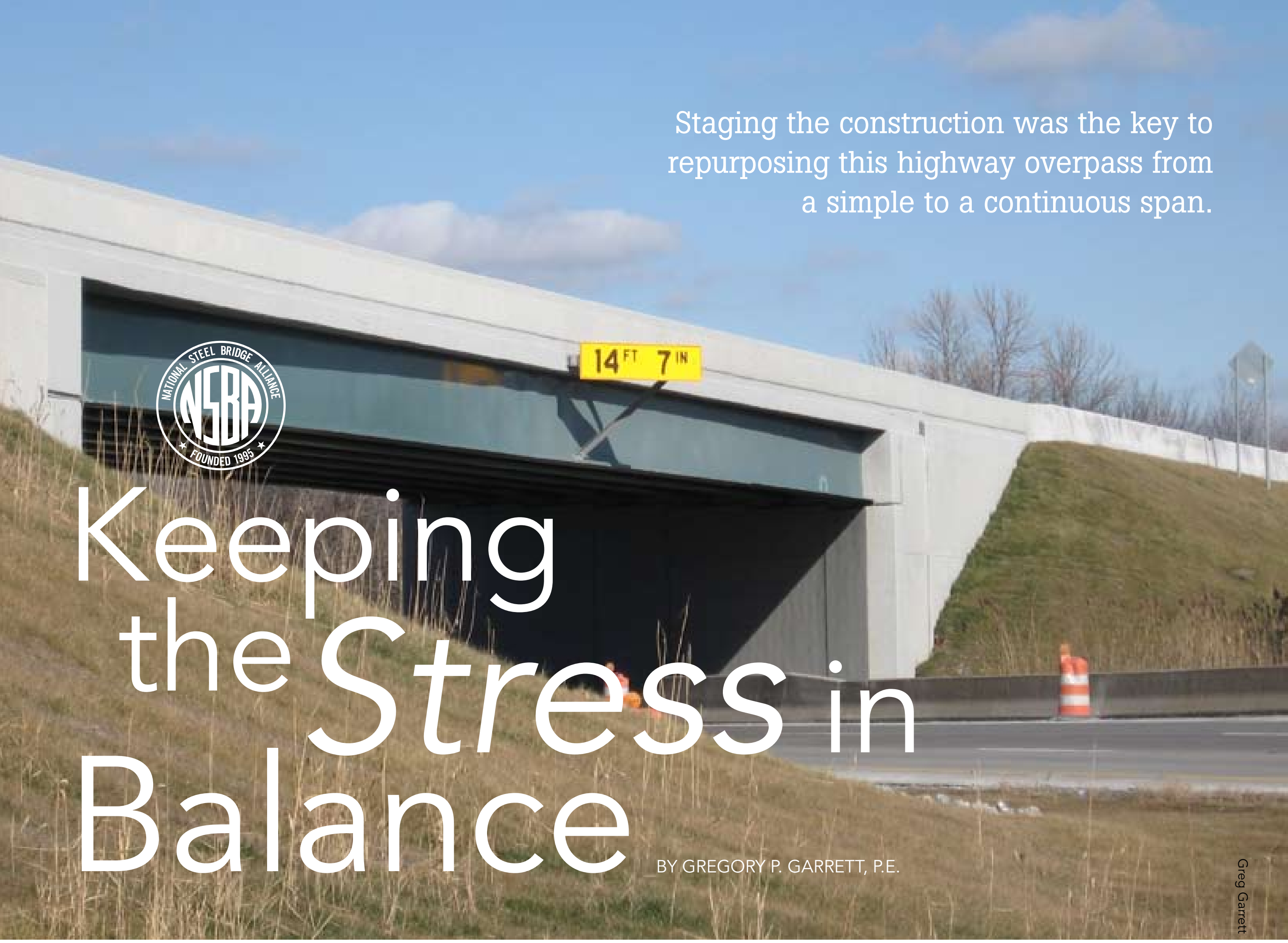

Greg Garrett

Staging the construction was the key to repurposing this highway overpass from a simple to a continuous span.

Keeping the *Stress* in Balance

BY GREGORY P. GARRETT, P.E.

WHEN ENGINEERS FROM the Grand Rapids, Mich., office of URS Corporation identified the opportunity to significantly boost traffic safety by adding an entrance ramp change to a larger highway reconstruction project, there was just one problem. The new ramp configuration would require a longer two-span bridge, about 330 ft overall, right where a 153-ft-long single-span structure had been constructed just four years earlier. A creative solution—which required some serious engineering—ultimately incorporated the existing simple span structure into a longer two-span bridge.

