

REPLACING AN INTERSTATE BRIDGE DECK WITHIN A WEEKEND CLOSURE – CASE STUDY OF ACCELBRIDGE DECK SYSTEM

Eddie He, AccelBridge, 312-952-3071, ehe@AccelBridge.com
John Whittaker, Kubricky Construction, 518-792-5864, jwhittaker@dacolins.com
John Gonyea, Fort Miller, 518-695-5000, JGonyea@fmgroup.com

ABSTRACT

The Colchester I-89 Bridges Project was a rehabilitation of four existing bridges (77N, 76N, 77S, and 76S) located on the busiest interstate segment in Vermont. Rehabilitation of these bridges included replacement of heavily deteriorated bridge decks with new precast deck panels, steel repairs, as well as replacement of the bridge backwalls, approach slabs, and sleeper slabs. This project allotted for 6 separate weekend shut downs to perform the rehabilitation work on four separate bridges, using AccelBridge™ full depth precast deck.

Work on a bridge typically involved two weekend closures. The first weekend was for rehabilitation work on abutments and sleeper slabs on the approach. The second weekend included demolition and replacement of the existing bridge deck. Decks of all four bridges were replaced successfully, each within a weekend closure. The use of match cast joint and compressing the precast deck with girder jacking makes AccelBridge™ installation straightforward. It significantly simplifies construction, reduces field labor and improves construction speed.

INTRODUCTION

AccelBridge™ is a patented technology, with the goal of making full depth precast deck construction simple by using conventional materials and proven methods. The system consists of match-cast deck panels compressed by jacking against bridge girders. The typical construction steps for AccelBridge™ are:

1. Erect precast deck panels on supporting girders.
2. Make both end panels composite with the girder while all the remaining deck panels are free to move in the longitudinal direction.
3. Apply jacking force at the jacking closure to compress deck panels against the steel.

Figure 1 shows schematics of AccelBridge™ deck panel jacking to provide the necessary longitudinal compression.

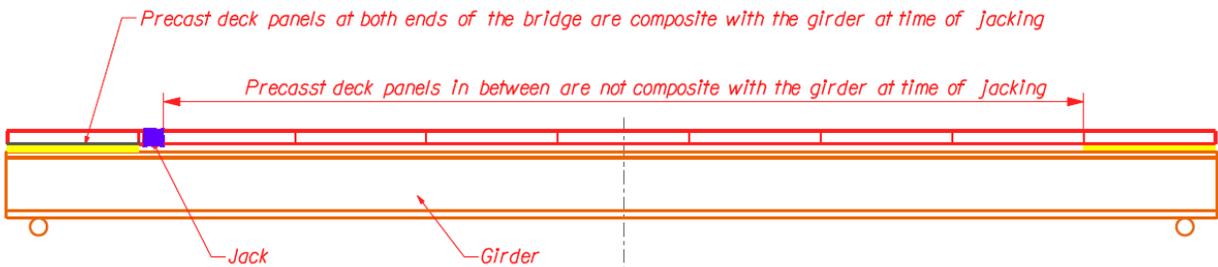


Figure 1. AccelBridge™ principles

At the time of jacking, only deck panels at both ends are fixed to the girder while all other panels between can move relative to the girder. The jacking force then results in compression in the deck and tension in the girder. After all panel to girder shear connectors are grouted, the deck compression will be permanently locked in. This method allows the deck to be in compression without any post-tensioning.

AccelBridge™ was first successfully used in the Bayou Lafourche Bridge, an FHWA technology implementation project with LADOTD. During construction, the technology was validated by instrumentation measuring deck compression, girder stress, and system stability. After completion, the structure was proven by a full-scale live load test.

