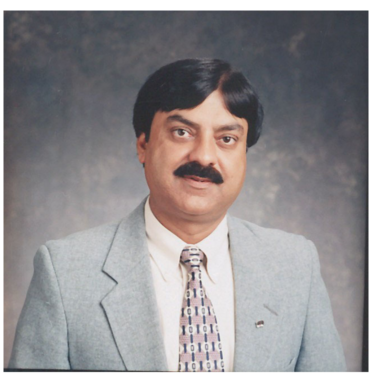
FAST-TRACK BRIDGE REDECKING

ROUTE 64 OVER POMME DE TERRE LAKE

FRANK BLAKEMORE, P.E.



BAKUL DESAI, P.E.

BIOGRAPHY

Frank Blakemore is a Senior Project Engineer with HNTB and has worked on a variety of projects including the Kansas City Triangle, the Gateway Boulevard arch bridge in Nashville, and the Great River Bridge (cable stay bridge over the Mississippi). Some of his other experience includes both segmental and cast-in-place post-tensioned box girders. Frank is a registered Professional Engineer in Missouri and Colorado and was the Project Engineer for this project.

Bakul Desai has been with HNTB for over 25 years and currently is an Associate Vice President with the firm. Bakul served as a Bridge Project Manager on this Triangle project. He has designed and managed several interchange bridge projects and major water crossings that includes suspension bridges, cable-stay bridges, arch bridges, cast-in place and precast post tensioned segmental bridges and other types of bridges. Bakul is a registered professional engineer in several states.

SUMMARY

A "fast-track" method of deck replacement has recently been completed in southern Missouri. The concept of full-deck replacement while maintaining traffic (in both directions on a two lane bridge) during the daytime was proven successful on the Route 64 Bridge over Pomme de Terre Lake. (A few temporary lane closures were required to complete some minor construction tasks.)

This 1,684' long continuous composite steel rolled beam bridge was redecked in only 6 months with the bridge being shut down during each night of construction from 7 pm to 7 am. The key to this innovative method is match-cast panels which are post-tensioned together after installation. The full-width and full-depth panels are supported by four girders and provide a roadway width of 24'-10". Several other bridges with similar concepts are also discussed.

Fast-Track Bridge Redecking
Route 64 over Pomme de Terre Lake

By
Frank Blakemore, P.E.
Bakul Desai, P.E.

PROJECT BACKGROUND

The bridge over Lake Pomme de Terre was originally designed and built by the Corps of Engineers in 1962. The bridge roadway is 22'-0" wide and carries two 11' lanes. The superstructure consists of four composite continuous steel plate girders. There are seventeen 90'-0" spans and end spans of 76'-10". The superstructure comprises five units (a typical unit is 360' long) that are joined by a pin and hanger connection located 18'-0" from the pier. The grade of the bridge is perfectly level (0% grade). The substructure consists of two column bents with spread footings. Because of the large pier heights, the superstructure girders are post-tensioned to the pier capbeams.

Although the plate girders and substructure were in good condition, the six inch composite deck was rated deficient by the owner, Missouri Department of Transportation (MoDOT), because of advanced deterioration brought on by deicing salts. Because the bridge connects the towns of Pittsburg and Nemo, and the length of the nearest detour route was 28 miles, MoDOT deemed it essential that the bridge remain in service during construction. Additionally, the local economy of these towns is very reliant on the tourism industry and most of their income is generated during the summer months.

PREVIOUS PRECAST PANEL BRIDGES

Full-depth precast panels have been used previously in varying degrees. Issa et al.(1) did some research on the use of precast panels in by the different state DOT's. They conducted a survey of states on the use of full-depth precast panel bridges and how this concept was used. A number of states indicated that some type of full-depth precast panel had been used. The uses ranged from cable-stayed bridges (closure pours placed between panels, then post-tensioned) to typical two-span bridges (grouted joints between panels). Of particular interest, was a bridge in Connecticut that was completely shut down for the deck replacement. The complexities associated with this bridge included openings for shear connectors, leveling bolts, and post-tensioning after the joints were grouted. Some of the solutions used on this bridge were also incorporated into the Route 64 bridge.

