

PRECAST REPAIR OF BRIDGE APPROACH SLAB SUPPORT

Dean Bierwagen, PE, Bridges and Structures, Iowa Dept. of Trans. Ames, IA

Michael D. LaViolette, PE, HNTB, Omaha, NE

Ahmad Abu-Hawash, PE, Bridges and Structures, Iowa Dept. of Trans. Ames, IA

Brent Phares, PhD, P.E., Iowa State University, Bridge Engineering Center, Ames, IA

ABSTRACT

Bridge owners are frequently faced with the need to replace critical bridge components during strictly limited or overnight road closure periods. This paper presents the development, testing, installation and monitoring of precast concrete bridge elements specifically designed for the Iowa Department of Transportation to address this condition.

A rapid precast paving notch replacement has been developed, which could be installed quickly using a single overnight bridge closure. The system consists of a precast prestressed concrete support that is connected to the rear of the abutment backwall using high-strength stainless steel rods and epoxy adhesive. Researchers at Iowa State University have performed full-scale laboratory testing of the paving notch replacement system and the Iowa Department of Transportation did a demonstration project on a bridge repair in central Iowa in the summer of 2007.

This paper presents the development of this fast-track bridge repair system, laboratory testing, and the field installation.

Keywords: accelerated construction, precast, post-tensioning, bridge repair, and epoxy repair

INTRODUCTION

Approach pavement settlement at the end of bridges has been an ongoing problem for Iowa bridges. The failure of the bridge paving support, generally referred to as the “paving notch”, has been documented through previous investigation by the Iowa Department of Transportation (Iowa DOT) as a contributing factor in this settlement. Figure 1 presents an example of a deteriorated paving notch that has been uncovered.



Figure 1. Deteriorated paving notch on an integral abutment bridge.

Deterioration of the paving notch is due to a combination of circumstances including:

1. Improper construction of the approach pavement. During casting of the approach pavement, the top of the paving notch is not properly cleaned off resulting in overstresses condition due to uneven bearing of the approach slab on the notch.
2. Debris collecting in the open joint between abutment and approach pavement. This debris is compacted each time the bridge expands with annual thermal cycles, allowing additional material to accumulate. Over the course of time, the approach pavement is “pushed” off the paving notch.
3. Improper installation of reinforcing steel in both the paving notch and the end of the approach pavement. The result is un-reinforced areas that are prone to spalling. Insufficient attention by contractors and inspection personnel has been identified as one of the leading causes of this condition.

4. Settlement and erosion of the backfill material beneath the approach pavement permit the pavement to rotate and may create a localized loading at the tip of the paving notch.

The current repair method by the Iowa Department of Transportation consists of removing the deteriorated paving notch concrete while preserving as much of the existing reinforcing as possible. Wood forms are constructed, and a cast-in-place concrete paving notch is placed (See Figure 2). Following sufficient curing of the new support, a replacement approach slab pavement is constructed.

