# Remove, Replace, Resume

A Louisiana highway overpass takes a hit from a semi but only requires partial replacement.

**BRIDGES ARE DESIGNED** for wear and tear over their lifespans. But sometimes a whole lot of wear and tear can happen all at once.

On July 14, 2008, an over-height vehicle travelling east on the Bert Kouns Industrial Loop Expressway in Shreveport, La., struck the west box girder of the southbound I-49 overpass. The vehicle was a tractor-trailer carrying a wind tower segment on its side.

The damaged overpass structure was a three-span continuous unit with span lengths of 90 ft, 147 ft and 90 ft. The 147-ft span (middle span) crosses over the four lanes of the Bert Kouns Expressway and consists of two steel box girders topped with the concrete deck.

The Louisiana Department of Transportation and Development's (DOTD) Shreveport District immediately assessed the damage and restricted overpass traffic to one lane, directly over the undamaged box girder.

Two days after the collision, engineers from the DOTD's Bridge Design Section in Baton Rouge and the Shreveport District conducted a thorough damage inspection. The impact point was found to be near the center of the 147-ft middle span—one of the highest stress points on the structure. The damaged span contained an 86-ft spliced segment that was centered within the span, placing the splice plates near the edges of the four-lane Bert Kouns Expressway and

➤ The box girder, post-collision.

➤ Damage to the cross-frame connection plate.

the impact point nearly equidistant from each splice. This was fortunate, as it meant that damage could potentially be contained within the spliced segment, which could be removed and replaced.

The impact point exhibited permanent deformation of the web and bottom flange. The deformation involved approximately 50% of the web and 50% of the bottom flange and was basically a very large dent centered on the web-to-flange weld. A dye penetrant test was performed and found no cracking along the web-to-flange weld within the impact zone.

Internal inspection of the box girder revealed buckled cross-frame members and fractured connection plates (which also serve as web stiffeners) throughout the full length of the 86-ft spliced segment, and one cross-frame connection plate crack was found just outside of the spliced segment. Luckily, the crack was small, non-critical and could have been from normal operational stresses rather than the impact, as sometimes seen on other bridges where connection plates are welded to the flange.

Review of the site indicated that the only anticipated environmental impacts from repair construction would be interruptions to vehicle traffic. Southbound I-49 traffic would likely experience short durations of single-lane closures and complete closures. The complete closures could possibly be relieved by diverting traffic through the off and on ramps, since this was a typical "diamond" interchange. The Bert Kouns Expressway would also experience short durations of closures.

### One Lane or Two?

The biggest question at this point was whether or not the overpass could go back to carrying two lanes of traffic while repair plans were being developed.

The overpass carries a 40-ft clear roadway width. As often seen on four-lane roadways, the right shoulder was wider than the left. The right shoulder was also nearest the damaged girder, which meant the two striped traffic lanes were closer to the undamaged girder. The design team determined that by closing the right shoulder, the damaged girder would experience an acceptable amount of live load with respect

photos courtesy of LA DODT

▲ The damaged section of the bridge, after being cut and before being removed.

▼ The damaged section is removed via self-propelled modular transporters.


The new section is put in place via a pair of cranes.

to its reduced safe service level capacity. Fatigue stresses were determined not to be an issue, thanks to the relatively short duration before repairs would be made.

On August 14, exactly one month after the incident, the Bridge Design Section (performing the evaluation) notified the Shreveport District office that the overpass could be opened up to two lanes of traffic with the right shoulder closed. To assure that strength was not an issue, no permit vehicles or vehicles above the legal weight limit (41.7 tons) were allowed on the structure. Additionally, all observed cracks and cross frame deflections were measured, marked and monitored for changes during repair plan development. Any changes observed in existing damage, or appearance of new damage, would result in evaluation and possibly reducing the overpass to one lane of traffic.

