# WIDENING THE HISTORIC RIVER ROAD ARCH BRIDGE OVER HARRODS CREEK

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## ABSTRACT

*The original River Road Bridge, constructed circa 1912, is a three-span, reinforced concrete, filled spandrel arch structure, carrying River Road over Harrods Creek in Jefferson County, KY. This bridge is eligible for listing in the National Register of Historic Places.*

*In 2000, the Jefferson County Public Works initiated a project with the goal of rehabilitating and widening the existing one-lane bridge to address safety concerns, and to execute this work in such a manner as to be sensitive to preserving the aesthetic and historic characteristics of the structure. The resulting plan was to "hide" the structural support framework of a modern prestressed concrete bridge inside the spandrel walls of the existing arches, while cantilevering the new bridge deck out over the spandrel walls to provide sufficient width for a two-lane roadway.*

*New abutment caps are supported on drilled shafts which are located behind the existing arch rings, cored down through the existing arch thrust blocks, and terminate in rock sockets. The new pier caps are supported on micropiles, which are drilled down through the existing arch infill and pier stems, and are anchored 11 feet into solid rock.*

*The superstructure is framed with three lines of closely spaced prestressed concrete box beams located in an excavated area inside of the arch spandrel walls. Precast, prestressed deck panels, placed on top of the box beams, cantilever 7'-9"beyond the edges of the box beams to form the bridge deck.*

*The rehabilitated and widened bridge, which opened to traffic in August 2010, won the APWA (KY Chapter) "2010 Project of the Year" award in the Historic Preservation Category (over $1 million).*

**Keywords:** Arch, Historic, Micropiles, Drilled Shafts, Prestressed Beams, Deck Panels

## INTRODUCTION

The original River Road Bridge, constructed circa 1912, is a three-span (64’-4”~ 66’-4”~ 64’-4”), reinforced concrete, filled spandrel arch structure, carrying River Road over Harrods Creek in Jefferson County, Kentucky (Fig. 1). Initially, the bridge was constructed to serve a few suburban properties in the vicinity. However, over the years, the traffic volume generated by local residents and others using the bridge for daily commutes to nearby Louisville has increased significantly, rendering the one-lane structure inadequate to handle the growth. Over the past several decades, motorists had grown accustomed to stopping at the ends of the bridge and taking turns crossing the bridge one at a time, in opposite directions.

In 2000, the Jefferson County Public Works (JCPW) initiated a project to rehabilitate and widen the River Road Bridge, to both address safety concerns associated with the deteriorating concrete balustrade bridge railing and the bridge’s narrow 16’-11” roadway. The goal of the JCPW was to execute this work in such a manner as to be sensitive to preserving the aesthetic and historic characteristics of the structure.

Fig. 1 – Elevation View of Existing Bridge

## PUBLIC AGENCY INVOLVEMENT

Located on a Kentucky Scenic Byway, and in close proximity to several historic districts, the bridge is eligible for listing in the National Register of Historic Places (National Register). It is flanked by one large tract of land to the northwest and one smaller parcel of land to the southeast, both of which are listed in the National Register. Acting in compliance with Section 106 of the National Historic Preservation Act (NHPA), the Federal Highway Administration (FHWA) provided the Kentucky State Historic Preservation Officer (SHPO) the opportunity to comment on whether the proposed project would have an adverse effect on either the existing bridge or adjacent historic properties. This was, in fact, deemed the case. Therefore, the bridge could not be replaced or relocated on a different alignment. Additionally, the remains of laid-up sandstone abutments – remnants from an historic interurban rail line that crossed Harrods Creek and are located immediately to the west of the existing bridge – could not be disturbed either.

As a result, a Memorandum of Agreement (MOA) was drawn up between the Kentucky SHPO, the Kentucky Transportation Cabinet (KYTC), and the JCPW, and submitted to the federal Advisory Council on Historic Preservation (ACHP). This document contained a list of stipulations that were to be satisfied during construction of the project, while being monitored by the FHWA to ensure compliance.

