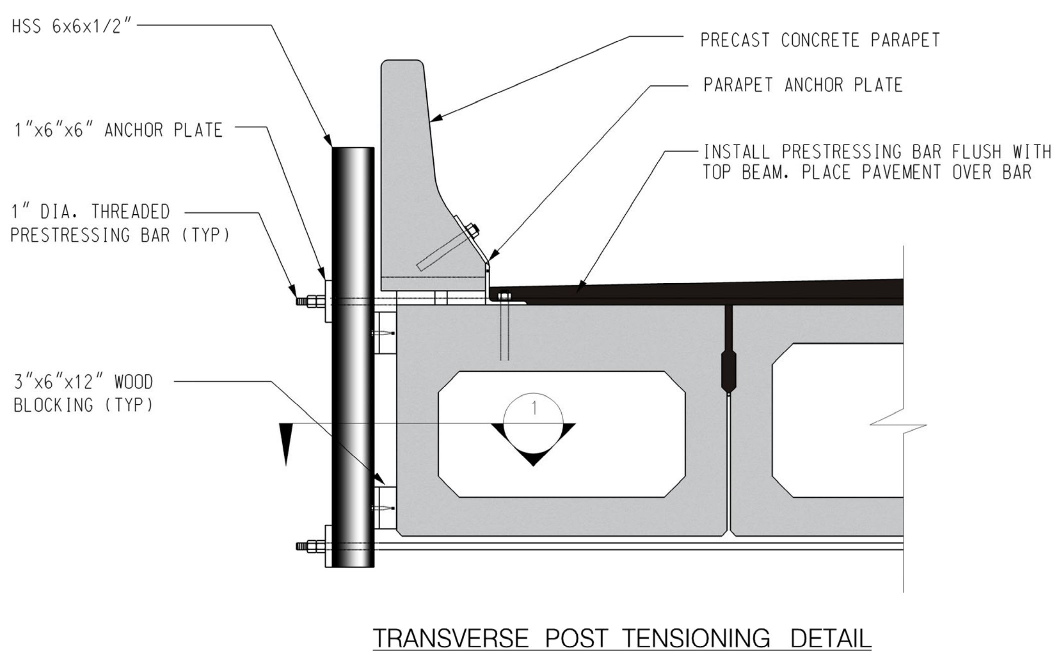


Figure 6

The transverse force is applied to the beam through a load distribution plate and wood blocking. The wood blocking ensures against force concentrations at the point of application of load. The anchorage for the thread bars is standard hardware supplied by the bar manufacturers.

There is an additional benefit to this system. The vertical member of the anchor bracket is a structural tube. This tube can be detailed as shown to provide a back up for the precast parapet anchorage. If the embedded anchorage fails during a vehicle impact, the post-tensioning bracket will be available to provide additional lateral support.

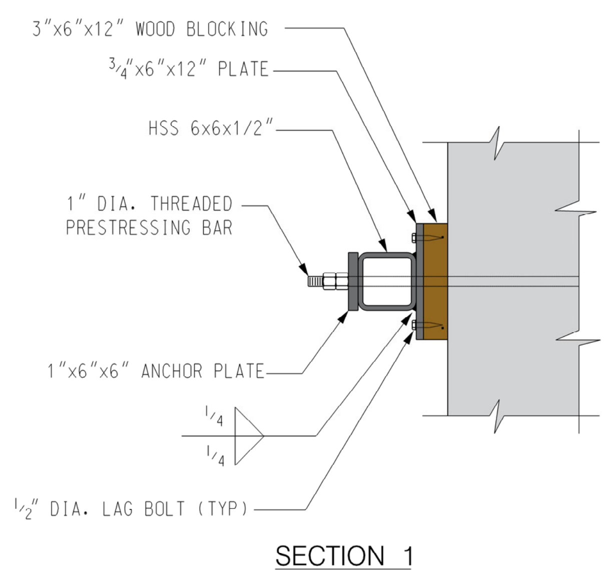


Figure 7: External Post-Tensioning Anchorage

SUBSTRUCTURE DETAILS

Abutment details can vary significantly for temporary bridges. The East Haddam bridge is a river crossing with the temporary abutments placed at the edge of the riverbank. The abutments were designed with steel pile supports because bedrock was within 50 feet of the surface. Temporary steel sheeting was detailed to retain the soil beneath the abutment cap. A simple abutment cap design transfers the beam reactions into the piles, thereby eliminating the large surcharge forces from the superstructure. The details of temporary abutments will vary from site to site depending on the layout of the bridge and the soils conditions at the site.