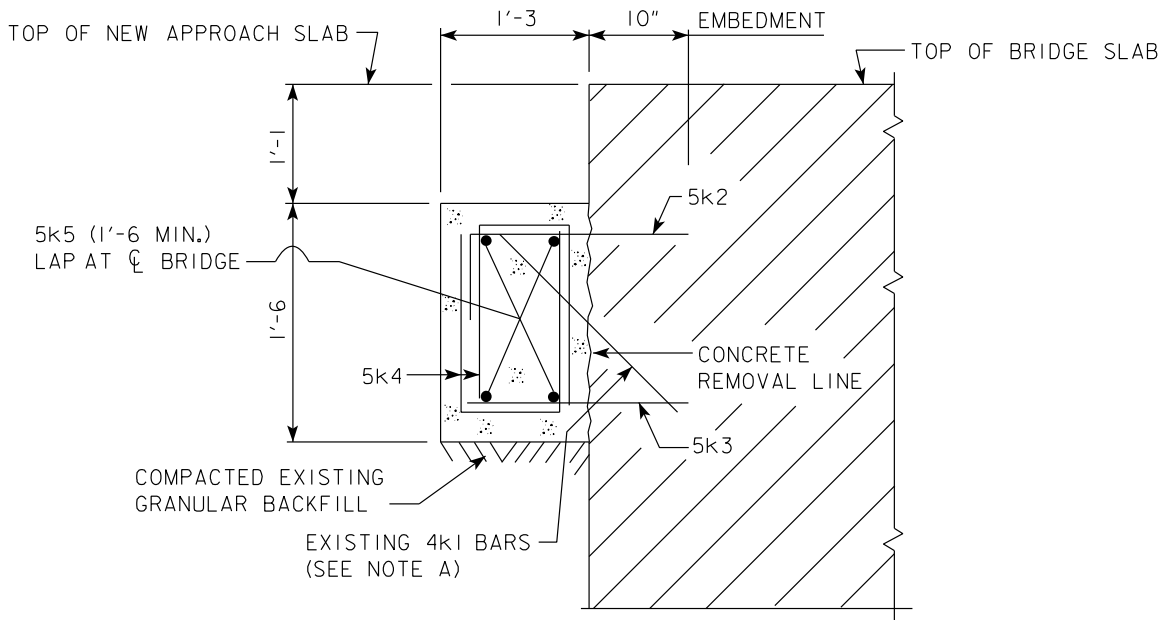


Figure 2. Cast-in-place paving support

This conventional replacement method requires that the bridge be taken out of service for an extended period of time. The bridges that tend to see the paving notch problem are usually in higher traffic volume locations which necessitate a more accelerated replacement method.

The objective of this research project was to demonstrate the feasibility of an accelerated replacement using a precast paving notch. If this system proved feasible, it could be used with a precast approach slab replacement for a limited closure of the highway allowing for repairs on a weekend or at night.

LABORATORY TESTING

Before this system was used in the field, a series of tests were performed by the Bridge Engineering Center (BEC) at Iowa State University (ISU) to determine the fatigue capacity and ultimate capacity of the system. The laboratory test specimen consisted of 1'-0 x 1'-0 x 4'-0 precast sections. Test loads were applied to simulate an AASHTO HS-20 wheel load of 16 kips. One million cycles of a 16 kip load was applied followed by 100,000 cycles with a 32 kip load. The specimen was then loaded to an ultimate load of 122 kips before failure (see Figure 3 for details of the test setup). Results of these tests were presented at the 2006 PCI National Bridge Conference.



Figure 3. Laboratory testing of support

EXISTING BRIDGE DESCRIPTION

The existing bridge (Bridge Number 6361.4L005) that was chosen for the repair project carries the east bound lanes of Iowa 5 bypass near Knoxville, Iowa (see Figure 4 for location). The three-span prestressed concrete beam bridge is 126'-4" long with a 40'-0 roadway and consists of spans of 34'-11", 56'-6" and 34'-11". The existing integral abutments have a 3'-0" wide backwall with #7 reinforcing bars spaced at approximately 1'-1" vertical. Design compressive strength for the existing abutment is 3,500 psi. Details of the existing paving notch and abutment backwall are shown in Figure 7.

