IOWA ACCELERATED BRIDGE CONSTRUCTION HISTORY

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ABSTRACT

This paper details the implementation of Accelerated Bridge Construction (ABC) by the Iowa Department of Transportation (DOT). The Iowa DOT constructed its first ABC demonstration project in 2006 and has completed eleven ABC projects to date. Projects have included the use of precast concrete approach pavement, precast concrete abutment footings, precast concrete wingwalls, precast concrete pier caps, precast concrete pier columns, full-depth precast concrete deck panels, modular bridge units and prefabricated bridge superstructure slides.

An overview and lessons learned from five key Iowa DOT ABC projects will be shared. These key projects have provided the foundation for moving the Iowa DOT from an ABC project demonstration phase to an ABC project implementation phase.

Keywords: Accelerated Bridge Construction, Rapid Renewal, Precast Concrete, Prefabricated Bridge Elements and Systems

INTRODUCTION

This paper details five key Accelerated Bridge Construction (ABC) projects that helped the Iowa DOT move from an ABC demonstration phase to an ABC implementation phase. A number of the demonstration phase projects were supported by federal funding grants such as the Innovative Bridge Research and Construction (IBRC) program, the Highways for Life (HfL) program and the Strategic Highway Research Program 2 (SHRP2) that assisted the Iowa DOT in developing ABC strategies and details.

In 2006 the Iowa DOT constructed its first ABC demonstration project for a full bridge replacement. The project was called the Mackey Bridge Replacement and was located in rural Boone County, Iowa. The Iowa DOT has completed eleven ABC projects and currently has three ABC projects in the design and development phase. A small number of the completed projects were purely demonstration projects with the intent of proof of concept for the design details. Other projects were both demonstration and implementation projects in order to fulfill a project mobility impact time constraint and to satisfy Iowa DOT transportation customer's needs. A complete listing of Iowa DOT ABC projects and be found in Appendix A: Table 6 – Iowa DOT ABC Projects.

MACKEY BRIDGE

The first major ABC project undertaken by the Iowa DOT was called the Mackey Bridge Project. The project was sponsored by an IBRC funding grant and the intent was to experiment with ABC details. The project was a partnership between the Iowa DOT and Boone County. The existing bridge was a historic Marsh Arch Bridge shown in Figure 1 – Marsh Arch Bridge. The bridge was classified as structurally deficient and functionally obsolete.

Figure 1 – Marsh Arch Bridge

The county entered into a programmatic agreement with the State Historic preservation Office that they would document all the historic Marsh Arch Bridges in the State of Iowa in exchange for being able to remove and replace this historic bridge. The Iowa DOT welcomed the opportunity to experiment with ABC techniques in a low pressure environment in order to learn prior to implementation on high profile projects with high pressure schedules. The bridge was located on a gravel county road with low traffic volumes and would utilize a full roadway closure for the duration of the project with an off-site detour. The single span March Arch Bridge was replaced with a three span Pretensioned Prestressed Concrete Beam (PPCB) Bridge. ABC components developed for this project were precast concrete abutment footings and particularly the connection detail between the precast concrete abutment footing and the deep foundation driven H-pile, precast concrete pier caps and full-depth precast concrete deck panels. A project summary can be found in Table 1 – Mackey Bridge Project Data Summary.

Name	Mackey Bridge
Location	120th Street over Squaw Creek
Year Constructed	2006
Owner	Boone County
Engineer	Iowa DOT
Bridge Type	PPCB
Size	151'-4 x 30'-6
Spans	47'-5, 56'-6, 47'-5
ABC Technologies	Precast Abutment Footing
	Precast Pier Caps
	Full-Depth Precast Deck Panels
Total Project Bid	$737,098.11
Bridge Unit Cost*	$90/SF
ABC Contract Period	None
Grant	IBRC
*Traditional unit cost at this time for PPCB = $60/SF	

Table 1 – Mackey Bridge Project Data Summary

The precast concrete abutment connection detail shown in Figure 2 – Precast Abutment Pile Pocket Connection was one of the major innovations of this project that has been carried forward to future ABC projects. The detail was conceptually developed by the Iowa DOT and then verified based on laboratory testing. Laboratory testing shown in Figure 3 – Laboratory Load Testing Pile to Precast Concrete Abutment Connection indicated the detail structural strength exceeded the allowable geotechnical capacity of the piling and was deemed a success. The testing goal was to test to ultimate failure but was stopped short due to reaching the allowable 400 kip load capacity of the testing frame. The piling used in this application was an HP10x57 pile. Additional testing information can be found in the publication "Precast Concrete Elements for Accelerated Bridge Construction[1]."

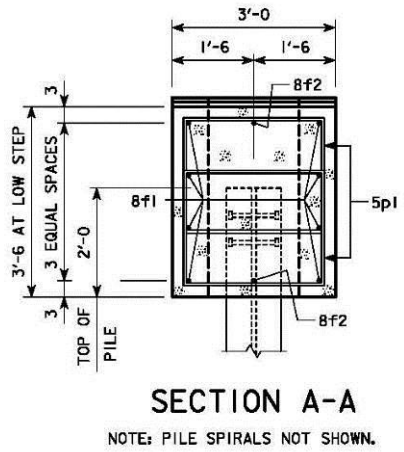

Figure 2 – Precast Abutment Pile Pocket Connection

Figure 3 – Laboratory Load Testing Pile to Precast Concrete Abutment Connection

Full depth precast concrete deck panels were used on the project. The panels were prestressed in the transverse direction and post-tensioned in the longitudinal direction. Figure 4 - Full-depth Precast Deck Panel Installation shows the panels being installed one unit at a time. Following installation the transverse joints were filled with a high-early strength concrete with a small top-size aggregate and high-range water reducer for workability and improved consolidation.