## EARLY LOCAL OPPOSITION

Several local residents and a proactive area watchdog group were in favor of rehabilitating the bridge, but were opposed to widening it. The principal argument of their opposition was that the one-lane bridge exhibited a "calming" effect on traffic, and they feared that widening the bridge would invite more traffic, with more trucks, and increased speed.

Anticipating that a construction project was imminent, the watchdog group filed a lawsuit against the project in May 2008. During the time the project was in the planning and design phases, the architectural concrete balustrade bridge railing had continued to deteriorate – so much that it had become dangerously unsafe (Fig. 2). The bridge was closed to traffic in November 2008.

Fig. 2 – "Barrel Shot" of Existing Bridge
Just Prior to Closure

The project was awarded for construction in March 2009, but in May 2009 the project was delayed due to a second lawsuit filed by the watchdog group. Over approximately the next five months, work was halted three more times before a Federal District Court Judge ruled to lift an injunction against the project so that construction could resume and continue uninterrupted.

## PROJECT CHALLENGES & OVERALL CONCEPT

One of the key challenges the design team faced from the onset was how to widen the existing bridge from one lane to two and leave the existing arches essentially unchanged. The concept that was proposed, evaluated, and then adopted was to construct a new bridge inside of the old and cantilever the new bridge deck out over the spandrel walls of the existing arches.

Since no original plans of the bridge were found, based on plans of similar type structures that were available, it was assumed that the inside faces of the existing spandrel walls were vertical. This would later prove to be an unfortunate assumption and would result in considerable preparatory retrofit work by the contractor.

Another design requirement was that all of the loads generated by the new bridge needed to be isolated from the existing arches. This was accomplished by locating three lines of precast, prestressed concrete box beams inside of the existing spandrel walls, in three spans such that new abutments would be located beyond the ends of the existing arches, and new pier caps would be located directly over the existing piers.

During the preliminary design phase, the design consultant proposed using precast, prestressed concrete deck panels, with alternating cast-in-place (CIP) concrete closure pours. The reason for this was two-fold. First, because local school buses use River Road, the JCPW had issued a directive to minimize the amount of time the bridge would be closed due to construction – precast, prestressed concrete deck panels could be manufactured ahead of time and then later delivered and erected fairly rapidly. Second, because of the extraordinarily large deck overhangs, and because no lateral loads could be transferred onto the existing spandrel walls, conventional overhang brackets necessary to construct a CIP concrete deck were not practical. To support the deck overhang forms, a support frame would need to be erected in Harrods Creek on each side of the bridge in a configuration that would not impede local boating traffic. These options were discussed conceptually with a reputable bridge contractor, and the preliminary recommendation was that the using precast, prestressed concrete deck panels was the preferred method of construction. The entire deck would be nominally post-tensioned in the longitudinal direction to provide a clamping pressure (approx. 200 psi) at the interface between the deck panels and the closure pours.

However, during the final design phase, because of its concern with future maintenance issues, the KYTC requested that the design be changed to a CIP concrete deck option. Therefore, the bridge was designed and let for bidding based on CIP concrete deck construction.

Immediately after being awarded the construction contract, the contractor submitted a request to use precast, prestressed concrete deck panels and CIP concrete closure pours – but without longitudinal post-tensioning. The completed deck would be topped with a 1 ½” thick asphalt overlay to provide a smooth riding surface. The request was approved by both the KYTC and the Louisville Metro Public Works & Assets (LMPW), with the stipulation that a waterproofing membrane be provided between the asphalt overlay and the bridge deck.

**NEW BRIDGE**

The new bridge is a three-span (71’-6”~ 66’-4”~ 71’-6”), continuous for HS-25 live load structure. The bridge is 32’-0” wide, carries two 12’-0” traffic lanes, two 2’-10” shoulders, and has 1’-2” wide architectural concrete bridge rails on each side that replicate the original concrete balustrade railing. The bridge deck is supported by three lines of 42” x 48” precast, prestressed spread box beams, spaced at 6’-3”. This narrow beam spacing is required to fit these three beam lines between the existing spandrel walls, and provide approximately 2 ½” minimum side clearance between the box beams and the inside face of the spandrel walls. This spacing also results in the deck being cantilevered 7’-9” beyond the edge of the box beams on both sides of the bridge (Fig. 3).