AccelBridge™ offers the following advantages over other deck systems such as post-tensioned deck or UHPC joint:

- **Enhanced durability** - deck is in compression during service condition and has no corrosive materials (such as rebar or PT) across deck joints. Thus, nothing to corrode at the joint.
- **Simple to build** – AccelBridge™ is straightforward to construct by using only conventional construction materials (epoxy, concrete and grout) and proven details (match-cast joint). This method greatly reduces field operations by eliminating the most cumbersome cast-in-place joints that are required in other precast deck systems.
- **Cost** – The bid price of Bayou Lafourche indicated that AccelBridge™ installation techniques costs much less than other full depth precast deck systems. In order to accurately gauge the cost, LADOTD specified an individual pay item for installing and jointing the deck with AccelBridge™ method (separated from the precasting of deck panels). The bid price of installing and jointing the deck with AccelBridge™ jacking method ranged from \$ 1.21 to \$1.36 per sq. ft. of deck for the lowest three bidders. In comparison, the average cost for installing and joint the deck is \$8 - \$11 per sq. ft. for post-tensioning system and \$15 - \$ 25 per sq. ft. for UHPC jointing system.
- **Speed** - The average panel erection cycle, from lifting a deck panel to complete jointing, is less than 20 minutes. AccelBridge™ has a fast version which eliminates jacking closure pour operations and further shortens construction time. The fast version is feasible for deck replacement with overnight-only closure for projects where maintaining traffic flow is critical.
- **Increased Girder Capacity** - AccelBridge™ jacking method typically benefits the supporting girders, by introducing a negative moment at girder midspan. Therefore, AccelBridge™ deck jacking can potentially increase the structure load rating without having to strengthen existing girders.
- **Versatility** - AccelBridge™ can be applied to most types of girder bridges; concrete or steel, I girder or box girder, single span or multiple spans. It can also be used for deck replacement or new construction.

PROJECT GENERAL DESCRIPTION

The four bridges were two pairs of I-89 bridges (76NB, 76SB, 77NB, 77SB). Each pair of bridges were identical, carrying two lanes of I-89 traffic in each direction. All bridges were similar in structure layout, with 34'-10" wide deck supported by five steel girders at 3-span continuous configuration. The bridge length was 151 ft for 76NB and 76SB, and 185 ft for 77NB and 77SB. Bridges 76NB and 76SB were at a 17-degree skew. The project scope was to replace each bridge deck, reusing the existing girders as well as removing and replacing the existing backwalls and approaches.

VTrans required each bridge be reconstructed in two weekend closures, one for abutment and approach work, and the other for removing / replacing the deck and approach slabs. Kubricky was retained by VTrans to deliver the project under a CM/GC contract. The final decision was to use an innovative full depth precast deck system (AccelBridge™) for the deck replacements.

Typical deck panels length (in the longitudinal direction of the bridge) was 11'-10' for Bridges 76 and 11'-6" for Bridges 77. Panels were cast full width of the bridge (34'-10") with three longitudinal crown lines. For bridge 76, panel joints are cast parallel to the 17-degree skew angle (see Figure 2 below).

A jacking closure, approximately 3 ft wide, was located close to the middle of the deck. The jacking closure was the only cast in place joint on a bridge, all other deck joints are epoxy match-cast joints.