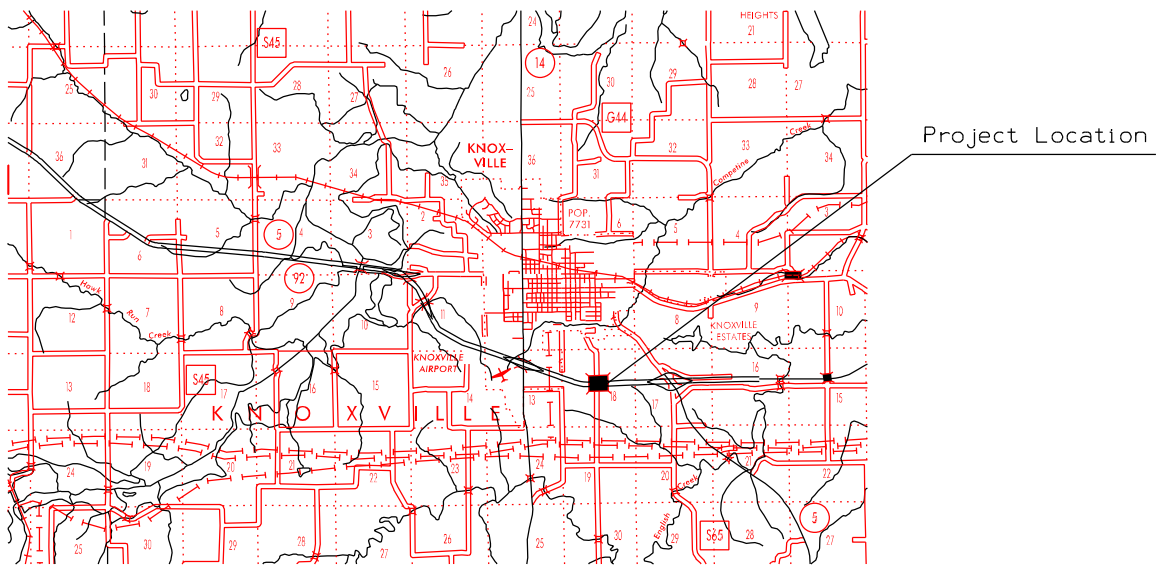


Figure 4. Project location

PRECAST SECTION DESCRIPTION

Based on the laboratory testing, a 1'-4" x 1'-4" cross section was chosen for the project, which allowed local fabricators to use standard precast pile forms for the section. The section used eight - ½ inch strands that were stressed to 75% of guaranteed ultimate for an initial prestress force of 248 kips. The design compressive strengths for release and final were 4,500 psi and 6,000 psi, respectively. The initial duct size for the threaded rod anchors was 1½ inches, which was revised during shop drawing review to 2 inches, to allow proper connection of the ½ inch diameter grout ports. In addition, the ends of each section were sealed with epoxy to prevent corrosion of the strands. See Figure 5 for cross section details.

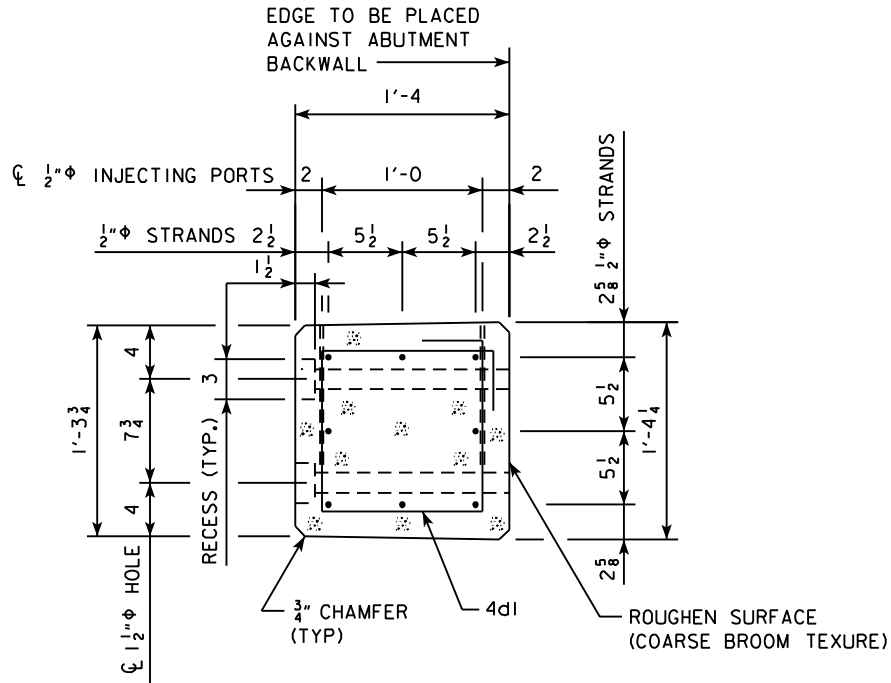


Figure 5. Selected precast section

Four precast sections per abutment (two 8'-11" and two 10'-11" long sections) were provided. To connect to the backwall, pairs of 3/4 inch diameter stainless steel threaded rods were epoxy grouted into the backwall at 1'-2 to 1'-10 spacing. The units were installed to match the existing crown of the bridge at 1.5 percent cross-slope. To allow for construction tolerances, 1" and 1/2" gaps were provided between units at the centerline and at the gutterline, respectively. After attachment of the precast section to the backwall, the ducts in the precast unit were be injected with an epoxy grout through the 1/2" diameter grout ports (see Figure 6).