Figure 4 – Full-depth Precast Deck Panel Installation

The deck panels were then post-tensioned. At the time of design of the Mackey Bridge the AASHTO Standard Specifications 17th Edition didn't explicitly address the design of full-depth precast deck panels that were post-tensioned. The focus of the specification that was current at the time was for the use of precast deck panels as forms for a cast-in-place deck. The designers were aware of future AASHTO LRFD code provisions that would recommend a compressive force in the deck of 250 psi after losses and so the full-depth precast deck design was based on that requirement. However the designers were not aware of a future post-tensioning distribution specification and concentrated the post-tensioning in channels over the PPC beams as shown in Figure 5 – Post-Tensioning Channel.

Figure 5 – Post-Tensioning Channel

The project included an instrumentation component and the stress (strain) was measured in the precast deck panels due to the applied loads from the post-tensioning. In the analysis of the instrumentation it was "concluded that the stresses induced by the post-tensioning operation are essentially distributed uniformly throughout the deck, regardless of the proximity to the post-tensioning operation or to the post-tensioning channel[1]." Many of the lessons-learned with respect to the full-depth precast deck panels were applied on the 24th Street Bridge over I-29/I-80 project in Council Bluffs.

While the Mackey Bridge was not constructed on an accelerated construction schedule the details developed and constructed on this project were instrumental in developing ABC knowledge for future projects.

There were many lessons learned on the Mackey Bridge that have been applicable to future projects. Lessons learned on the Mackey Bridge ABC project included the following:

- Consider prestressing precast substructure units for transportation dynamic impact loads. One of the precast abutment footing pieces was delivered to the construction site with a tight hairline crack at the mid-span. The crack was ultimately determined not to be detrimental to the project. It was felt that the crack had developed in the shipping due to the dynamic loading and support and tie-down scheme used to transport the precast abutment footing.
- Consider individually encased h-pile bents instead of the painted pipe piling bents. The designers thought that the individual concrete encasement would be on the critical path for the project. Contractors have indicated that the encasement could potentially be installed off of the critical path after the precast pier caps were installed. The individual concrete encasement is thought to be a more desirable h-pile protection system than the painted pile due to the difficulties with field painting.
- The special concrete mix for the joints and post-tensioning channel was successful. The mix consisted of high cement content, small top-size aggregate and a high range water reducer for workability.
- Tolerance was needed for the deck panels which were cast just slightly on the high width side. The net result was a length increase of nine inches from PT anchorage to PT anchorage. In this case there was a cast-in-place end diaphragm that could accommodate the increased length. The designers were surprised at the nine inches of increased length.
- Stresses determined by instrumentation in the precast deck panel reinforcing was lower than predicted by modeling but there were torsion issues due to the precast deck panel skew that were not predicted by the modeling.
- There were two different top flange widths on the project. The mid span beam flanges were sixteen inches wide and the end span beam flanges were thirteen inches wide. The precast deck panel post-tensioning channels were ten inches wide. The wider flange gave better tolerance for setting the deck panels and having the deck overlap the flanges which helped with forming. Consider having

a minimum flange width of six inches wider than the post-tensioning channel if a system like this is used in the future.

- The haunch forming system used was a wood system and took a considerable amount of manual labor by the contractor. A more efficient system should be developed. A compressible material bonded to the beam flanges may be a more efficient method.
- There was more stirrup interference than anticipated due to the stirrups being normal to the beams with the panels reinforcing at a skew. Consider a skewed stirrup or other methods to minimize the conflict.

MADISON BRIDGE

The Madison Bridge was a partnership between the Iowa DOT and Madison County to replace an existing single span timber bridge using ABC details. The project was on a low volume gravel road and the concept was to use a precast abutment footing similar to the Mackey Bridge and pretensioned prestressed box beams with an integral deck surface. Similar to the Mackey Bridge the Madison Bridge was constructed with a conventional construction time period and the intent of the project was to experiment with ABC details rather than truly accelerate the project. A project summary can be found in Table 2 – Madison Bridge Project Data Summary.

Name	Madison Bridge
Location	290th Street over Branch Clanton Creek
Year Constructed	2006
Owner	Madison County
Engineer	Iowa DOT
Bridge Type	Precast Box Beam
Size	46'-8 x 24'
Span	46'-8
ABC Technologies	Precast Abutment Footing
	Precast Box Beams
Total Project Bid	$159,937
Bridge Unit Cost*	$98/SF
ABC Contract Period	None
Grant	IBRC
*No traditional unit cost data available for box beam bridges	

Table 2 – Madison Bridge Project Data Summary

While the construction contract period was not an accelerated schedule the contractor was able to construct this bridge in an expedited fashion over 3 weeks in December of 2006. The existing structure being replaced was a 22’ x 17’-7 single span timber bridge originally constructed in 1940 shown in Figure 6 – Madison Timber Bridge.

Figure 6 – Madison Timber Bridge

The precast abutment footing utilized the same pile pocket connection detail as the Mackey Bridge. The pile pocket design allowed for a driving tolerance of 3 inches in any direction in order to fit the precast abutment footing over the piling. The contractor took care in the pile driving operation in order to ensure fit up of the precast footing pile pockets over the H-piling. Installation of the precast footing is shown in Figure 7 – Precast Abutment Footing. The contractor proposed to use flowable mortar to fill a void beneath the abutment footing created by the temporary blocking used to set the precast abutment footing to the correct elevation. The flowable mortar concept was approved and seemed to work well.

Figure 7 – Precast Abutment Footing

The precast concrete box beam design was based on a typical Illinois DOT design for precast concrete box beams. The beam was a 27" deep beam with a span of 46'-8 and was prestressed. Beams were connected adjacently by shear keys and a high strength bar tie. There was also a dowel tie between the precast box beam and abutment footing in order to make an integral abutment style connection. One of the concerns of the designers was the live load transfer between adjacent box beams. The performance of the shear key and high strength bar tie load transfer was investigated via field load testing with weighted trucks and instrumentation on the bridge. According to the test report "When the experimental test results are compared with the Iowa DOT design values and the AASHTO Standard Specification recommendations, the experimental results show the bridge performance is conservative[2]." The designers chose a live load distribution factor of 0.5 and load test results indicated a live load distribution factor ranging from 0.43 to 0.25. Field load test results also indicated minimal rotational restraint at the end supports even with the dowel ties into the abutment footing. Designing the precast box beams for these ABC details should continue to be on a simply supported beam basis.

