Project of the Year Submissions

Date Received 12/1/2021 ☑ Files submitted **Score:** _____

Title: **Hernando de Soto Bridge Emergency Repairs**

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Category

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Hernando de Soto Bridge Emergency Repairs

ESWP Project of the Year
Submitted by Michael Baker International

Hernando de Soto Bridge Emergency Repairs

Project Description

The Hernando de Soto Bridge is a steel-tied arch structure that carries Interstate 40 (I-40) across the Mississippi River between West Memphis, Arkansas, and Memphis, Tennessee. As one of only two crossings of the Mississippi River in the Memphis area, the bridge is a vital transportation, commerce, and defense link, carrying approximately 60,000 vehicles daily.

On May 11, 2021, inspectors from Michael Baker International were conducting a routine inspection of the upper portions of the Hernando de Soto Bridge they noticed a fracture in the tie girder of the bridge below deck, located within the Arkansas Department of Transportation's (ARDOT) scope of inspection. With safety as the top priority, the Michael Baker inspectors sprang into immediate action, contacting local authorities to shut down all traffic across and under the bridge.

The emergency closure quickly gained attention across the country from the public, media outlets and politicians alike. Tennessee Governor Bill Lee, Arkansas Governor Asa Hutchinson and U.S. Secretary of Transportation Pete Buttigieg all visited the bridge in the days following the closure, with Secretary Buttigieg noting “We want to make sure that national attention and resources are available to help the state and local authorities who are resolving this and working toward a safe reopening of the bridge...Even for people outside this region, it is important that we restore this connection quickly because like so much about the Memphis region, it is an area of national logistical importance.”

Following the initial discovery of the fracture, the extent of the damage was unknown. The Michael Baker team used unmanned aerial systems (UAS) to rapidly scan the rest of the structure. No additional damage was observed by the team and plans for repair moved swiftly into design and construction.

Under the Tennessee Department of Transportation (TDOT), a three-phase plan was devised for the Hernando de Soto Emergency Bridge Repairs project with Michael Baker serving as the lead designer. Phase 1 consisted of the design and installation of temporary stabilization plating and was completed within 14 days of the closure (May 25, 2021). Phase 2 used post tensioning to reduce the stresses in the tie and fully bolt repairs over the fracture and 150 feet of its length. Phase 2 was completed 53 days after the closure (July 3, 2021). The third and final phase addressed additional defects noted in the tie during inspection and was completed on July 31, 2021.The same day, all I-40 eastbound lanes opened and on August 2, 2021 all westbound lanes opened.

Of the bridge opening, West Memphis Mayor Marco McClendon noted: “For my city, we are partying in the street...It’s a great day, having both sides of the bridge open. It's some type of normalcy." State Senator Keith Ingram, D-West Memphis recognized the "tremendous coordinated effort" between ARDOT and TDOT to get the bridge reopened quickly.

Both ARDOT and TDOT share responsibility for the bridge: ARDOT handles inspections and TDOT handles repairs. Michael Baker provided inspection services for the portions of the bridge above-deck, including the arch ribs and hangers, for ARDOT. The firm also served as the lead designer for TDOT.

Initial Assessment

The fracture of the tie girder, the main tension element in the tied-arch bridge, left the structure in a very precarious state. Both vehicular and barge traffic were immediately halted. With nautical traffic paused for three days, initial physical and analytical assessments were completed. Once the structure was deemed stable, the U.S. Coast Guard reopened the river for navigation. Vehicular traffic across the structure remained halted for the duration of the repairs.

The Michael Baker team first leveraged their considerable experience with unmanned aircraft systems (UAS) – or drones – to fly the fracture location to inform ARDOT and TDOT of the apparent extent of the damage. The initial UAS video confirmed that the fracture included the complete loss of one of the two web plates, one of the two flanges and partial fracture of the second flange. More than 50% of the member cross-section was lost in the fracture. Within hours, engineers from ARDOT, TDOT and Michael Baker were working toward the ultimate goal of safely repairing the fractured tie girder. At this time, Michael Baker was contracted for design of an emergency repair by TDOT.

Thorough analysis and evaluation of the bridge began immediately: within a single day, Michael Baker assembled teams across numerous offices to gather data, perform calculations and increase the team's understanding in order to better evaluate the bridge's condition. Engineers generated detailed finite element models of the bridge and the local fracture to begin to shed light on the criticality of the bridge's condition. Field inspection teams assisted with obtaining critical information to support early investigative efforts obtained by UAS. Michael Baker, alongside ARDOT's UAS pilots, monitored the fracture to track any changes during those first critical hours. To support the initial temporary repairs, additional measurements of the crack, tie distortion and other critical field measurements were needed. This information was gathered by a Michael Baker rope access inspector on the bridge. During the inspection, Michael Baker established a live feed via UAS video linked to a web meeting. This allowed design engineers in multiple locations to communicate in real-time with the inspector while he took measurements and allowed them to request additional information and clarifications as needed. This creative use of technology gave designers real time results and a first person understanding of the implications of the distortion that would need to be considered in the repair design.