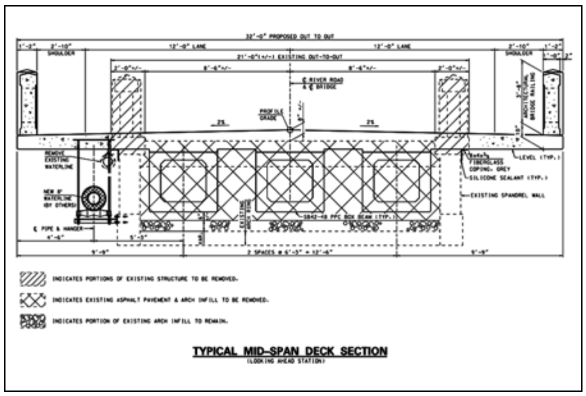


Fig. 3 – Typical Bridge Section

One of the first tasks of construction was to remove the existing asphalt paving and begin removing portions of the arch infill. At this time, the upper portion of the concrete balustrade railings were torn off – an easy task because of the extensive deterioration that had occurred in both the concrete and the reinforcement. The existing cobble infill was removed down to the plan removal elevation – approximately 6” below the bottom of the box beams. This clearance ensures that the box beams do not come in contact with, or bounce against, the crown of the existing concrete arches when vehicles cross the bridge.

Unfortunately, during the removal of the cobble infill, it was discovered that the inside face of the spandrel walls were not vertical, but battered approximately 1 ¼” per foot – bringing to light the painful realization that the box beams would not fit between the spandrel walls as planned (Fig. 4). Raising the roadway profile grade was not an option because nearby property entrance profiles would be raised also, extending construction outside of the right-of-way limits. After some discussion, the decision was made to allow the contractor to chip a vertical notch into the inside face of each of the existing spandrel walls to provide the desired side clearance to the box beams. This required a considerable amount of meticulous manual work using hand-held pneumatic chisels.

Fig. 4 – Removing Portions of Arch Infill

Occurring simultaneously during the removal of the arch infill, the bottom portion of the existing concrete balustrade was removed. This was accomplished by making horizontal cuts with a water-powered, carbide-tipped, rotary saw through the plinth block at the base of the existing concrete balustrade railing. The elevation of this cut was pre-calculated to provide the 2 ½” of vertical clearance between the top of the spandrel walls and the bottom of the prestressed deck panels to be erected later (Fig. 5).


Fig. 5 – Sawing Spandrel Wall Below Plinth Block

**SUBSTRUCTURE**

PIERS

Four micropiles are located inside of each of the existing piers, spaced on 4’-2” centers along the centerline of pier – in holes drilled down through the existing cobble infill, through the existing pier stems, and anchored 11 feet minimum into solid rock. Each micropile consists of a 9 ⅝” O.D. steel casing (API, fy = 80 ksi), with a central #28 (3 ½” dia.) all-thread bar (fy = 75 ksi), and pressure grouted with 5 ksi grout (28-day). A reinforced concrete cap is located on top of the micropiles at each pier to provide support for the box beam spans. The micropiles are anchored into the cap by means of a cruciform-shaped steel cap secured to the top of each micropile with a H.S. steel nut screwed onto the all-thread bar (Fig. 6).

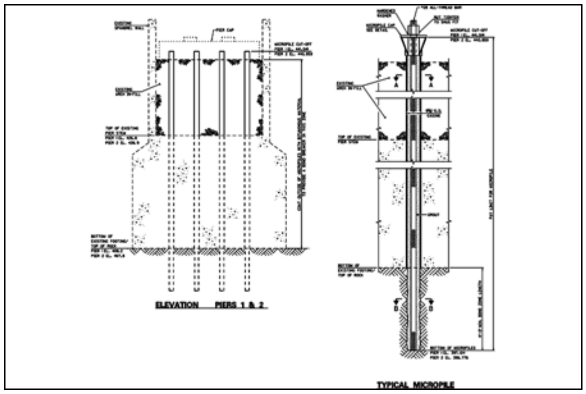


Fig. 6 – Micropiles at Piers

Because of the need to access the pier locations for drilling the micropile holes, the pier work began in advance of the abutment construction. Each of the holes were drilled through the existing pier stem with a slightly larger diameter than the casing, to allow for a small amount of lateral movement of the micropiles that might occur due to temperature and/or vehicular braking forces acting on the completed structure.