An additional concern of the designers was the potential for corrosion on the prestressing strands in the precast box beams. The beams were instrumented with corrosion detection sensors on strands in the top of the beam and bottom of the beam. Follow up field testing indicated that corrosion of ¼ of the selected strands for monitoring was active. The active corrosion was present in both the top and bottom strands.

The Madison County Bridge ABC concept is a promising ABC concept for low volume roadways and especially gravel roadways where de-icing chemicals will not be applied. The design results in an aesthetically pleasing structure shown in Figure 8 – Madison Completed Bridge. In the photo of the completed bridge it appears a gravel overlay has been placed on the bridge although this gravel has been carried onto the bridge naturally by traffic over time.

Figure 8 – Madison Completed Bridge

A second generation ABC precast box beam bridge was constructed in Buena Vista County in 2009 on an accelerated construction schedule. The project details were substantially the same with minor changes to the backwall detail on the Buena Vista bridge replacement project. The Buena Vista project contract was bid with a 10 day critical closure with Incentive/Disincentive. The maximum incentive was 5 days at $5,000 per day of which the contractor received the maximum incentive of $25,000. The bridge contracted was constructed in 4 days. Buena Vista County chose to do the approach roadway earthwork with their own forces and that took an additional 14 days to complete the work. Had the approach earthwork been contracted it could've been completed much more quickly.

Lessons learned on the Madison Bridge project include the following:

- The contractor's method of temporary support of the precast abutment footing followed by a flowable mortar fill beneath the abutment footing was a viable method for future ABC projects. The flowable mortar fill was a quick and effective way of avoiding a void beneath the abutment footing that could potentially lead to pile corrosion.
- The project included a cast-in-place abutment diaphragm closure that adds time on the construction critical path. This cast-in-place closure was eliminated from the subsequent Buena Vista project successfully with a precast unit.

24TH STREET BRIDGE OVER I-29/I-80 IN COUNCIL BLUFFS

The 24th Street Bridge over I-29/I-80 in Council Bluffs was the Iowa DOT's first high profile ABC project. The 24th Street Bridge shown in Figure 9 – Original 24th Street over I-29/I-80 Bridge, serves a busy commercial interchange in Council Bluffs and the traffic volumes on the combined I-29/I-80 and on 24th Street are high at 78,300 VPD and 15,000 VPD respectively. The Council Bluffs Interstate System (CBIS) is undergoing a multi-year reconstruction and the 24th Street Bridge was one of the first projects in the CBIS reconstruction. Due to the need to maintain traffic at this interchange a staged construction approach was selected. The bridge carries two lanes of traffic in each direction plus turning lanes for making left turns onto the Interstate ramps. The typical concept for a staged bridge replacement of this size would be for a two construction season staging. The Iowa DOT had a desire not to maintain a staged condition over the winter time and accelerate the construction to complete the project in the single construction season.

Figure 9 – Original 24th Street over I-29/I-80 Bridge

There were two primary ABC techniques incorporated on the project in order to meet the single construction season goal. The first was the use of full-depth precast post-tensioned deck panels and the second was the A+B contracting method. A project summary can be found in Table 3 – 24th Street Bridge Project Data Summary.

Name	24th Street Bridge in Council Bluffs
Location	24th Street over I-29/I-80
Year Constructed	2008
Owner	Iowa DOT
Engineer	Consultant
Bridge Type	CWG
Size	353'-6 x 82'
Spans	178'-6, 175'-0
ABC Technology	Full-Depth Precast Deck Panels
Total Project Bid	$12,506,262.87
Bridge Unit Cost*	$140/SF
ABC Contract Period	A+B with 210 days max. @ $1,500/day
Grant	HfL
*Traditional unit cost at this time for CWG = $120/SF	

Table 3 – 24th Street Bridge Project Data Summary

The full-depth precast post-tensioned deck panels shown in Figure 10 – Full-depth Precast Deck Panel Installation built on some of the lessons learned from the Mackey Bridge project. Improving the forming of the transverse joints and adapting to the new design specification requirements for distribution of post-tensioning in post-tensioned bridge decks were two of the primary improvements over the Mackey Project. The

precast post-tensioned deck panels were prestressed in the transverse direction and sized 52’ wide by 10’ long and 8 inches thick. The transverse joint improvement was to make the joint as a tighter joint shown in Figure 11 – Precast Deck Panel Transverse Joint Detail to install backer rod in the bottom as a form rather than wood forming beneath the deck. Grout was used to make the connections rather than the concrete mix with the small top-size aggregate.

Figure 10 – Full-depth Precast Deck Panel Installation

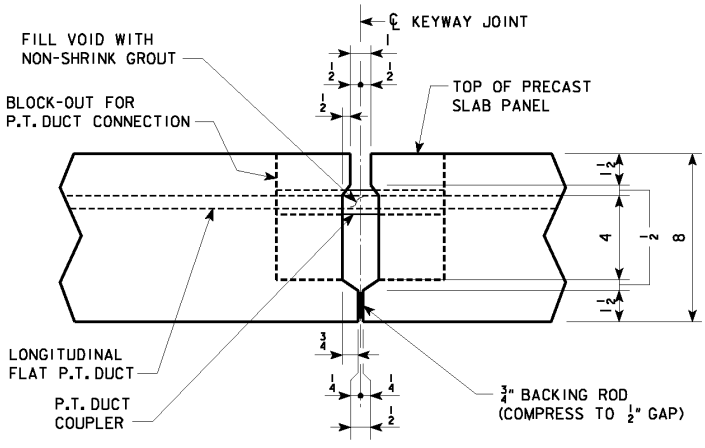

Figure 11 – Precast Deck Panel Transverse Joint Detail

While the girders were steel girders rather than prestressed concrete beams the lesson learned on the Mackey Project regarding the shear stirrup interference was extrapolated

to the 24th Street Bridge Project and there was careful consideration given to the configuration of the shear stud connection pockets. A mock-up was commissioned to determine if the stud field welding would be feasible with the pocket size and shape ahead of construction. The mock-up was successful and the shear stud welding in the field was time consuming but successful. The same concrete mix used on the Mackey Bridge Project was specified for filling the shear stud pockets and haunch areas on the 24th Street Bridge, shown in Figure 12 – Shear Stud Pocket. The contractor elected to use a slightly different mix of Self-Consolidating Concrete (SCC) which worked well.