UAS inspection

Rope-access inspection

Technical Design Process and Construction

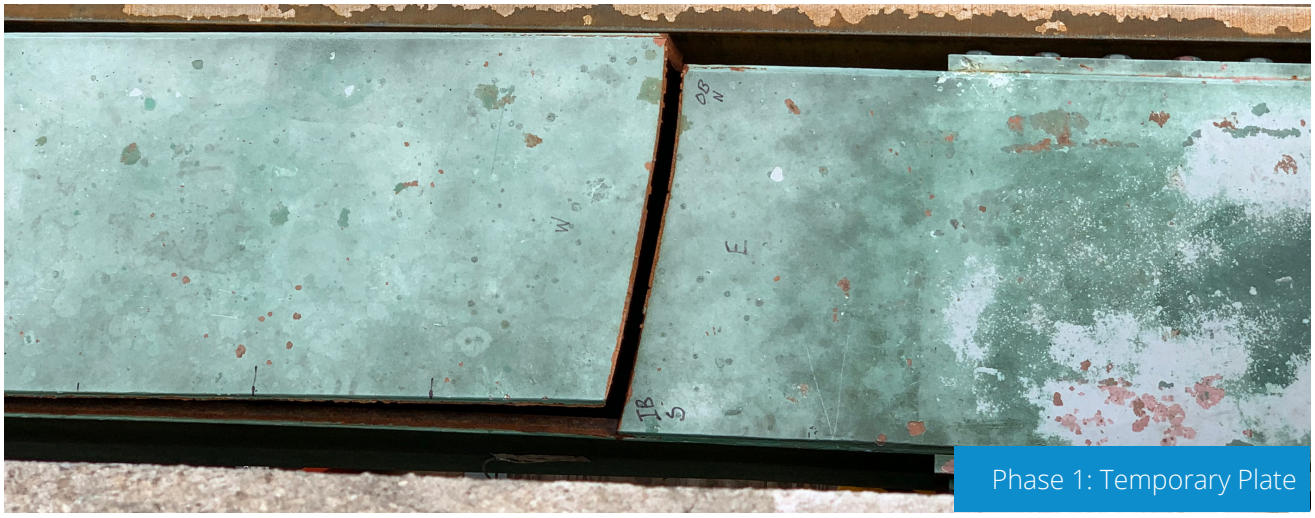
The team recognized that collaboration and efficiency in design and schedule would be important to repairing the fracture and reopening the bridge as quickly as could be properly accomplished within a week. As lead designer for all phases of repair, Michael Baker called on more than 60 engineers from 20 of the firm's offices around the country to contribute to the project in design and review/oversight roles to ensure that timely and prudent decisions were made at all phases of the work and that multiple phases could be advanced in parallel to minimize the overall project schedule.

TDOT selected the Construction Manager/General Contractor (CM/GC) project delivery method, recognizing the benefit to the project as it allowed owners, engineers and contractor to collaborate on the repairs. Within a week of the fracture being discovered, General Contractor Kiewit Infrastructure South Co. had also been brought onboard. All partners on the project proceeded in lockstep as repairs commenced, with daily working meetings to resolve challenges and frequent status meetings held throughout the entirety of the project. The Federal Highway Administration (FHWA) was also a key partner throughout the project, aiding with the repair plans.

With the team in place, ARDOT and TDOT collaborated on a three-phase repair plan – created and executed in collaboration with Michael Baker and Kiewit – with design and construction overlapping between the phases. The plan included:

Phase 1: Stabilization

The Michael Baker team took a "do no harm" approach to the initial repairs as there was concern that the bridge was severely compromised. The initial evaluations found the remaining section was dangerously close to yielding. The Michael Baker team found no evidence from the structure that the load had found an alternate path beyond the opposing web and remaining flange. Stabilizing the member was not a long-term fix, but it was the first step toward the repair, ensuring the safety of subsequent phases of work. The Michael Baker team established safe working load levels for construction crews and equipment staged on the bridge. Within the first week of the closure, a stabilization splice was designed to temporarily restore the capacity of the fractured section of the tie and the fabrication of roughly 30,000 lbs. of structural steel plates began by Stupp Bridge. To install the splice, Kiewit assembled a suspended platform from which iron workers secured the plating with nearly 450 temporary bolts. The splice provided additional redundancy to the partly severed member without applying any corrective twist or loading to the damaged tie. The suspended platform allowed the contractor greater access to establish a more permanent repair in Phase 2.



Phase 1: Temporary Plate

Technical Design Process and Construction (continued)

Phase 2: Member Repair

Knowing that time was of the essence to get this vital transportation link re-opened, analysis and design of the longer-term fix began immediately with Michael Baker engineers evaluating ways to repair this bridge. Faced with a range of potential repairs from reconstruction of the bridge to temporarily supporting the structure for the repair, the project participants found a creative solution to repair the structure in place and collectively cut significant cost and schedule impacts out of the project timeline. Advancements in the understanding and application of concepts in fracture mechanics and redundancy allowed for the fractured member to be repaired rather than completely replaced.