A second paper by Issa et al.(2) discussed the field performance of the bridges with full-depth panels. Of significant interest was the fact that numerous bridges without post-tensioning experienced leaking in the joints. Additionally, various types of overlays used to protect joints were evaluated based on field performance. Both longitudinal post-tensioning and an overlay were incorporated on the Route 64 bridge.

ADVANTAGES OF PRECAST PANELS

To replace the deck, the initial choice was to use the typical method of cast-in-place stage construction. During the analysis of the existing deck for stage construction, it was determined that the interior deck cantilever overhang did not have sufficient strength to allow emergency vehicles or school buses. Another major concern was that the lane width during construction would only be 9'-6" on the bridge during Stage I traffic.

At this point in the project, the MoDOT District Maintenance Engineer, Dave O'Connor, proposed using some type of deck replacement that could be done in overnight closures. HNTB then studied various types of deck replacement schemes and recommended using full-width full-depth precast panels that are post-tensioned together longitudinally. The safety barrier curbs would also be cast with the segments in the casting yard. Additionally, a 1.5 inch overlay would provide a smooth riding surface and an extra layer of protection at the joints from chloride penetration.

The significant advantage of using the full-width full-depth panels is that they could be cast off-site ahead of time and then be brought to the job site for placement during the nightly closures. Match-casting and post-tensioning of the panels was provided to eliminate any closure pour joints in the deck. On other bridges using precast panels, closure joints had been found to be vulnerable to chloride penetration and thus deterioration. Figure 1 shows the typical cross-section with the locations of the post-tensioning bars.

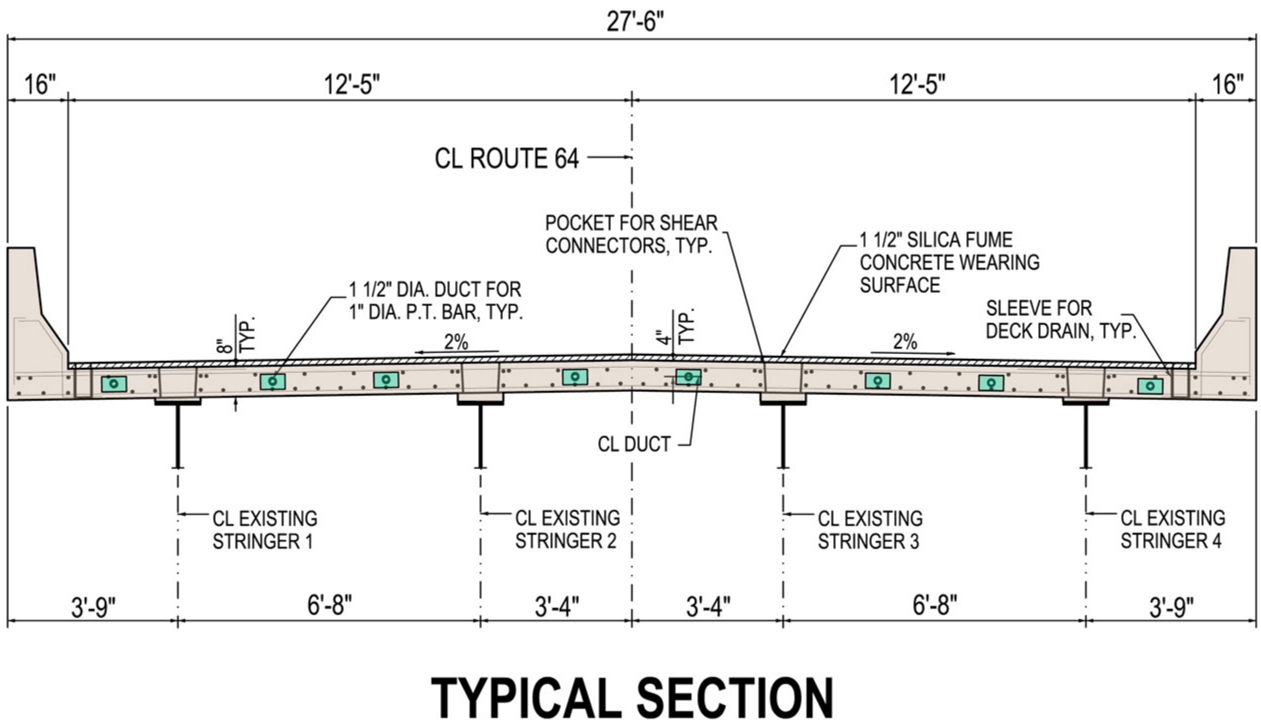


Figure 1. Typical Cross-Section

To provide the superstructure with sufficient capacity, the deck was required to be composite (consistent with the original design). To accomplish this, 9"x12" blockouts were provided in the panels to allow for shear connector installation on the girders after the panels were placed. See Figure 2 for details of a typical panel. Also note the partial depth blockouts provided for the post-tensioning bar couplers.