The stud pockets were sand blasted for roughness to bond to the newly placed concrete. Ahead of construction the Iowa DOT commissioned research to study the bond strength of various surface finishes for bonding new concrete to precast concrete. The different methodologies investigated included using a form-liner with a raised pattern, roughening by sand blasting, using a chemical retarder followed by power washing following form removal and finally just a unfinished surface following timber form removal. Comparatively, the sand blasted surface performed the best in bond strength testing and was utilized for the 24th Street Bridge.

Figure 12 – Shear Stud Pocket

A+B contracting procedures were used on the 24th Street Bridge project and can be successfully used on ABC projects for providing contractor schedule flexibility and incentivizing and disincentivizing a contractor to meet a desired construction schedule. The A component of the bid is the cost of the itemized bid items for the project. The B component of the bid is a time unit bid by the contractor at a set cost per time unit with a cap on the maximum number of time units that can be bid. For the 24th Street Project the B unit was bid in days at a unit cost of $1,500 per day and capped at a maximum allowable number of 210 days that could be bid. The winning bidder bid 175 calendar days for the project. For each day they finished in advance of the 175 days bid the

contractor would receive and incentive of $1,500 per day. For each day the contractor exceeded the 175 days bid there would be a disincentive applied to the contractor at $1,500 per day.

Lessons learned on the 24th Street Bridge project include the following:

- Sand blasting is the preferred method of roughening precast concrete surfaces for bonding precast concrete to cast-in-place concrete.
- The incentive/disincentive cost set for the project needs to be significant enough to motivate the contractor to accelerate work to meet the desired schedule. While the 24th Street Project was completed on schedule the Iowa DOT was told by the contracting community that the $1,500/ day incentive/disincentive was very small compared to the contractor's actual costs for overtime and daily labor costs. The contractor may have considered paying disincentive instead of overtime but for the pride and goodwill of completing the project on-time. For this size project the contractor thought the daily incentive/disincentive wouldn't get a significant amount of their attention until it reached about $7,000 to $8,000 per day.

KEG CREEK BRIDGE

The US 6 Bridge over Keg Creek shown in Figure 13 - Existing US 6 over Keg Creek Bridge was a bridge replacement project originally designed and detailed for replacement using conventional construction techniques. The original intent was to detour traffic for the duration of the project as the project had a concept completed prior to the implementation of the Iowa DOT routinely screening projects for the appropriate application of ABC techniques. The Iowa DOT was approached about potential projects for a SHRP2 R04 ABC demonstration project and in the review of projects under development the Keg Creek Bridge rose to the top of the viable candidates. The strategic goal of the SHRP2 R04 project was innovative bridge designs for rapid renewal. The intent was to develop standards using ABC techniques such as Prefabricated Bridge Elements and Systems (PBES) to accelerate construction. The existing bridge was a three span continuous concrete girder bridge classified as structurally deficient and functionally obsolete. The detour length for the project roadway closure was 22 miles with 12 miles of out-of-distance travel. Reducing the time the bridge was out of service for replacement was a significant improvement on the mobility impact for the Iowa DOT's transportation customers.

Figure 13 – Original US 6 over Keg Creek Bridge

There were several innovative components used on this project. The project utilized precast concrete pier caps and columns, precast concrete abutment footings and wings, precast concrete approach pavement, a precast modular bridge system, Ultra-High Performance Concrete (UHPC) joints and grouted splice couplers for connecting precast concrete components. A project summary can be found in Table 4 – Keg Creek Bridge Project Data Summary.

Name	Keg Creek
Location	US 6 over Keg Creek
Year Constructed	2011
Owner	Iowa DOT
Engineer	Consultant
Bridge Type	Rolled Steel I Girder
Size	204'-6 x 44'-0
Spans	67'-3, 70'-0, 67'-3
ABC Technologies	Precast Abutment Footing
	Precast Wingwalls
	Precast Pier Caps
	Precast Pier Columns
	Modular Units
	UHPC Joints
	Grouted Splice Couplers
Total Project Bid	$2,658,823.35
Bridge Unit Cost*	$161/SF
ABC Contract Period	14 day critical closure w/ $22,000/day I/D
Grant	SHRP2 R04
*Traditional unit cost at this time for I Girder = $90/SF	

Table 4 – Keg Creek Project Data Summary

The contractor for the Keg Creek project was able to obtain a lease of farm land adjacent to the project site to utilize as a production site for the various precast concrete components on the project shown in Figure 14 – Temporary Bridge Production Site.

Figure 14 – Temporary Bridge Production Site.

The bridge modular units were constructed nearly as if they were in their final position with the only difference being forming to create the joints for the modular units. During the production of all the precast components the contractor also worked on new drilled shafts outside the footprint of the existing bridge. The new bridge was wider than the existing bridge and so a straddle bent was utilized with drilled shaft deep foundations. The drilled shafts were installed off of the project critical path and so they were immediately ready for installation of the precast concrete pier columns once the existing bridge demolition was completed. An emerging technology was used for making the connection from the drilled shaft foundation to the precast concrete columns called grouted splice couplers. Prior to this project grouted splice couplers had never been used on a bridge project in Iowa. Installation of the precast pier column is shown in Figure 15 – Precast Column Installation (Grouted Splice Couplers). The grouted splice couplers worked very efficiently for this project. A template is critical to line up the reinforcing projecting from the drilled shaft to the grouted splice couplers. The grout installation is a reasonably simple operation using a small pump to pump grout into the ports of the grouted splice couplers. While the Iowa DOT is aware that these couplers can be linked for mass grouting, for this project each coupler was grouted individually.