The final solution from Michael Baker consisted of using external post-tensioning to reduce tension in the existing tie, lessening its level of stress and possibility for further damage. Eight 3" diameter high-strength steel post -tensioning tendons were connected to steel weldments at either end of the fractured tie.

High-pressure rams were utilized to deliver the required force to partially de-tension the tie. Extensive real-time monitoring of the post-tensioning operations was implemented to ensure success. While the tie was partly unloaded, the temporary Phase 1 stabilization plates were removed and new strengthening plates were installed that have nearly the capacity of a completely intact tie by themselves.

These new plates, acting in tandem with the existing steel, provided a redundant load path in the unlikely event of future fracture. The Michael Baker team worked closely with Kiewit and fabricators W&W/AFCO and G&G Steel to design the repair around readily available HPS70W material.

During the completion of the work, an 18" section of the tie containing the fractured web and flange plates was removed for further forensic examination. Once the strengthening plates were installed and fully bolted, the post tensioning was removed, signifying successful repair of the damaged tie girder.

Phase 2: Post-Tensioning

Phase 2: Permanent Repair

Technical Design Process and Construction (continued)

Phase 3: Overall Tie Girder Repair

While Phase 2 repairs were going on, extensive nondestructive testing (NDT) of all similar welds in the tie girders was completed and provided information leading to what became the Phase 3 repairs of the tie. NDT discovered indications ranging from very small to very large. The remedy for many of these smaller indications was to either core or grind them out, thereby removing the potential flaw. Larger indications were plated over to provide a redundant solution. The details used in Phase 2 were readily adaptable for Phase 3 and Kiewit worked with supplier AFCO/W&W Steel to obtain the necessary HPS70W plate.

Tests were conducted on a portion of the damaged member that was removed as part of the Phase 2 repairs. The removed portion underwent forensic examination at the labs of Wiss Janney Elstner Associates Inc. (WJE) in Northbrook, Illinois. The WJE team is conducted various tests on the material to document its properties, as well as microscopically examining the weld and the fractured surfaces to determine where and how the fracture began. By having the fractured component in their possession, the engineers at WJE were able to provide guidance for field-testing of other welds that were completed as part of the inspection in Phase 3.

The Michael Baker team at the Hernando de Soto Bridge

Commercial Implications

The impact of the shutdown of the Hernando de Soto Bridge was almost immediately felt. The bridge connects I-40 between Arkansas and Tennessee, making it a vital transportation corridor over the Mississippi River. With the movement of good and people halted, the 60,000 vehicles that use the route daily needed to be rerouted. This includes 12,500 trucks each day that travel I-40 – these trucks now had to join the 14,000 trucks that utilize the nearest crossing on Interstate 55 (I-55). The resulting bottlenecks and delays therefore impacted all 26,500 trucks relying on the major freight corridor. Arkansas Trucking Association President Shannon Newton noted: "Using GPS data, we can discern that a previous eight-minute drive is now averaging 84 minutes. This additional transit time at $1.20 a minute for 26,500 trucks is costing the trucking industry more than $2.4 million each day that the bridge is closed." The delays impacted not only shipping and logistics, but also the traveling public, so expediting the repairs was critically important.

In the end, the bridge repairs were completed less than three months from the initial closure, with both directions of traffic opening several days earlier than anticipated. Although there were economic implications from the closure, CEO and President of the Greater Memphis Chamber Beverly Robertson noted of the reopening: "We'll be able to see probably within the next month a significant bounce back. I think what has happened is that people had to adjust so the supply chain slowed."

Budget and Schedule

The project's mission was clear from day 1: ensure the safety of the public and workers, repair the fracture and rectify other identified issues. For several weeks, activities progressed 24 hours a day to meet these goals, supported by extended shifts. Initially, the eastbound and westbound lanes of I-40 over the bridge were scheduled to open on August 2 and August 6, 2021 respectively, but the team was able to expedite this opening and the eastbound lanes opened on July 31, 2021, while the westbound lanes opened on August 2, 2021. The project was complete and traffic again flowing just a short 83 days after the fracture was initially discovered.

To reduce the costly closure time, repair plans were designed around available materials. Michael Baker worked with NSBA and the fabricators to locate the HPS70 steel to replace 100ksi material for Phase 1 and Phase 2 repairs. Simplification of the bolted splice details and the use of HPS steel led to efficient fabrication and erection and a shortened closure. Similar details were repeated during Phase 3 repairs to other identified locations in the bridge. The final cost for the bridge repairs was $9,700,000.

Of the project, former TDOT Commissioner Clay Bright noted: "Back in May, we speculated that it would be the end of July, first of August to work through all the phases needed to reopen the bridge…We did not know then what all would be involved, but what I do know is we have all been fortunate to have had a great team that personally took on this project and worked tirelessly to safely reopen the bridge as soon as possible."

Awards

The project was selected by ACEC Tennessee to receive the Grand Conceptor Award in the Engineering Excellence Awards.

The Hernando de Soto Bridge reopened all lanes to traffic within 83 days of the discovery of the fracture.