The full panel size was 10'-0" long and 27'-6" wide, which was dictated by shipping considerations. The panels that were placed directly over the pier locations required extra consideration because the post-tensioning bars connecting the girders to the pier extended into the deck. The solution to this dilemma was to provide a larger blockout (approximately 2'-4"x3'-3') in those locations. Because of these large blockouts, the shipping and handling stresses became very important in the design of these panels.

To fill the haunches and blockouts for the shear connectors and post-tensioning couplers, a flowable grout was required that would reach a compressive strength of 2500 psi before traffic could be allowed on the bridge. After discussing this requirement with several concrete suppliers, several products were found that could provide this strength in as little as 2 hours.

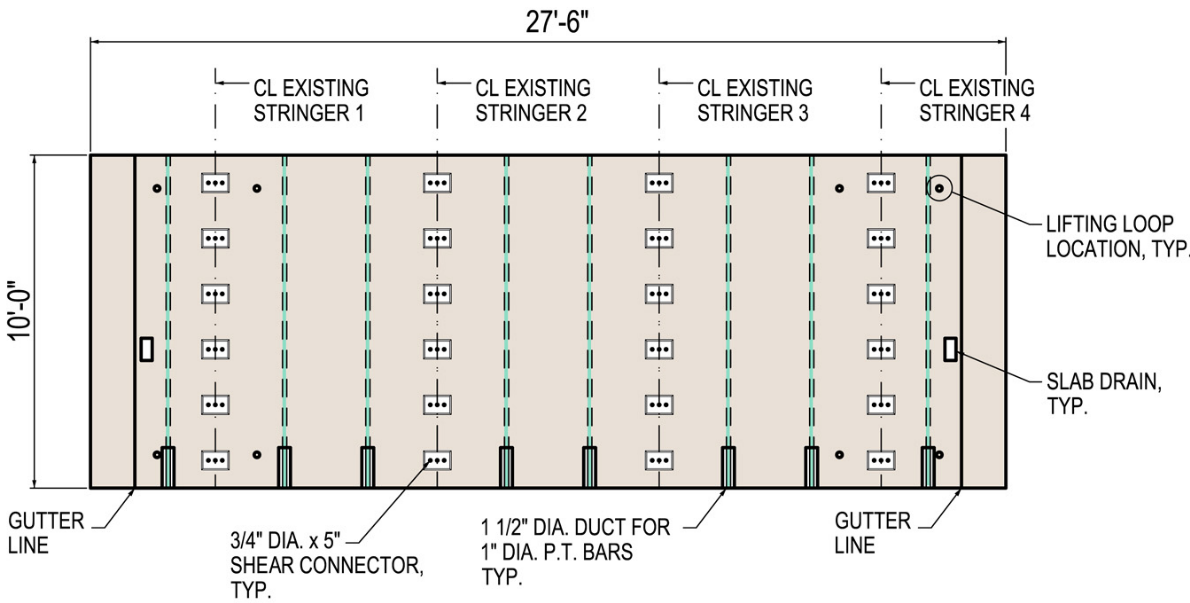


Figure 2. Plan View of Typical Panel

CONSTRUCTION

The project was let on March 19th, 2004 and Columbia Curb & Gutter (CCG) was awarded the contract based on low bid. Notice to Proceed was issued on May 17th, 2004, and CCG was allowed to have the first nightly bridge closure on June 21st, 2004. The last panel was placed on August 31st, 2004.

For the overnight replacement concept to be successful, the contractor needed to have a reasonable amount of time to complete this work. Before the project was bid, HNTB and MoDOT determined a bridge closure window of 7 p.m. to 7 a.m. (with a work week of Sunday night through Thursday morning) and this was specified in the contract documents.