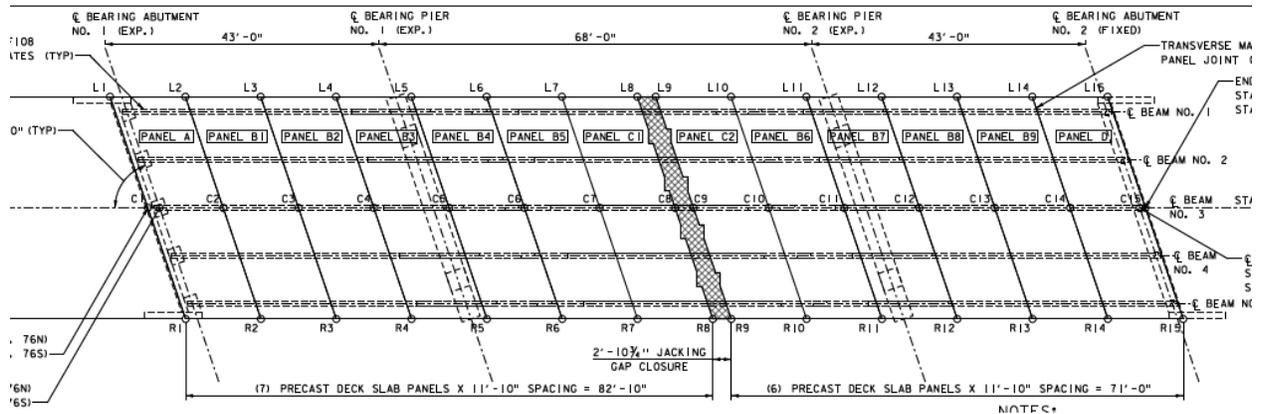


Figure 2. Deck panel layout of Bridge 76N



Figure 3. Bridge 77S (upper) in construction, Bridge 76N (lower) is completed.

PRECAST OPERATION

Precast work was performed by Fort Miller using the long line casting method. Panels were poured in two sets, in a “checkerboard” pattern to achieve match-cast. After the first set of panels was poured, the forms were removed from the edges that butt up to the next set of panels. The second set of panels were poured directly against the surface (with keyway) of the first set, so that the pieces would fit perfectly. The joint between the two panels had a release agent applied so when the concrete cured they could be separated.

Match-cast deck panels can be produced in a manner similar to that of precast segmental, but greatly simplified in terms of geometry control and form work setup. One of the difficulties with match-cast in segmental bridge is geometry control, which has been a major concern of precasters. However, deck panels in AccelBridge™ can be cast flat without consideration of the actual profile of the bridge. Since the depth of precast deck is small (only about one-tenth of that for a typical segmental box designs), the joint opening due to deck vertical curvature is small and can be absorbed by the epoxy filler layer; eliminating the need to consider the vertical profile in deck panel casting. This results in significant construction simplification and cost savings.

Before the panels are taken apart, geometry control marks are installed and surveyed. These marks will then later be used to guide the erection.



Figure 4 (left), A phase one panels with transverse forms and rebar

Figure 5 (right), A phase two panel ready to be poured against phase one panels

Panels were cast to the full width of the roadway, which is 34'-10". Panels were shipped with a rocking frame to ensure they will not be subjected to torsion due to torsional deformation of the trailer while travelling on uneven road surface.

FIELD INSTALLATION

The deck replacement sequences were:

- a) Remove existing deck
- b) Clean girder top flange
- c) Conduct girder top flange elevation as-built survey to calculate panel haunches
- d) Install panel support shims and haunch forms
- e) Erect deck panels using come-alongs to close the epoxy joint
- f) Grout the shear connector pockets and haunches for both end panels
- g) Form jacking closure and install jacks
- h) Apply jacking force (after the end panel grout reaches 3.5 ksi)
- i) Pour jacking closure phase 1 (area around the jacks)
- j) Grout all remaining shear pockets and haunches
- k) Release jacks (after jacking closure phase 1 pour reaches 2.5 ksi)
- l) Pour jacking closure phase 2

Haunch forming and panel support

Panel elevations are set by shim packs located at panel joints at each girder. A Shim pack consists several 4"x6" HDPE sheets. The height of the shim pack at each location is calculated from the as-built survey of girder top flanges.

Haunch forms consisted of a pair of steel angles with a top layer of soft foam. Haunch forms were set before panel erection, and the top of soft foam was set to be ¼" higher than final elevation. When the panels were erected, panel weight compressed the soft foam to achieve a tight seal.