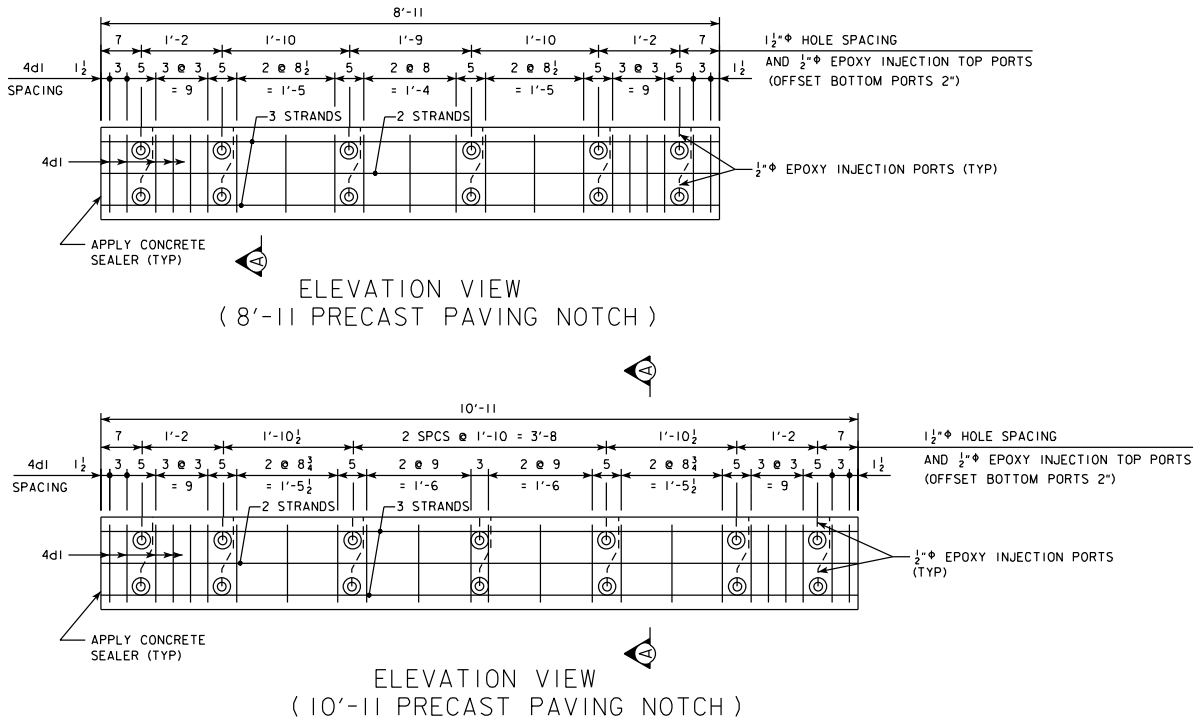


Figure 6. Elevation View of Two Precast Sections

The approach slab replacement at the site was a doubly reinforced 1'-0" thick standard cast-in-place approach slabs using Iowa Standard Road Plans, RK-19C and RK20. The approach slabs were not attached to the paving support, but allowed to slide with temperature changes. The joint between the abutment and approach slab is a rubber buffing expansion joint (CF-1) that is 2 inches wide.

The existing paving block shown in Figure 7 was removed flush with the back-wall. The replacement precast unit was connected to the existing backwall with 3/4 inch diameter stainless steel dowels drilled in and epoxy grouted as shown in Figure 8 and 9. The dowels were anchored approximately 1'-0" into the existing backwall to avoid the existing prestressed beam. In the design details an attempt was made to miss the existing reinforcing steel in the backwall. The new notch was lowered 3 inches for the larger thickness of the replacement approach pavement of 1'-1". See Figure 9.

