REHABILITATION OF BRIDGE V. D. MP 72.0

OVER

OUACHITA RIVER

MONROE, LOUISIANA

The Kansas City Southern Railway Company

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In 1993, the Kansas City Southern Railway Co. suspecting that the center pivot pier of Br. VD M.P. 72.0 was moving and had a system of survey reference points installed to monitor for any movement. A survey made in 2006, indicated the pier had settled approximately 2 ½” and rotated approximately 9” since 1993. To maintain rail traffic on the bridge the ends of the two approach spans were adjusted to match the movements of the swing span. This resulted in an “S” curve in the track alignment. Following an investigation and analysis it was decided to replace the pivot pier, rehabilitate / replace elements of the mechanical and electrical systems, and strengthen the bridge. Four 96” dia. drilled shafts were constructed around the existing pier, and outside of the Navigation Channel. Two steel box girders, supporting a 4’- 6” thick machinery slab, span between the drilled shafts. On October 30th, an 18 day Navigation Outage started. During numerous track curfews, the jacking system was completed, the swing span lifted off the existing pier, realigned, and supported on the new pier. The mechanical turning equipment was rehabilitated or replaced, and the top eight feet of the existing pier removed. Late on November 16th the river was reopened to unrestricted traffic. Additional electrical, mechanical and structural repairs / upgrades were still required to complete the rehabilitation. But the major goal of replacing the pivot pier had been accomplished.

Key words: bridge, rehabilitation, swing span, navigation channel
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INTRODUCTION

The existing Ouachita River Bridge was constructed in 1906, by the Vicksburg; Shreveport & Pacific Railway Company. Bridge V.D. MP 72.0 is currently owned by the Meridian Speedway LLC\(^1\). The Kansas City Southern Railway Co. (KCSR) is the designated operator of the Bridge. Bridge V.D. MP 72.0 is a vital link in Meridian Speedway LLC’s, Orion Project to up-grade track and structures between Meridian, Mississippi and Shreveport, Louisiana.

The Ouachita River is navigable and under the jurisdiction of the U.S. Coast Guard, 8\(^{th}\) District.

DESCRIPTION OF EXISTING STRUCTURE

The bridge consists of four through truss spans. The main span over the navigation channel is a 295 ft. center pivot span; supported on a 29ft. dia., brick masonry / rubble filled pier on timber piles. The rest piers are 32ft. by 8ft. brick masonry piers believed to be supported on timber piles. The east and west approach spans, immediately adjacent to the pivot span, are 242 ft. spans. The west approach is

\(^1\) Meridian Speedway LLC is jointly owned by the Kansas City Southern Railway Co. and the Norfolk Southern Railroad
extended by a second 120 ft. span. The abutments are massive concrete structures supported on timber piles. Total length of the structure is 914 ft.

In October, 2006, when the project was started, the bridge carried an average of 24 trains per day. The bridge was posted at 10 mph. The approach speeds were limited to 40 mph because of an interlock located at the east end of the bridge. According to the bridge tender’s log the bridge was opened 197 times between March 1, 2006 and October 15, 2006. On average the bridge was opened 6 times per week.

INSPECTIONS

On October 11, 2006, a letter was sent to the U.S. Coast Guard requesting permission to perform the following:

1. An underwater inspection of the piers
2. A structural inspection of the bridge
3. A geotechnical investigation, within the navigation channel
4. An Electrical and mechanical inspection of the turning and end lift machinery

This was to be the first of many such letters and requests.

Underwater Inspection

Two underwater inspections were performed.