Figure 15 – Precast Column Installation (Grouted Splice Couplers)

The abutments used driven H-pile for a deep foundation with a precast concrete footing similar to the Mackey Bridge project. Once all the substructure was complete the modular units were installed, shown in Figure 16 – Placement of Modular Units. Joints between the modular units were connected using UHPC.

Figure 16 – Placement of Modular Units

The project was the first ABC project for Iowa to utilize UHCP joint connections. The UHPC is a good product for making these types of connections due to its very high compressive strength. The cylinder tests indicated 10,000 psi compressive strength at 48 hours and 21,000 psi compressive strength at 28 days. The UHPC also has very high bond strength and low permeability. Placement of UHPC, shown in Figure 17 – Placement of UHPC, is quite different than conventional concrete. Its workability is

limited and it cannot be vibrated for consolidation. The UHPC material is essentially self-consolidating. Forming must be very tight to prevent leakage of the UHPC material.

Figure 17 – Placement of UHPC

One area where the forming was difficult was at the semi-integral abutment detail with the overhanging backwall shown in Figure 18 – Semi-integral Abutment Detail.

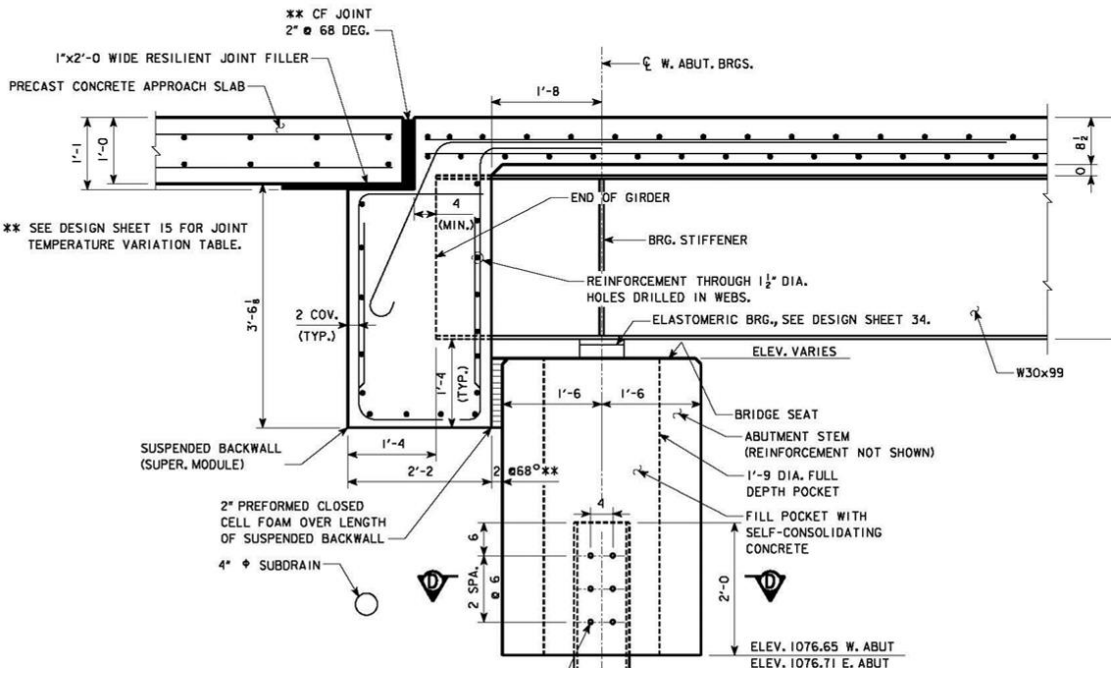

Figure 18 – Semi-integral Abutment Detail

Forming the area between the overhanging backwall and the precast abutment footing proved to be difficult and the contractor lost some volume of UHPC to form leakage before the leak was discovered and could be stopped.

The total bridge replacement was completed in 16 days from the time of diverting traffic off of US 6 over Keg Creek to the time that traffic was restored. The contract critical closure period with incentive/disincentive was 14 days. There was a contract modification on the project to add post-tensioning over the piers that also added two days on to the original contract period. The post-tensioning was added as a result of fatigue testing of the UHPC joint over the piers in the laboratory. The testing indicated that the strength of the connection was adequate and the resistance to the full negative moment was easily developed. However over many load cycles the joint exhibited cracking at the interface between the UHPC and precast deck. It was decided to add the post-tensioning to keep the joint closed tightly to avoid long term deterioration of the joint. Never the less completing this entire bridge replacement in a 16 day critical closure was deemed a successful project.

Lessons learned on the Keg Creek Bridge project include the following:

- Templates for the grouted splice coupler connections are critical. There is minimal tolerance for those connections. The survey has to be very accurate as well.
- The grouted splice couplers appear to be a very efficient and effective technology for connecting precast components.
- At the concrete deck edges of some of the modular units there was reinforcing congestion that led to lack of consolidation in the lower corners and concrete cracking during form removal. Edge distance and congestion of the reinforcing needs to be evaluated to reduce this problem.
- The bridge design used a semi-integral detail with an overhanging backwall. The overhanging backwall detail proved to be troublesome to form the connection joints ultimately leading to form leakage during UHPC placement. The details either need to be modified or a concept for forming those difficult areas needs to be developed. The shape of the overhanging backwall also made the approach roadway backfill difficult to compact.
- Survey errors contributed to two problems at the abutments. For future ABC projects with critical survey consider specifying an independent check survey.
- Training for inspectors for ABC projects may be necessary. Many of the details and materials were innovative on the project and advanced training of the inspectors may be worthwhile.