The HNTB design team had determined that it would be feasible (and demanding) to remove a significant amount of deck and replace it during the closure window. This inventive concept required many operations to occur in one night:

- Remove the existing deck, including shear connectors
- Clean and prime the top flange of the steel girders
- Place and align the full-depth match-cast panels
- Connect post-tensioning bars
- Post-tension the panels together
- Weld new shear connectors
- Fill the shear connector blockouts with grout

The original concept was to perform all of the operations listed above in the 12 hour construction window, but CCG decided to split the operations into a 2-step process that overlapped on consecutive nights. For a typical location, the deck removal and preparation of the top flange were performed on one night and then the panels were installed at this location the following night. Figure 3 shows a panel being placed and aligned. In order to accomplish this, the contractor fabricated a set of temporary bridge panels (consisting of steel grating and W sections) that could be reused each night. See Figure 4 for a photo of a temporary deck panel. The contractor also proposed using a temporary barrier system utilizing part of the existing bridge barrier rail so that the permanent safety barrier curb could be slip-formed at the end of the project.

Figure 3. Panel Placement


Figure 4. Temporary Deck Panel

For the first few nightly closures, the contractor only placed two or three of the 10’ long panels. After the initial learning curve was over, however, the contractor was able to place five to seven panels on a given night. Since the connections of the existing vertical post-tensioning at the piers were required to be inspected, these locations impeded the contractor’s progress slightly. Additionally, when the contractor reached an expansion joint location, the panels were dimensioned to be a few feet from each side of the joint. At these locations, the contractor would “skip” over the joint and place the panels to start the next unit. After construction progressed into the next span, during one of the nightly closures the new expansion joint was placed and a small area of deck poured. This pour was also required to reach a compressive strength of 2500 psi before being opened to traffic.

After all of the deck panels were placed, a typical stage construction sequence with only one lane of the bridge open to traffic was set up to allow for slip-forming of the safety barrier curb followed by placement of the 1.5” thick overlay on each half of the deck. See Figure 5. By contract, the stage construction portion of the project could not start until after Labor Day (the traditional end of the tourism season). The total stage construction time with a median divider on this project was only 7 weeks!


Figure 5. Stage Construction at End of Project

COST COMPARISON

During the initial study, cost implications of using the full depth panels were considered. The initial thought was that this concept would cost slightly more than conventional stage construction, but would be offset by reduced traffic control costs. The low bid for this job was only about 9% higher than the original estimate that included stage construction. (This project also included repainting the superstructure and retrofitting the pin & hanger connections.) By looking at some other projects that were primarily deck replacements (see Table 1), the costs can be compared for the Pomme de Terre bridge. (Except for the Franklin County bridge over the Missouri River, all projects have been converted to 2005 dollars.)

County/Project	Deck Cost	Removal Cost	Total Cost
St. Louis (stage construction)	$32 / SF	$3.50 / SF	$35.50 / SF
Chariton (bridge closed to traffic)	$40 / SF	$6 / SF	$46 / SF
Franklin (1996)	$32 / SF	$8 / SF	$40 / SF
Rte. 64 Bridge	$56 / SF	$8.50 / SF	$64.50 / SF

Table 1.

Although the costs are highest for the Pomme de Terre bridge, the deck removal costs reflect the complexity of each project. This project has the highest unit cost, largely due to the fact that 90% of the work had to occur over water. Another important item that is not considered above is the benefit of reduced traffic control costs.

CONCLUSION

This innovative method of using full-width full-depth precast panels proved to be cost competitive with stage construction and beneficial for minimizing the impact to the traveling public and local economies. The benefits to the local community included minimizing the impact on tourism, maintaining emergency vehicle and school bus access during the day, and reducing the construction impact from daily for two years to 2½ months of overnight work. This "fast-track" concept could be further extended to replacing bridge decks in areas with high traffic control costs, bridges with skewed supports, or on larger bridge rehabilitation projects where construction time is a significant factor.

REFERENCES

[1] Issa, M. et al., "Full Depth Precast and Precast, Prestressed Concrete Bridge Deck Panels", PCI Journal, Precast/Prestressed Concrete Institute, January-February 1995.

[2] Issa, M. et al., "Field Performance of Full Depth Precast Concrete Panels in Bridge Deck Reconstruction", PCI Journal, Precast/Prestressed Concrete Institute, May-June 1995.