Figure 6. Lifting panel

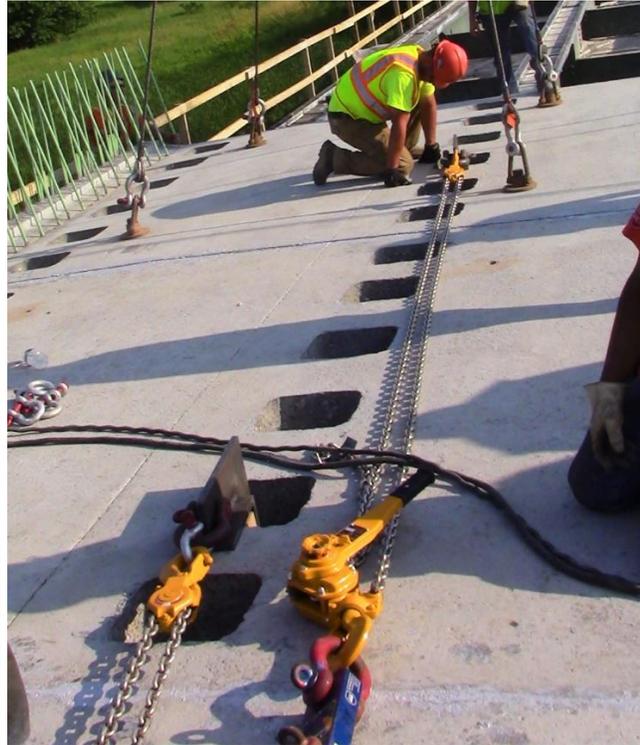


Figure 7. Using come-alongs to close panel joints.

Panel installation

Panel installation is very straightforward. The average erection rate of this project was about 20 minutes per panel (see Figure 7).

All joints between precast panels were match-cast. The panel joint is clean with no exposed rebars.

Epoxy is first applied to the match cast surface, then panels are pulled together to squeeze the epoxy and close the joint. Shear keys on the match-cast joint simplifies panel placement by self-guiding the panel into final position. The temporary joint compression force is provided by come-alongs. Due to the simple geometry of deck panel, the joint can be closed tight with much less compression than that of segmental box. Experience with AccelBridge™ erection indicated that an average compression stress of 10 psi is enough to achieve a tight match-cast joint (see Figure 8)

Shear pocket

The composite action between panel and girder is provided by shear studs housed in shear connector pockets. Studs were welded after the deck panel was in place. This is a preferred approach from a safety stand point, since construction crews can work from a stable platform. Non-shrink grout was then used to grout haunches and shear pockets. Gravity grouting is then utilized as long as the mix is made and installed in a flowable state..

Jacking

The jacking was accomplished by utilizing a system that is not only strong enough to create the 1400 kip jacking force required but also can apply that force securely distributed to the deck panels(see Figure 9). The jacking procedure for this application was set up to be applied over seven incremental steps. Each step was set up so that the panels can be monitored as to how they react. Once the preferred jacking force was met, jacking collar locknuts were utilized to lock in that force while other work was completed

Jacking closure

Jacking closures were poured in two stages. Stage 1 (areas outside of the jacks) was poured right after the target jacking force was achieved. After the stage 1 pour reaches 2.5 ksi, jacks were removed, and the stage 2 closure was poured.



Figure 8. A close-up picture of a complete deck joint.

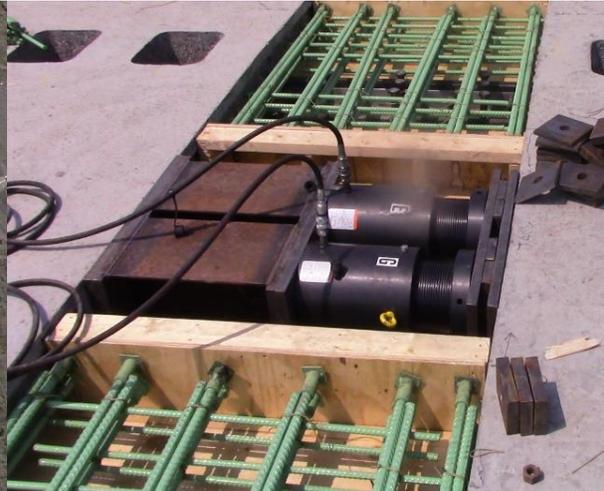


Figure 9. Jacking closure.