MASSENA LATERAL BRIDGE SLIDE

The Massena Lateral Bridge Slide was the Iowa DOT's first use of Slide-In Bridge Construction (SIBC) as an ABC tool. The project was located on IA 92 over Small Stream near the town of Massena. The existing bridge was a 40' x 30' steel I-beam bridge originally constructed in 1930 and shown in Figure 19 – Original IA 92 over

Small Stream Bridge. The bridge was classified as structurally deficient and functionally obsolete and posted at a lower limit than legal truck loads. The bridge was programmed for replacement and identified as an ABC candidate due to a 13 mile detour with 7 miles of out-of-distance travel. Due to the width and condition of the existing bridge staged construction was not an option. The most viable options were an on-site runaround or the use of ABC techniques to reduce the mobility impact. The site conditions were favorable for the use of SIBC due to a nice zone of right-of-way on the north side of the existing bridge where the new bridge superstructure could be constructed prior to demolition of the existing bridge.

Figure 19 – Original IA 92 over Small Stream Bridge

SIBC was chosen as the preferred concept with the goal of reducing the mobility impact time to a 9 day duration instead of a full summer construction season that would typically be allotted. The replacement structure chosen was a 120’ single span pretensioned prestressed beam bridge utilizing a 45” deep bulb tee. The project also specified precast concrete abutment footings and precast concrete wingwalls supported on driven h-piling for a deep foundation adapting the connection details from the Mackey Bridge project. A project summary can be found in Table 5 – Massena Bridge Project Data Summary.

The geotechnical exploration indicated a substantial zone of poor soils necessitating a considerable number of HP 10x57 piling in the initial design. In order to reduce the number of pile to precast concrete abutment footing connections the engineers redesigned the deep foundation utilizing much larger HP14x117 piling. The designers did not feel entirely comfortable extrapolating the original HP10x57 pile to pile pocket connection testing from the Mackey Bridge to the much larger HP14x117 piling. Laboratory testing was commissioned on the HP14x117 pile to precast abutment footing pile pocket connection and the design strength of the connection was verified. The larger piling were

also used to support the precast concrete wingwalls which had the added benefit of limiting lateral deflection of the wingwalls to a nominal and acceptable amount.

Name	Massena Lateral Slide
Location	IA 92 over Small Stream
Year Constructed	2013
Owner	Iowa DOT
Engineer	Iowa DOT
Bridge Type	PPCB
Size	120'-0 x 44'-0
Span	120'
Key ABC Technologies	Slide-In Bridge Construction (SIBC)
	Precast Wingwalls
	Precast Abutment Footing
Total Project Bid	$1,346,647.90
Bridge Unit Cost*	$112/SF
ABC Contract Period	9 day critical closure w/ $10,000/day I/D
Grant	HfL
*Traditional unit cost at this time for PPCB = $85/SF	

Table 5 – Massena Bridge Project Data Summary

The new bridge superstructure was constructed adjacent to the existing structure while maintaining traffic on the existing structure shown in Figure 20 – PPC Beams on Falsework. One of the benefits of the SIBC method is that the superstructure construction aside from the falsework utilizes conventional construction practices that contractors are well versed in.

Figure 20 – PPC Beams on Falsework

Following completion of the bridge superstructure construction the contractor was ready to begin the allowable 9 day critical closure on the project. The critical closure was defined as the time period when traffic was detoured and the existing bridge removed and the new bridge construction completed. The critical closure was a 9 day incentive/disincentive contract at $10,000 per day. The 9 day critical closure began with demolition of the existing structure followed by pile driving and placement of the abutment footing.

The original design specified a precast concrete footing but the contractor proposed to cast the entire footing in place using a high early strength concrete mix. Casting the abutment footing in place had two primary benefits from the contractor's perspective. The first was that the pile driving tolerances were no longer as critical eliminating the risk of the pile pockets not fitting over the top of the H-piling. The second benefit was related to cure time. The contractor reasoned that the larger mass of the entire footing curing would generate more heat of hydration than the smaller mass of concrete in the pile pockets leading to a faster cure time. The cure time was on the project critical path because the bridge superstructure could not be slid into position until the concrete design strength was verified. The strength of the concrete was verified using the maturity method. Once the abutment footing concrete strength was verified bridge slide preparations were underway shown in Figure 21 – Slide-in Bridge Construction Preparation.

Figure 21 – Slide-in Bridge Construction Preparation

The contractor proposed another modification from the original design plans related to the lateral slide. The design had details for a lateral slide using stainless steel sliding shoes sliding over a neoprene pad with bonded polytetrafluoroethylene (PTFE). The contractor proposed an alternate which was allowable by the specifications to perform the lateral slide using heavy duty rollers. The alternate was permitted and the stainless steel

sliding shoes and PTFE was deleted from the contract. The change resulted in minor modifications to the details to accommodate the loss of thickness of the bearing material. The contractor also proposed alternate reaction points for the rollers. The original design had jacking pockets shown in Figure 22 – Diaphragm Jacking Pockets Detail and the slide shoe was located at the beam bearing points. The contractor proposed installing the heavy duty rollers in the jacking pockets in order to reduce the require jack stroke length and eliminate a multi-staged jacking operation that would require temporary blocking and shimming the jacks. The contractor's engineer submitted calculations for review of the alternate reaction points and this alternate was accepted.