One micropile at each pier was successfully proof-load tested in compression to 265 tons (160% of the design load) (Fig. 7).


Fig. 7 – Proof-Load Testing Micropiles

ABUTMENTS

Three 48” diameter drilled shafts are spaced on 5’-3” centers and are located just behind the arch ring in each tail span. Each drilled shaft was constructed by drilling down through the cobble infill, coring through the existing arch thrust block, and terminating in an 11’-6” deep rock socket. The holes through the existing thrust block concrete were cored oversize to provide a 2 ½” minimum thickness annulus between the outside of the permanent steel casing and the thrust block. This annulus was backfilled with loose sand to provide room for some lateral movement of the drilled shafts, to prevent transferring loads into the existing arches.

Similar to the piers, a reinforced concrete cap is located on top of the drilled shafts to provide support for the box beam spans.

CURTAIN WALLS & RETAINING WALLS

Since the new roadway is much wider than the existing, an “L-shaped” reinforced concrete curtain wall and retaining wall arrangement is connected to the sides of each existing spandrel wall to contain the roadway embankment at the bridge ends. The curtain wall extends perpendicular to the spandrel wall, turns a 90° angle and then changes to a retaining wall that runs parallel with the roadway approaches. This arrangement occurs at all four corners of the bridge. The curtain walls and retaining walls are founded on a combination of drilled shafts (48” and 42” dia.), grade beams and spread footings (Fig. 8).

Fig. 8 – Installing Drilled Shafts at Abut. 2 (back)
Curtain & Retaining Walls at Abut. 1 (fore)

**SUPERSTRUCTURE**

PRESTRESSED CONCRETE BOX BEAMS

Because the new beams are located inside the existing arch between the spandrel walls, making them permanently inaccessible, three lines of 42” x 48” precast, prestressed concrete box beams, fabricated with 7500 psi concrete (28-day), were selected for several reasons:

Strength – Because the existing bridge is approximately 20’-11” wide and the new bridge is 32’-0” wide, the new deck cantilevers 7’-9” beyond the edge of the box beams (approx. 5’-6” outside the existing spandrel walls) on each side of the bridge. These beams require significant flexural strength, shear capacity, and relatively shallow depth to clear the crown of the existing arch rings and minimize the height the roadway profile grade would need to be raised.

Future Maintenance – The concrete beams, which will be subjected to a moist and humid environment, will not require painting and will exhibit superior durability and resistance to moisture over the life of the structure.

Serviceability – One of the design requirements was to ensure that the beams don't bounce against any part of the existing arch due to vertical deflection or lateral movement (wiggle) of the beams caused by transient live loads moving across the structure. The flexural stiffness of concrete box beams results in much smaller deflections than that of steel beams of comparable size.

Because Harrods Creek is affected by backwater from the nearby Ohio River, both ends of each box beam are tied down to the abutment/pier caps to prevent float-off due to buoyancy during periods of high water. Tie-down is accomplished by passing a 1-⅜" diameter threaded rod through a slotted hole in the ends of each box beam, secured with a nut on top and embedded into the abutment/pier caps at the bottom (Fig. 9).

Fig. 9 – Erecting Prestressed Beams -
(Note Preparatory Chipping of Spandrel Walls)

PRESTRESSED CONCRETE DECK PANELS

The bridge deck is comprised of twenty precast, prestressed concrete deck panels, with alternating CIP concrete closure pours. Each deck panel is 32'-0" wide, with lengths varying from 5'-10 ½" to 7'-11 ⅝", and with a panel thickness varying from 10" at the gutterlines to 1'-1 $^{9}/_{16}$" at the crown. The deck panels, also fabricated with 7500 psi (28-day) concrete, are prestressed transversely to handle the large deck overhangs, which, incidentally, support an 8" dia. waterline suspended from one side of the bridge (Fig. 10).