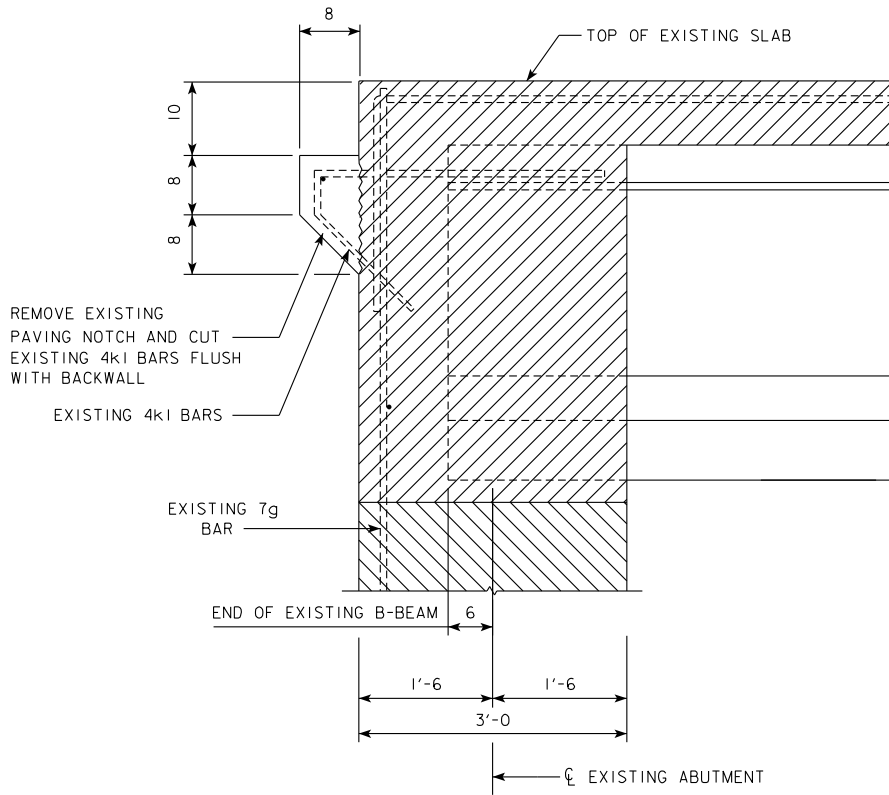


Figure 7. Side view of existing bridge abutment

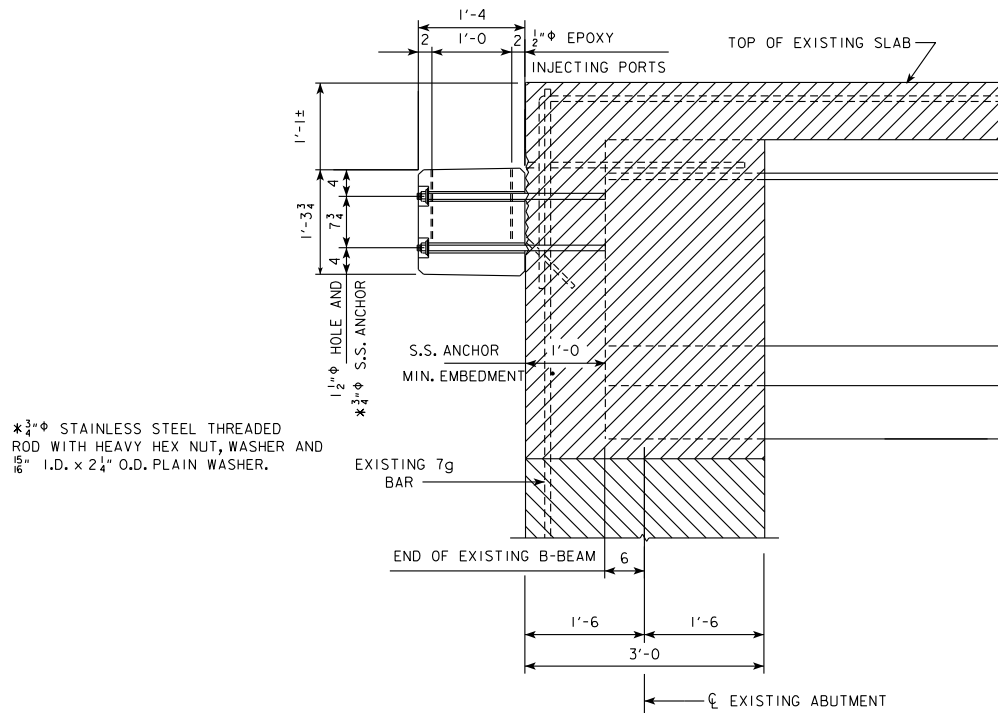


Figure 8. Side view of existing bridge abutment w/ precast section

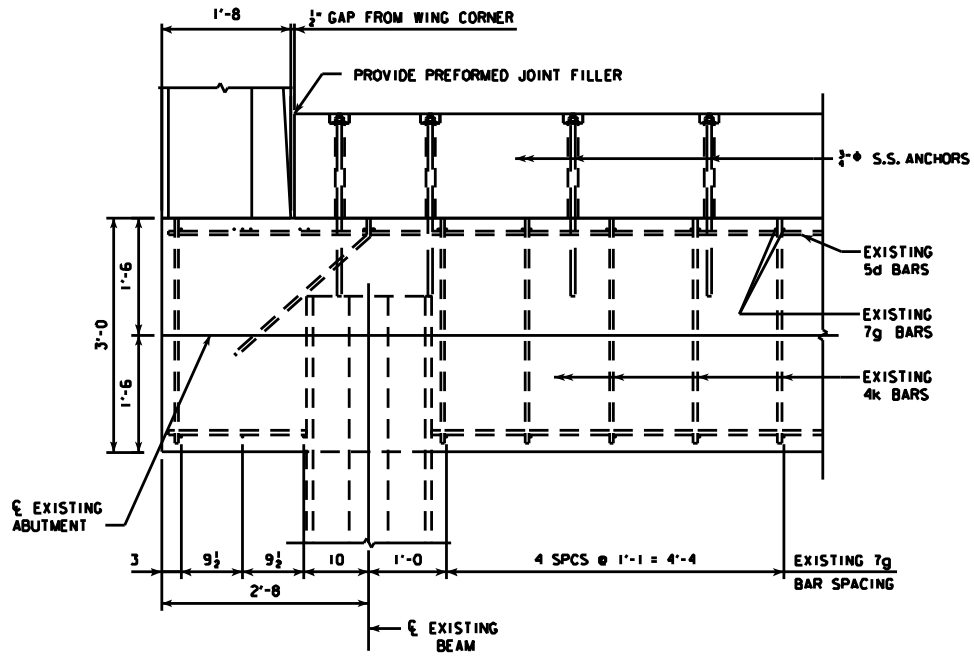


Figure 9 Part Plan View at Abutment Gutterline

INSTALLATION

The following sequence of pictures shows the field installation of the precast sections. Installation went smoothly; however, the contractor was not under time constraint for this demonstration project. Figure 10 is a view of the precast sections on their side at the construction site before installation. Note the ends were sealed with an epoxy compound to prevent corrosion of the strands.



Figure 10. Precast units at the bridge site

Figure 11 shows the backwall with the existing paving notch removed. A large concrete saw was used to cut off the majority of the notch along with a small jackhammer to complete the removal. The jack hammer was also used to roughen the contact area of the existing backwall to improve the epoxy bond between surfaces.



Figure 11. Existing abutment paving support removed

Figure 12 shows the drilling operation and the installation of the threaded stainless steel dowels. This portion of the installation was the most time consuming because of the difficulty of drilling through the existing concrete and reinforcing bars that were encountered in the backwall. The contractor was not allowed to shift the dowels because of the preset dowel locations in the precast section.



Figure 12. Drilling and installation of dowels

Figure 13 shows the application of the epoxy adhesive to the backwall and back of the precast section before the sections are bolted on. A two part epoxy paste (Rezi-weld) was used in the connection.



Figure 13. Applying epoxy paste to backwall

Figure 14 shows the first section being connected to the back wall at the gutterline, and Figure 15 shows final tightening of the connections. After tightening, the ducts were epoxy injected through the grout ports as shown in Figure 16. The additional sections were connected in a similar manner. Figure 17 shows the existing abutment with the four precast sections installed.