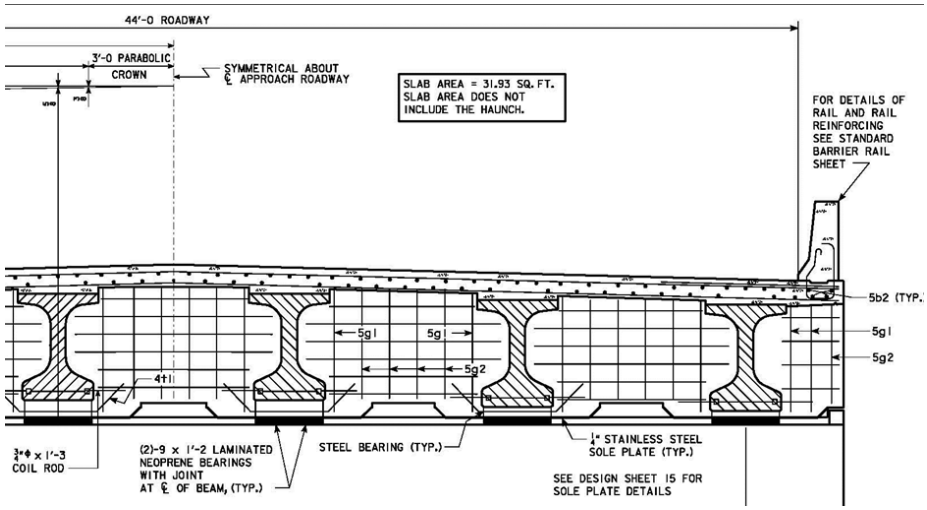

Figure 22 – Diaphragm Jacking Pockets Detail

The slide of the bridge was completed efficiently over the course of 6 ½ hours starting on day four of the critical closure shown in Figure 23 – Massena Bridge Slide 30% Complete.

Figure 23 – Massena Bridge Slide 30% Complete

Once the bridge slide was completed, there were several more construction items on the critical path including installation of the precast concrete wingwalls shown in Figure 24 - Precast Wingwall Installation. The precast wingwalls were similar to those used on the Keg Creek project with subtle geometric differences for the Massena Bridge. Additionally, on the Keg Creek project the precast wingwalls were positively attached to the precast abutment footing with a cast-in-place concrete closure. For the Massena project the precast wingwalls were installed independent of the abutment footing and the lateral deflection was controlled by the stiffness of the large HP14x117 piling to allowable deflection limits.

Figure 24 – Precast Wingwall Installation

The contractor completed the remaining bridge construction work expeditiously and the bridge was reopened to traffic at the end of the nine day critical closure. The completed bridge is shown in Figure 25 – Completed Massena Bridge.

Figure 25 – Completed Massena Bridge

Lessons learned on the Massena Lateral Bridge Slide project include the following:

- ABC projects with significant working drawings and calculation submittals should be let in the fall to allow time for review and processing of those submittals so the contractor can be ready to commence work in the springtime.
- The current standard specification for incentive/disincentive uses the unit of days. For some short duration ABC projects like the Massena project that unit should be specified in hours.
- The engineer needs to be prepared to review alternate concepts when allowed by the specifications. Allowing alternate ABC concepts with guidelines on submittal helps economize projects.
- Consider letting the project with both a precast concrete and cast-in-place alternate for the abutment footing so the contractor can choose the option that best meets their operations.
- While the larger than typical HP14x117 pile size had many benefits it also had some drawbacks which included needing a large pile driving hammer and long duration of pile splice welding time. Consider piling alternates as well that would be coordinated with the precast concrete and cast-in-place alternate for the abutment footing. The large pile would be associated with the precast concrete abutment footing and the smaller but more numerous piling would be associated with the cast-in-place alternate.
- The project was let with the pay item for the falsework and the prefabricated bridge move all in one bid item. Consider a separate item for falsework from the prefabricated bridge move due to cash flow considerations. The falsework is installed early in the project and then the prefabricated bridge move comes late in the project.

- Driven pile acceptance criteria per the current standard specification is that the entire length of the pile will be installed even if design bearing capacity has been reached long before the remaining pile has been driven, unless the contractor reaches practical refusal. Consider pile acceptance based on the wave equation analysis program so that the contractor can terminate pile driving upon reaching design bearing saving time on these ABC projects.

ABC POLICY DEVELOPMENT

Policy has been developed by the Iowa DOT in an effort to clarify how bridge projects are selected for the use of ABC technologies. The policy development effort used a multi-disciplinary team to draft and refine the policy so that it could be presented to the Iowa DOT Highway Division Management Team where it was adopted as the current Iowa DOT policy for ABC. The multi-disciplinary team consisted of representation from various Iowa DOT offices and representative from external organizations including the following:

- Office of Bridges and Structures – Iowa DOT
- Office of Design (roadway) – Iowa DOT
- Office of Right-Of-Way – Iowa DOT
- Office of Construction and Materials – Iowa DOT
- Office of Location and Environment – Iowa DOT
- FHWA – Iowa
- AGC – Iowa
- Iowa State University Institute for Transportation
- Precast/Prestressed Concrete Institute – Iowa Members

The Iowa DOT ABC policy uses a first level screening method to evaluate all bridges on the primary system for a base level score for ABC compatibility. When a bridge on the primary system is programmed for replacement this score is available for determining at a glance if the bridge is a good candidate for replacement using ABC techniques. The data for the first level screening is readily found in the National Bridge Inventory (NBI) database and includes:

- Average Annual Daily Traffic (AADT)
- Out of distance detour travel in miles
- Daily road user costs
- Economy of scale (number of spans).

All bridges on the primary system have been scored using the first level screening method and a histogram of score distribution is shown in Figure 26 - ABC Rating Score for Bridges on the Primary System. A little over one fourth of the bridges on the primary system score over 50 points in the scoring methodology used. 50 points has become the current default for automatically looking closer at a bridge for potential use of ABC techniques. The concept review team may choose to look closer at a bridge with a score of less than 50 points if there are special local circumstances that may lead to a desire to use ABC techniques. Special circumstances may include close proximity to a hospital or

fire station or the bridge being located on a school route that may cause considerable inconvenience if construction isn't completed prior to the start of the school year. The Iowa DOT will continue to evaluate the 50 point default cutoff to determine if the cutoff needs to be adjusted to meet the Iowa DOT ABC implementation goals.