Fig. 10 – Erecting Prestressed Concrete Deck Panels

The prestressed deck panels have vertical open slots cast in them that align with and accept shear stirrups (epoxy-coated) that protrude from the tops of the box beams. After the panels were erected, both the slots and the fillet gap between the top of the box beams and the bottom of the deck panels were pressure grouted to provide composite action between the beams and the deck panels. The deck panels are isolated from the tops of the existing spandrel walls by a 2 ½” minimum vertical gap between them (Fig. 11).


Fig. 11 – Typical Deck Panel in Erected Position

## CAST-IN-PLACE CONCRETE CLOSURE POURS

To provide continuity of the longitudinal deck reinforcement, 3’-0” long CIP concrete closure pours placed with 5 ksi (28-day) concrete are located between each deck panel. All of the lines of longitudinal reinforcement in the top and bottom of the deck are spliced together within the closure pours by screwing the reinforcing bars into couplers cast into the faces of each deck panel. The bars are either straight (for #5 bars) or terminate in a 180° hook (for #6 bars). To provide the required flexural strength over the piers and negative moment regions, and to address the limited opening available for a conventional lap splice in a closure pour, #9 bars are spliced together with screw-lock type mechanical connectors. All of the reinforcing bars, couplers and mechanical connectors are epoxy-coated (Figs. 12, 13).


Fig. 12 – Pre-attaching #9 Screw-Lock Type Mechanical Connectors


Fig. 13 – Reinforcement for CIP Concrete Closure Pour at Pier (Note Grouting of Stirrup Slots)

Formwork for the deck overhangs at the closure pours were supported by temporary needle beams hung on threaded rods passed through PVC pipe sleeves pre-cast into the deck panels.

All of the closure pours in the positive moment regions were poured first. Once these pours were completed, the screws on the mechanical connectors for the #9 negative moment bars over the piers were then tightened and the closure pours in the negative moment regions were placed.

## ARCHITECTURAL CONCRETE BRIDGE RAILING

The new reinforced concrete architectural bridge railing, which was designed to replicate the original concrete balustrade bridge railing, was cast in-place with the formwork for the bridge railing and pilasters fabricated and assembled on-site. Openings for the windows were formed using pre-cut styrofoam blocks. The concrete railing is connected to the prestressed deck panels and closure pours via stirrup bars projecting up from both the deck panels and closure pours.

## REHABILITATION OF ARCH ELEMENTS

Over the years, the ravages of time caused some of the concrete in the arch rings to delaminate and spall off, leaving the existing reinforcing bars exposed. During the design process, site visits were made to identify and quantify as accurately as possible these distressed areas. Typical details were included in the contract plans for making these repairs, which included chipping out bad concrete, cutting out corroded reinforcement and splicing in new reinforcement, and then applying the new epoxy concrete. A subcontractor that specializes in concrete restoration and repair was brought in to perform this work, all of which was performed from a manlift mounted on a small work barge (Figs. 14, 15).

Fig. 14 – Worker Chipping Out Bad Concrete

Fig. 15 – Installing Formwork for Epoxy Concrete

After all of the repairs are completed, the entire exposed surface of the existing arches and spandrel walls will receive a masonry coating finish.

## CONCLUSIONS

Widening a 100-year-old one-lane bridge to two lanes and rehabilitating it, while preserving the architectural and historic characteristics of the original structure, provided the opportunity to implement some creative solutions and innovative engineering techniques. Even though the project was initially met with some opposition, once the project was completed, public feedback indicated that the overall results were well received and that the project was perceived as an overall success (Figs. 16-18).


Fig. 16 – Looking South Along
Newly Widened Bridge Roadway


Fig. 17 – Looking West at Rehabilitated Bridge

Fig. 18 – Oblique View of Rehabilitated Bridge