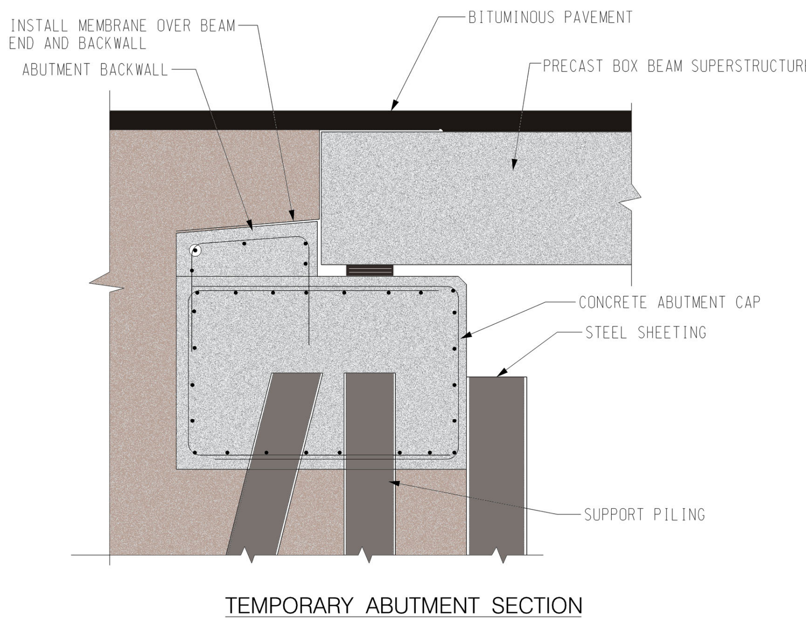
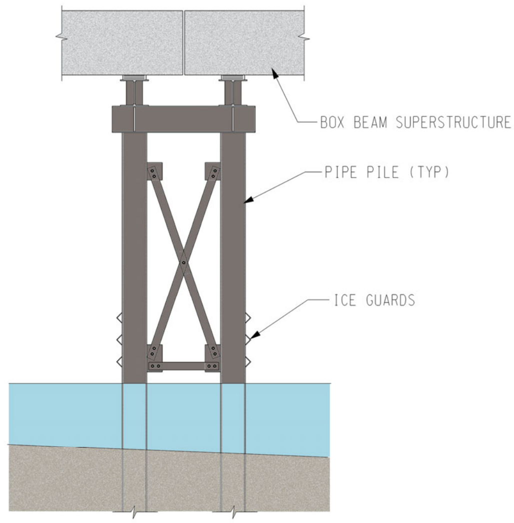


Figure 8

The details used for the abutment are somewhat like the standard details for permanent bridges in Connecticut (see Figure 8). The longitudinal and transverse forces such as braking, wind, and seismic loads are transferred to the abutments through an abutment backwall that is cast against the beam ands and sides after erection. The bridge superstructure is floated on the substructure (expansion bearing at each beam end). This system eliminates the need for anchor rods, which greatly facilitates the installation (and later removal) of the bridge superstructure.

The temporary piers were designed as simple pile bents (see Figure 9). A significant amount of cross bracing was included in the design due to the large ice floes that are present at the site. Pile driving in rocky soils may result in drift of the piles, but this can be accommodated by adding a double layer of beams at the top of the bent. If any of the piles are misaligned in either direction, the cap beams can accommodate them.

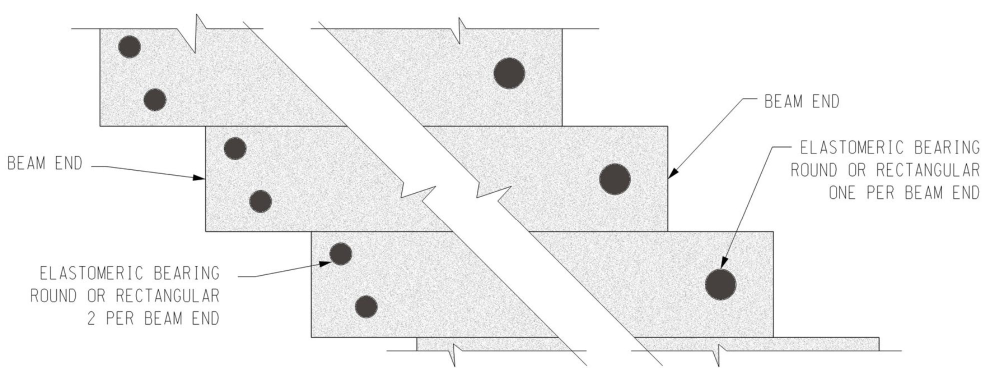


TEMPORARY PIER DETAILS

Figure 9

BEARING LAYOUT

The erection and setting of precast adjacent box beams can be difficult, especially on uneven beam seats. May states use elastomeric strip bearings, and some states use two bearings at the end of each beam. If the beam seats are not close to perfect, the beams have been found to rock on the diagonal corners. In an effort to simplify this problem, the PCI Northeast Region bridge technical committee adopted a bearing layout that includes three bearings per beam[3] with 1 bearing at one end, and two bearings at the other end (see Figure 10). This configuration allows setting of the beams on three determinate points (similar to a tri-pod). Minor deviations from a perfect beam seat are easily accommodated with this approach.



PLAN VIEW OF THREE BEARING LAYOUT

Figure 10

CONCLUSIONS

A system of constructing a temporary bridge using precast prestressed adjacent box beams was developed and used on a bridge in the 1990's by the Connecticut Department of Transportation. The beams were used for a large viaduct across the Connecticut River. The original design was for a zero skew superstructure. The Department made a decision to re-use the beams on a current project in East Haddam Connecticut that involved a three span temporary structure that needed to be skewed at 45 degrees. Details were developed to re-use the squared end beams on a skew using an external transverse post-tensioning system.

The use of precast adjacent box beams for temporary bridges has several key advantages to other temporary bridge structures:

- The beams are very durable and can be re-used many times.
- The superstructure construction is rapid, and in most cases can be erected and open to traffic in a few days.
- There is no limit to the width of the bridge. Many prefabricated temporary steel bridges have limitations on width based on the size of the floorbeams required. Precast adjacent box beams can be arranged to meet the requirements each site.
- By using the details included in this paper, skewed bridges can easily be accommodated with square end beams.
- By using and stockpiling precast adjacent box beams, a state or county department of transportation can have access to a temporary bridge for future construction projects and emergencies.

REFERENCES

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