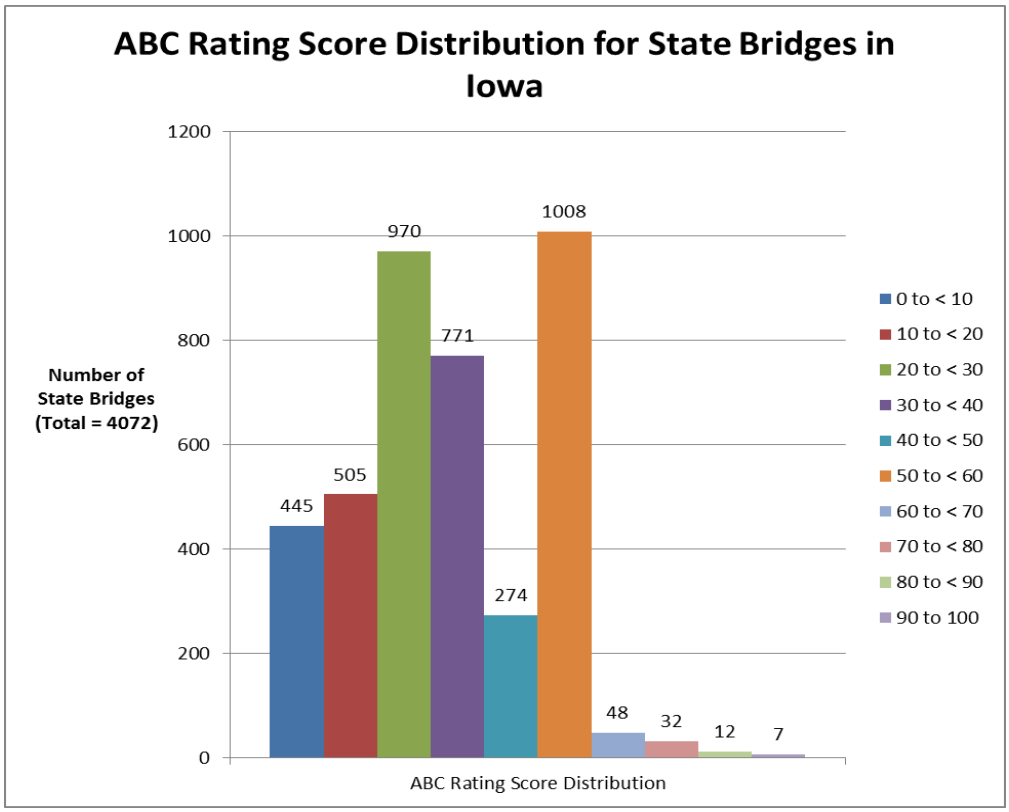

Figure 26 – ABC Rating Score for Bridges on the Primary System

A second more refined scoring tool is used once it appears that a bridge replacement may be a good candidate for replacement using ABC techniques. The second tool is called the Analytical Hierarchy Process (AHP). The AHP is a pairwise decision making comparison tool that can be used to mathematically compare two different alternatives by ranking the importance of scoring criteria and then scoring each alternative in terms of how the alternative best meets the criteria goal. When a bridge replacement project has passed the first scoring criteria, typically the Iowa DOT will write a concept for a bridge replacement project with two alternatives, one being bridge replacement using ABC techniques and the second being bridge replacement using conventional construction techniques. Criteria for evaluation may include items such as schedule constraints, indirect costs, directs costs, and site constraints. The various criteria are scored in terms of importance to the project and then the two alternatives (ABC and conventional) are scored to determine how they best meet the criteria. In the end, a score is developed indicating a preferred alternative. The AHP is typically run by a multi-disciplinary team in the Iowa DOT central complex and also run independently by Iowa DOT District

representatives. The results of the independent AHP runs have been reasonably consistent and led to several projects selecting ABC techniques for the final concept.

CONCLUSION

The projects detailed in this report have been some of the key ABC projects undertaken by the Iowa DOT for advancing the state of practice for accelerated bridge construction in Iowa and possibly nationally. Precast concrete components are a viable technology and the pile to precast concrete pile pocket connection is detail that will continue to be utilized moving forward. Full-depth precast deck panels are another technology that shows promise both in terms of accelerated bridge construction and long term deck durability through post-tensioning minimizing cracking and chloride intrusion. Slide-in-bridge construction was utilized successfully by the Iowa DOT and will be an excellent option for projects with favorable sites for that type of ABC method. Grouted splice couplers for connecting precast concrete units are a promising emerging technology in the bridge construction industry that will continue to be tested and developed for future ABC projects.

The Iowa ABC policy gives the Iowa DOT a framework for choosing the best projects to implement ABC and effectively use our funding to benefit our transportation network users. The Iowa DOT will continue to work with our industry partners to incrementally advance the state of practice with respect to ABC technologies to improve roadway safety and minimize roadway mobility impacts of bridge construction.

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3. Iowa Department of Transportation, Office of Bridges and Structures. Draft ABC Policy, 2012.

4. Iowa Department of Transportation, Office of Bridges and Structures. LRFD Bridge Design Manual, 2012.

APPENDIX A

ABC Components	703 O'Brien	106 Boone (Mackey Bridge)	106 Madison	305 Marion	508 Pottawattamie (CB 24th)	208 Bremer	109 Buena Vista	210 Washington	111 Pottawattamie (Keg Creek)	L-#39--73-90Wapello (Waffle Deck)	113 Cass (Massena)
Approach pavement	X					X		X	X		
Abutment wings							X		X		X
Integral abutments		X	X				X				
Semi-integral abutments									X		X
Drilled shafts									X		
Pile bents		X									
Frame piers									X		
T-piers											
Box beams			X				X				
PPCB + diaphragms		X								X	X
RSB + diaphragms											
Full depth precast deck		X			X					X	
Rails											
RSB + deck + rail									X		
Paving notch repair				X							
A + B contracting					X						
Staged construction					X						
I/D contracting							X		X		X
Slide-in bridge constr.											X
UHPC									X	X	
Post-Tensioning		X			X						
Grouted splice coupler									X		

Table 6 – Iowa DOT ABC Projects