The first inspection, performed November 1st & 2nd, 2006; was to:
1. Determine the structural condition of the brick masonry piers
2. Locate any scour holes near the existing piers
3. Locate the edges, and determine the shape and condition of a timber mat constructed between the timber piles and the concrete base supporting the pivot pier

The second inspection performed April 3\textsuperscript{rd} thru 5\textsuperscript{th}, 2007; was to:

1. Expose and mark with buoys the edges of the timber mat. Four yellow buoys were anchored to the corners
2. Assist AT&T and ITC DeltaCom to obtain a more exact location for two underwater cables. The AT&T cable was located north of the bridge and the ITC DeltaCom cable was located south of the bridge.
   a. The AT&T cable was located approximately 16 feet from the face of the existing pivot pier. This placed the cable approximately one foot from the edge of the proposed 8.00 ft. dia. drilled shafts.
   b. The ITC DeltaCom cable could not be located even with the more advanced and accurate locator equipment provided by the diving company.
3. An underwater inspection of the substructure elements was made using “Multi-Beam Sonar” and a “Real Time Graphic Analyzer”, which produced underwater pictures of the piers and the channel bottom.
**Geotechnical Investigation**

A Geotechnical Investigation was performed starting November 13th thru 18th, 2006. Three borings were drilled. Two at the center pivot pier and one at the east rest pier. Because we were looking at large diameter drilled shafts to support the new pivot pier, the borings were advanced to 150 ft. below the river bed. The borings were made from a construction barge.

A second set of borings, scheduled to be drilled April 3rd thru 6th, 2007, were cancelled because we could not accurately locate the two underwater cables.

**Structural Inspection**

The bridge (substructure and superstructure) inspection started on November 1st and was completed on November 6, 2007.

*Swing Span (span 2):*

The trusses for the most part were in good condition, they exhibited a light surface rusting. There were holes rusted through the vertical legs of some of the angles in the end portal bracing. The lower diagonal bracing was in poor condition. Many of the angles were rusted through or were detached from their gusset plates. Several of the angles were cracked. At many locations hangers, supporting the bracing angles at the stringers, were badly rusted or gone. The bottom flanges of the end floor beams were distorted and bent (possibly from improper jacking of the span). The top flanges of the end floor beams and the rail supports were cracked. Two interior floor beams had holes rusted through their webs just above the top stringer flanges. Several stringers exhibited rusting of the bottom angles adjacent to the floor beams. The bottom angles of both of the tower lateral struts were rusted.
through at their gussets. The floor beams, track stringers, drum girders, and diaphragms of the center pivot framing members were rusted.

Figure 1: View from East Abutment; track alignment prior to pivot pier replacement

Approach Span (spans 1 & 3):
The trusses for the most part were in good condition, they exhibited a light surface rusting. There were holes rusted through the vertical legs of some of the angles in the end portal bracing. The lower diagonal bracing was in poor condition. Many of the angles were rusted through or were detached from their gusset plates. At many locations hangers, supporting the bracing angles at the stringers, were badly rusted or gone. Several interior floor beams had holes rusted through the webs just above
the top stringer flanges. Several stringers exhibited rusting of the bottom angles adjacent to the floor beams. The top flanges of the end floor beam and the rail supports at the east end of span 3 were cracked.

Approach Span (span 4):
The trusses for the most part were in good condition, they exhibited a light surface rusting. The lower diagonal bracing was in fair condition. Several of the angles exhibited pack rust at their connections to the gusset plates. At several locations hangers, supporting the bracing angles at the stringers, exhibited pack rust. Several interior floor beams had holes rusted through the webs just above the top stringer flanges.

Mechanical Inspection
The overall condition of the machinery was poor. The area of roller contact with the upper and lower tracks has been reduced by almost 50% at about 25% of the rollers. The spider hub bushing has failed and been repaired numerous times. Several of the spider rods have been broken and poorly repaired. The rollers are not adequately restrained radially. These conditions cause the span to become unstable and greatly increase the pinion torque required to rotate the span. The lateral rotation of the center pivot pier is the main cause of the problem by introducing lateral loads into the rollers. Counterweights added at the west end of the span to help balance the span, have caused an imbalanced vertical load on the
west facing rollers and are pushing the rollers out from between the top and bottom tracks.