The goal of repairing damage from such an incident is to return the structure to its condition just prior to the incident, and to do so without adding any additional maintenance or inspection requirements for the remaining bridge life (the structure was built in 1991, making it only 17 years old at the time of the incident, with most of its intended service life remaining). The options of patching, spot repair or fortifying the girder would prevent future collapse, but would leave the structure with special inspection requirements and possibly make it more vulnerable to a future collision. Seeking a more long-term solution, DOTD decided the best option would be to fabricate a new girder segment, deliver it to the site, remove the spliced girder segment with deck and concrete railing and reconstruct the segment.

Analysis revealed that existing dead-load shears and moments in the splices should allow the splices to be unbolted, with the splice loads released onto the remaining structure without producing excessive stresses or deflections. Consideration was given to both non-composite and composite moments at splice locations in order to determine the total amount of moment that would be transferred to the splice prior to girder removal.

The analysis also indicated that shoring would not be required for the replacement project. Under the chosen repair solution, slight stress increases would be locked into the undamaged box girder due to sequence of loading, but analysis indicated these values would be within limits. A separate contract was initiated during plan development to install strain gauges on the structure to both monitor stresses during construction, and to verify stress effects from the repair.

The repair plans provided a camber diagram for the new box girder segment and highlighted that the camber diagram shown in the original bridge plans was not to be used, since different loadings would be placed on the new girder segment. The plans required the general contractor, Gibson and Associates, to field-verify all dimensions and determine splice rotations prior to all fabrication. Splice rotations would not only be affected by the possible elected use of shoring and other removal means and methods, but also by the actual loads in the splices and stiffness of the structure, which could only be approximated by the analysis performed during plan development. At the splices, a gap larger than the existing gap was allowed to facilitate differences between the calculated and actual rotations that would likely occur. Therefore, the splice plates could be fabricated larger than existing as well, in order to obtain the required bolt edge distances. The repair plans required shop drilling of all splice plate holes, but allowed either shop or field drilling of bolt holes in the new girder segment.

## Cut it Out

The repair sequence began with removing a 4-ft-wide strip of deck concrete longitudinally along the center of the roadway in order to provide enough splice development length in the transverse (main) deck reinforcement. The removal strip turns transverse to the roadway just beyond the girder splice points to facilitate installing new girder flange splice plates, provide enough development for the longitudinal deck steel splices and to have some flexibility in the remaining box girder ends to allow splicing of the new girder segment.

The deck strip removal was initiated with a 1-in.-deep saw cut, for control purposes. Large-radius corners were used where the strip turns transverse, in order to minimize corner stresses in the deck. The concrete was then removed by hydro-demolition in order to preserve the integrity of all deck reinforcement. Once the concrete strip was removed and the reinforcing steel was cut, the damaged box girder, along with its composite portion of deck and barrier railing, was supported, un-spliced and removed.

Upon installing the new box girder segment, one lane of traffic was allowed over the undamaged girder. Previously placed temporary concrete barriers along the roadway centerline kept vehicles from entering the open hole in the deck, which measured half the bridge width and 91 ft long, with only the steel box girder beneath. Placing the deck and barrier concrete required a full roadway closure. After curing, the overpass was once again opened to full traffic. (Traffic on the Bert Kouns Expressway below was also closed during the removal and replacement of the box girder, installation of formwork and a few other brief operations.)

The new girder (approximately 23 tons, the same weight as the original) fit with very little difficulty. Self-propelled modular transporters (SPMTs) were used to remove the damaged girder, deck and barrier segment, and two cranes were used to erect the new box girder. This required the use of slings, straps, blocking, flange edge softeners and clamps to lift and hold the girder in position while the splices were connected.

Construction was completed October 2009, for a total construction time of eight months. However, the total duration of complete lane closure on the overpass was only five nights and one day, in which the Bert Kouns Expressway was closed and I-49 was diverted through the interchange. MSC

**Owner/Designer**

LA DOTD (Louisiana Department of Transportation Development)

**Steel Team**

**Fabricator**

Hirschfeld Industries - Bridge, Greensboro, N.C. (AISC Member/NSBA Member/AISC Certified Fabricator)

**Detailer**

ABS Structural Corp., Melbourne, Fla., (AISC Member)

**General Contractor**

Gibson and Associates, Inc., Balch Springs, Texas