Overall schedule

The deck replacement of each bridge was completed within one weekend closure although the actual progress of each bridge varied. Each closure period schedule is mainly affected by weather conditions and grout / concrete strength gain. The general timeline of each deck replacement was:

- Friday night to Saturday noon, removal of existing deck and cleaning of steel girders.
- Saturday afternoon and evening, erecting panels.
- Sunday morning, installation of jacking closure forms and jacks.
- Sunday noon jacking, / jacking closure concrete pour/ grouting haunches.

In addition to the deck replacement, precast approach slabs were also installed during the same weekend closure. These were typically installed after the deck slabs were in place and the cranes were available to set them. Approach slabs on this project were set on a fine graded bed of subbase and high performance concrete was poured in the joints to lock them together.

The earliest time that the interstate was opened to traffic for this project was 3am (56hrs) Monday for Bridge 77S. Bridge 77N however took the longest time, opening to traffic at 9am (62hrs). The reason for this was mainly due to two rain storm events during Saturday and Sunday, resulting in a work stoppage of approximately 6 hours.



Figure 10. Panel erection completed by Saturday night.

OBSERVATIONS AND LESSEN LEARNED

Planning and coordination

Planning and coordination is extremely important for such a time critical job. For this project, the resident engineer, designer, supplier and contractor worked closely together to prepare a very detailed hourly schedule identifying every task at hand. The contractor also worked closely with AccelBridge to prepare detailed work execution plan, including an over 150 step by step list to cover tools, materials and actions. This provided to be extremely beneficial in setting up the work prior to the closure periods as well as keeping the project on schedule.

Geometry control

Placing the first panel accurately was extremely important since any placement error in panel orientation will be magnified many times as more match-cast panels are assembled. The placement of all subsequent panels was straightforward since the match-cast shear keys prove the self-alignment function. Panel offset must be closely monitored during erection however as debris and other elements can cause the joints to not completely align causing offsets. If assembled panel offset is over the limit, geometry correction could be introduced, by shimming the match-cast joint similar to that of which has been well established in segmental construction. Geometry correction was utilized on only one out of the four bridge decks for this project and placement tolerance was within the allowable tolerance (max $\frac{1}{2}$ " offset).

Assembling panels

By utilizing a shared shim stack at each joint location, vertical geometry of the panels was kept consistent and created the desired profiles of the bridge. The match-cast shear key guides were then lined up extremely closely to start allowing the panel to shift to the correct longitudinal and lateral position automatically.

Although it took time to set the first panel accurately, subsequent panels could typically be placed within 20 minutes, from lifting panel from the delivery trailer to closing the epoxy joint.

Strength gain of grout and closure concrete

The uncertainty in strength gain of grout and closure concrete did become the major challenge in this project as it was on the critical path of the project schedule several times throughout the shutdown.

There are three key milestones in strength gain:

- 1) 3.5 ksi grout strength for end panel haunch before jacking force can be applied,
- 2) 3 ksi for jacking closure phase 1 concrete before removing jacks, and
- 3) 3 ksi for jacking closure phase 2 concrete before opening to traffic.

The time it took to achieve such strength varied significantly in the project. In future projects, there is great need to focus on acquisition of materials with a highly reliable early strength gain time.

CONCLUSION

The AccelBridge™ precast deck has been proven to be a simple and practical Accelerated Bridge Construction method. Using only conventional materials and straightforward details (match-cast joint) significantly reduces the risk, in terms of schedule and quality. Compared with other full depth precast deck systems, such as Post-tensioning and UHPC joints; AccelBridge™ reduces field work, is quicker to install, and is more cost-effective. In addition, there is no rebar or PT across the panel joints, which enhances durability since there is nothing to corrode.

ACKNOWLEDGEMENT

The success of this project is a result of great collaboration of our team members: Vermont Agency of Transportation (Owner), Kubricky Construction (CM/GC), Fort Miller (precaster), VHB (designer) and AccelBridge™ (deck technology developer).