Figure 2: Center pivot pier and tower section, with swing span in open position

**Electrical Inspection**

The bridge is currently provided with a 100 amp., 240 volt, 3 phase electrical service, sufficient to operate the bridge in its current configuration. It provides power to operate the hydraulic power unit, misc. convenience receptacles, and the navigation lighting system. However, it does not allow for any future expansion. There were electrical power issues and problems that should be corrected.
Effectively there was no electrical control system. There were no safety interlocks except for the hydraulic pump power unit motor contactor, which is interlocked with the railroad signal system. Once the hydraulic power unit is powered, the bridge tender can manually operate the machinery in any sequence, some of which may cause serious damage.

There is no redundant power supply, either in the form of an emergency generator or separate power feed from the opposite side of the river.

**SURVEYS AND BRIDGE MOVEMENT MONITORING**

In 1993, the Kansas City Southern, suspecting that the center pivot pier of Br. VD M.P. 72.0 was moving and had a system of survey reference points installed to monitor for any movement. A review of the survey data collected from 1993 thru July 2007, indicated the pier had settled approximately 2 ½” and rotated approximately 9” since 1993.

A survey Base Line was established by splitting the rail gage east and west of the bridge abutments. The top of both rails were profiled, and Base Line offsets for both rails were measured to obtain an accurate record of the existing horizontal and vertical track alignment.
LOAD RATING AND EVALUATION

The individual structural elements were analyzed using conventional manual and computer methods. Load rating provided an indication of the capacity of the individual members to support dead and live loads based upon its existing physical condition. Using the original construction drawings and the results of the field investigation, section properties of all of the main members were calculated. Live load moments, shears and reactions were based upon the AREMA - Cooper E-80 train configuration. The ratings also considered two reduced train speeds (40 mph & 30 mph) to evaluate actual train speeds anticipated following completion of structural repairs / rehabilitation.

Two rating levels were determined for the various structural members, Maximum Rating and Normal Rating. The individual member ratings varied greatly within the different categories.

Swing Span (span 2):

The controlling Normal Rating was the floor beams with an E-76 at 40 mph; all other members rated greater than E-80. The Maximum Rating for all members was greater than E-80 at 40 mph.

Spans 1 and 3:

The Normal Rating for all truss members was less than E-80 at 40 mph; except for the end portals (L0-U1), the end top chord members (U1-U2), and vertical members (L3-U3). The Maximum Rating for all truss members was greater than E-80 at 40 mph.
mph. The Normal and Maximum Ratings of the stringers and floor beams were greater than E-80 at 40 mph.

**Span 4:**

The controlling Normal Rating was the end hanger (L1-U1) with an E-61.2 at 40 mph. All other members rated greater than E-80. The Maximum Rating for all members was greater than E-80 at 40 mph.

**SITE UTILITIES**

Utility locates for the geotechnical investigation identified another challenge. Two underwater fiber optic cables were identified. One owned by AT&T, located upriver (North) of the bridge, provides service to Barksdale Air Force Base. The other cable, owned by ITC DeltaCom was located downriver of the bridge. A letter was sent to AT&T and ITC DeltaCom advising them of the proposed work on the bridge. Particularly the drilled shaft construction, and requested they temporarily relocate their cables. After much discussion, ITC DeltaCom installed a temporary cable on top of the existing bridge. AT&T decided to permanently relocate their cable to the Interstate 20 Bridge located approximately ¼ mile south, where they had a conduit attached to the bridge with excess capacity.

There were no indications that either cable had been damaged during construction of the six drilled shafts. ITC DeltaCom put their underwater cable back into service and removed the temporary cable from the bridge. Since AT&T had permanently
relocated their underwater cable, no attempt was made to determine if the cable was still intact.

A gas main and several overhead telephone and electrical power line were located east of the bridge and outside of the flood wall. Therefore, they didn’t interfere with construction.

**DESIGN CRITERIA AND REPAIR OPTIONS**

Per the General Notes on the original plans: “All work [was to be] in strict accordance with “Queen & Crescent Route Specifications” for 1903. All material “Class B” Steel except rivets which are “Class A” Steel.” The bridge had been designed for loads similar to a Cooper E-40, except the axle spacing(s) were smaller than for the Cooper train. There was no indication of the Impact requirements.