Figure 16. Grouting dowel ducts in precast units



Figure 17. Final Grouting dowel ducts in precast units

Flowable mortar was used for backfilling under the paving notch to prevent voids and achieve complete compaction. Figure 18 and 19 shows final placement of the mortar and the completed installation.



Figure 18. Backfilling the notch area with flowable mortar



Figure 19. Backfilling the notch area with flowable mortar

The Bridge Engineering Center at Iowa State University is currently monitoring the completed repair. Strains of the precast units and differential displacements with the existing backwall are being recorded. No research results are available at this time.

CONCLUSION

This project demonstrated the feasibility of doing a rapid replacement of an approach pavement support (paving notch) during approach slab replacement. Plans are to use this method as part of an accelerated approach replacement with precast approach pavement.

Bridge owners are frequently faced with the need to replace critical bridge components during strictly limited or overnight road closure periods. This paper presents the development and installation of precast concrete bridge elements specifically designed to address one of these needs. It should be noted that this research work is ongoing and a final report remains to be submitted. It is anticipated that this project will help the Iowa DOT develop the experience to apply rapid bridge and pavement repair and construction techniques in high traffic areas where the time of repair and disruption of traffic must be kept to a minimum.

ACKNOWLEDGMENT

We would like to acknowledge the following people that have contribute their time and effort to this project.

Iowa Department Of Transportation - Norm Mcdonald, Thayne Sorenson, and Brian Worrel

Bridge Engineering Center at ISU –Dr. Terry Wipf, Doug Woods, and Travis Hosteng

Iowa Prestressed Concrete - Ordean Johnson, Craig Brown, Darrel Olynick

Manatts PCC Paving Division - Cortney Graber