The budget did not allow for upgrading all members to an E-80 capacity. Members with a Normal Rating of less than E-76 @ 40 mph were to be strengthened. Plates, angles and rolled sections were to be non-weathering steel, with a 50.0 ksi. yield strength. High strength tension rods were to have an Ultimate Strength of 150.0 ksi. All bolts were to be ASTM A325.
PERMITS

Numerous permits were required for this Project, including the following:

1. U.S. Coast Guard
   a. Bridge Permit issued on June 27, 2007
   b. Construction Permit issued on July 20, 2007
   c. Amended Bridge Permit issued on September 4, 2007
   d. Numerous permits authorizing work within the navigation channel
   f. Construction Completion Report

2. U.S. Army Engineers
   a. Nationwide Permit No. 3 issued June 4, 2007


6. Ouachita River Valley Association (ORVA): while not a permitting agency, it is the political arm of the Owners, Operators, and Shippers on the Ouachita River.

At the invitation of the ORVA, we made a presentation at their April 1, 2007, meeting. Our intent was to explain what we planned to do to the bridge and why, to present Transystems and the KCSR’s concerns, to ask and answer questions, and to solicit and discuss options and recommendations on how to mitigate the impact of the work on navigation and shipping.
Three ideas came out of this meeting:

1. Providing a low head tug, during the 18 Day Navigation Outage, to pass barge tows from a tug downriver, under the bridge, to a waiting tug upriver would help move material up and down the river.

2. When work was being done in the navigation channel that could not be stopped or interrupted (such as setting drilled shaft casings, placing concrete, setting steel, etc.), an approaching barge tow would move toward the bank and wait (go on standby) until the critical work could be completed and construction equipment moved from the navigation channel. The KCSR would pay a pre-set hourly fee for the delay time.

3. By keeping Owners, Operators, and Shippers advised of the timing of the navigation outage; where possible, materials could be stockpiled.

CONSTRUCTION

TranSystems and the KCSR were concerned about the stability of the center pivot pier, as it continued to move, and about being able to continue operation of the swing span. On a cold night in December, 2006, the span was opened for a barge tow. As they started to close the swing span it locked up and took over 12 hours to correct the problem and complete closure. To expedite construction, the KCSR, decided to select a contractor before the design and plans were completed.

On February 28, 2007, a pre-bid site meeting was held; two of the pre-selected contractors attended. The group inspected the work site, including the pivot pier and
machinery of the swing span. An Exhibit was given to each contractor with the following information:

1. Conceptual drawings of the new pivot pier and proposed construction sequence
2. Draft – Inspection and Evaluation Report of the swing span for:
   a. Proposed structural repairs or modifications
   b. Proposed mechanical repairs, replacements & modifications; including a list of owner provided equipment
   c. Proposed electrical repairs, replacements and code upgrades
3. Geotechnical Engineering Report
4. Proposed Project Schedule
5. Available – Original drawings of the existing bridge.

OCCI, Inc., Fulton, Missouri was the only Contractor to submit a proposal for the work identified at the Pre-bid Meeting. Contract negotiations were started between the Kansas City Southern Railway Company and OCCI, Inc. During the negotiations additional work items were identified and added to the scope of the project. The Contract became an evolving document as the design and plans were completed.

The goal for this phase of the Contract was to:

1. Construct the new Pivot Pier
2. Replace / rehabilitate the turning machinery
3. Re-align the entire bridge and re-balance the swing span
4. Rehabilitate the existing swing span end bearings
5. Repair and modify the existing hydraulic end lift system
6. Make preliminary improvements to the control system (hydraulic & electrical) to improve reliability
7. Repair / strengthen the end floor beams; the lower lateral bracing; the center pivot framing (track support system); and the upper tower lateral struts
8. Upgrade the electrical system and replace the submerged power cable. Install a new electrical feed point and an emergency generator, and replace / upgrade the navigation lighting

Additional work would be Change Ordered into the contract as the design and plans were completed. Additional work included:

1. Strengthening of the approach spans
2. Repair or replace the span centering device and span lock
3. Install a Fender System on the pivot pier per plans to be Approved by the U.S. Coast Guard
4. Complete modifications to the end lift system
5. Complete improvements and modifications to the control system using sensors to indicate when an operation was completed, such as the end lifts extended or retracted, or the rocker bearings in the up or down position. This would help to prevent operator errors and damage to the operating system.
A minimal impact construction plan was developed. The work was to be done in stages to maintain as near normal railway and river traffic as possible. On July 30, 2007, the contractor began moving equipment and barges from their staging yard, upriver to the north side of the bridge.

On August 1, 2007, the contractor moved equipment and barges into the navigation channel and began drilling the northwest drilled shaft. The drilling sub-contractor (Case Atlantic) essentially worked around the clock, installing the temporary and permanent casing, and drilling the shaft. Once the drilling was completed the contractor set the reinforcing steel cage and placed concrete in the shaft. The contractor completed construction of the two upriver shafts, then moved the equipment and barges to the south of the bridge, and constructed the two downriver shafts.

The contractor requested that the upriver protection pier be moved closer to the pivot pier. This would allow the protection pier to be used as staging for construction of the new concrete pier cap / machinery platform. This required submitting a request to the U. S. Coast Guard for an Amendment to our Bridge Permit. We received the approved Amendment the day the contractor was placing concrete in the last of the pivot pier drilled shafts. The following day the drilling contractor moved back upriver and drilled the two protection pier shafts.
The bottom 14” of the concrete of the shaft caps was pre-cast at the contractor’s staging yard. The pre-cast segment of the caps was re-designed to support the concrete and form dead loads, and construction loads. This required adding reinforcing steel in the top of the pre-cast segment. After curing, the pre-cast segment, including the forms and reinforcing steel, was delivered to the site and set on top of the drilled shafts. Concrete was then placed to complete the cap.

Figure 3: Pre-cast concrete slab, forming and reinforcing steel on top of upriver pier.

Two 72 ft. steel box girders were erected on the shaft caps, one on either side of the existing brick pivot pier. Transverse beams and diaphragms were then erected up and downriver of the pivot pier. False work beams, spanning from the upriver shaft
pier to the protection pier, were erected. Forms for the pier cap / machinery platform were constructed on the false work. Reinforcing steel was placed and the bottom 18” of the pier cap cast while still on the upriver false work.

Concurrent with this concrete work, an elaborate truss jacking / lifting system was being installed on the swing span tower section. As prep-work, select rivets in the tower-columns were removed and replaced with temporary A325 bolts one by one, between trains. During a track curfew and a navigation outage the temporary bolts were removed and angles bolted to the tower-columns with new permanent A325 bolts. T beams were bolted to the angles and large rolled beam columns bolted to the T beams. Stiffeners had

Figure 4: Elevation of Jacking System. Normal to center line of bridge

Figure 5: Elevation of Jacking System. Parallel to center line of bridge
been welded to the bottom of each column to provide jacking points for four 100 ton hydraulic jacks.

The top and bottom flanges of the floor beams and the top flange angles of the stringers and diaphragms of the Drum Section were replaced. As prep-work, rivets were removed and replaced with temporary A 325 bolts one by one, between trains. During a track curfew and a navigation outage, the temporary bolts were removed, and the existing angles replaced with new angles, using new permanent A325 bolts. The tower lattice struts were replaced with rolled beam sections, similar to the above procedure. The bottom lateral bracing was repaired by replacing the rusted, cracked and detached bracing angles, and the rusted and missing hangers.

On October 30, 2007, at 12:01am, the 18 day Navigation Outage started. Working around the clock, the remainder of the jacking system was installed, and on October 31, 2007 at 8:20am the swing span was lifted off of the existing pivot pier and supported on the new pivot pier. The end rockers were removed for refurbishing. Using blocking, the ends of the swing span were supported on the existing rest piers and the rail curfew released. The existing turning machinery was removed and the top 8 ft. of the existing brick pivot pier removed. The following day the swing span was again lifted and moved west along the bridge centerline approximately 3”. The ends of the swing span were again supported on the existing rest piers and the rail curfew released. November 2, 2007, the swing span was raised and moved laterally downriver. The east end was moved 4", the center 8 ½" and the west end 12".
It was also raised approximately 2 ½", but further refinement would be required as the new turning machinery was installed.

![Figure 6: Pre-cast portion of pier cap / machinery platform in position under tower section of swing span. Ring gear and lower roller track set into position and leveled.](image)

With the existing turning machinery and the top of the existing pier removed, the pre-cast cap segment was slid into position under the swing span and the remainder of the pier cap / machinery platform constructed. The tasks of installing the new, repaired, or refurbished turning machinery, and making final hydraulic and electrical connections were completed. On November 16, at about 11:00pm, the U. S. Coast Guard was notified that the bridge was released to navigation.
There was still a lot of work to do to complete the project; but the major task of replacing the pivot pier and the turning machinery was complete.

It was determined during the jacking of the swing span and leveling of the drum section that the east end of the span was approximately 6” high. In order to keep the swing span operational as the pivot pier moved, the eye-bars linking the east span to the tower had been “heat shortened” to raise the end of the span above the east rest pier bearings.

Because of time constraints it was decided to “heat lengthen” the existing eye bars. We were concerned that the heating process could fracture the existing bars dropping the entire swing span into the river, or could reduce the cross sectional area of the bars or affect the yield strength of the steel, significantly reducing the capacity of the members. High strength steel tension bars with “hair pins” were added to both of the east sets of eye bars. After three separate attempts of heating the eye bars, the end of the east span was lowered 5 ½”, which was declared close enough. The remaining ½” could be taken up in the rail supports and ties.

During the navigation outage, the work of repairing and strengthening the three approach spans was started. The top and bottom chords of the 242 ft. truss spans were strengthened by adding side plates to typical built up members, or by adding a high strength tension bar with “hair pins” to eye bar members. Diagonal members,
usually eye bars, were strengthened by adding a high strength tension bar with “hair pins”.

The end hangers (L1-U1) of all three approach truss spans were strengthened by adding high strength tension bars. The tension bars were placed inside of the existing hanger and anchored to the top and bottom chords with either a “hair pin”, or a bearing plate and double nuts. The bottom lateral bracing was repaired by replacing the rusted, and detached bracing angles, and the rusted and missing hangers.

Following completion of the navigation outage the bridge was fully operational, but was still manually operated. The only safety interlock was between the hydraulic pump and the railroad signal system. The operating sequence had become more complicated, with steps that had to be performed in the proper sequence. Several incidences occurred where the bridge tender missed a step or performed one out of sequence, resulting in damage to an end lift hydraulic cylinder.

At the request of the Owner, plans for a new end-lock/centering device and additional modifications to the controls were prepared. It was determined that the additional work on the control system exceeded the project budget and would have to be deferred until additional funds could be found.
The current allowable speed over the bridge has been increased to 40mph. The interlock at the east end of the bridge has been upgraded and at grade crossings signalized or closed, increasing the approach speed to 59mph. There is an average of 45 trains per day crossing the bridge.

During the seven months from August 2007 thru February, 2008, while actually working on the bridge, the bridge was opened 184 times plus 12 tows that were moved under the bridge during the 18 Day Navigation Outage. On average the bridge was opened 7.5 times per week.
ACKNOWLEDGEMENTS

The Kansas City Southern Railway Company

OCCI, INC - Prime Contractor

- Case Atlantic – Drilling Sub Contractor
- Koontz Electrical – Electrical Sub Contractor

TranSystems – Prime Consultant

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- Tiburon Divers / G&G Marine - Underwater Inspections
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- Kuhn Professional Services - Sub Consultant

U.S. Coast Guard, 8th District

U.S. Corps of Engineers, Vicksburg District

Ouachita River Valley Association