The $53 million reconstruction and realignment of Interstate 75 from South Huron Drive to Gibraltar Road in Monroe County, Mich., just south of Detroit, provided full median shoulders and replacement of four bridge structures and three culverts. As part of the reconstruction, URS additionally proposed adjusting the southbound I-75 alignment, which would run parallel to northbound I-75, to change the existing left-hand entrance to a safer right-hand ramp entrance. However, that adjustment would require replacing the existing single-span state Route 85 structure, which had been constructed in 2005, was in excellent condition, and was designed for HS-25 live loading, with a new two-span bridge.

The existing southbound Route 85 over northbound I-75 structure was a composite plate girder bridge with a 9-in.-thick reinforced concrete deck on seven 56-in. straight plate girders of AASHTO M270 (Grade 50 ksi) steel. The-single span structure was approximately 153 ft long with a 44-ft clear roadway width. The existing minimum vertical clearance was posted as 14 ft, 7 in., slightly more than the required minimum of 14 ft, 6 in. The structure was on a horizontal curve with a radius of 2,291 ft, 7½ in., and superelevated at a constant 5.6%, which met current standards.

The design alternatives originally considered for the structure focused solely on total replacement. Due to the young age and excellent condition of the existing structure, saving the existing span while adding a second became an additional avenue to pursue. Economically, adding a span rather than a completely replacing the structure was advantageous, but it also presented several challenges. The existing structure's vertical and horizontal geometry limited what could be done with the new span. Additionally, the existing northbound I-75 traffic passing under the existing structure had to be maintained during construction of a new pier.

The proposed southbound I-75 vertical profile under the new span was controlled by the 100-year flood water elevation and was set as low as possible. The vertical profile of the new span also was required to match the vertical and horizontal curve of the existing span. Prestressed concrete and steel plate girders were considered for the new span. Due to the curved and skewed horizontal alignment of the proposed southbound I-75 under the new span, in addition to clear zone requirements, the new span required beam lines approaching 188 ft in length. That length would require splic-

◀ Elevation view of the original structure.

▶ Pier and abutment construction with the existing span on temporary supports.

ing PCI beams, and the associated beam depth would not meet vertical clearance requirements. A second simple span plate girder superstructure would also not meet the depth limitations, which led to consideration of a second span made continuous with the existing bridge.

The existing superstructure was supported by full height abutments on HP14×73 steel piles with dependent backwalls. The addition of a second span required a median pier where the original abutment existed. The engineer decided to transform the abutment to a new pier while saving as much as possible of the abutment footing and existing piles. An investigation of the existing footing revealed that the existing abutment back row of piles would not be adequate for the new pier and would require additional piles. The approach fill was excavated, abutment wall and return walls removed, and four additional HP14×73 steel piles were added to the back row through cutout sections of the existing footing. Once the piles were placed, reinforcement was doweled into the existing footing and the removed sections were replaced with an additional 6 in. of concrete over the back half of the entire pier footing. The existing footing had relatively little longitudinal reinforcement, which is typical for an abutment footing. The longitudinal flexural capacity was increased by adding a stiffening strut incorporated as a pier crash wall.

Construction

A temporary support frame was placed to support the existing span while the abutment was converted to a pier. The supports were placed over the existing abutment front row of piles using the existing footing. This location kept the supports near the original span-bearing location, eliminating any detrimental tension effects on the existing deck from a temporary support location further into the span. This location also kept the protected supports away from traffic being maintained on northbound I-75, while effectively unloading the abutment back row of piles where new piles were added for the pier.

After removal of the existing abutment wall and the negative moment area of the existing deck, new piles were placed and the new pier was constructed above the footing. The dead load from the new pier was spread equally to the existing and new steel piles throughout the construction process. Once the pier and new abutment were constructed, the new span's superstructure was erected.

The final continuous span configuration exposed the existing girders to stresses for which they had not originally been designed. The existing girders would accept negative moment stresses imposed by superimposed dead load and live load, but additional dead load from the continuous configuration had to be limited. That meant the pier splice could not be made until after the deck concrete placement for the positive moment area of the new span.

As a result of limiting the dead load continuous span stresses on the existing girders, the proposed girders had to be designed for additional dead load positive moment in the simple-span support configuration. The new girders also had to be designed as continuous for the deck pour over the pier, superimposed dead load and live load. Deflection calculations also were more involved for the structure as a result of the transformation from simple span to continuous configuration. Typical girder-line analysis was not appropriate for this structure due to significantly skewed beams and curved deck plan. Therefore, the bridge design software DESCUS I, developed by the University of Maryland,

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▲ The first new fascia girder being erected with the existing span and new pier shown in the background.

▼ Pier splice location (prior to splicing) showing new girders to the left and existing girders to the right.

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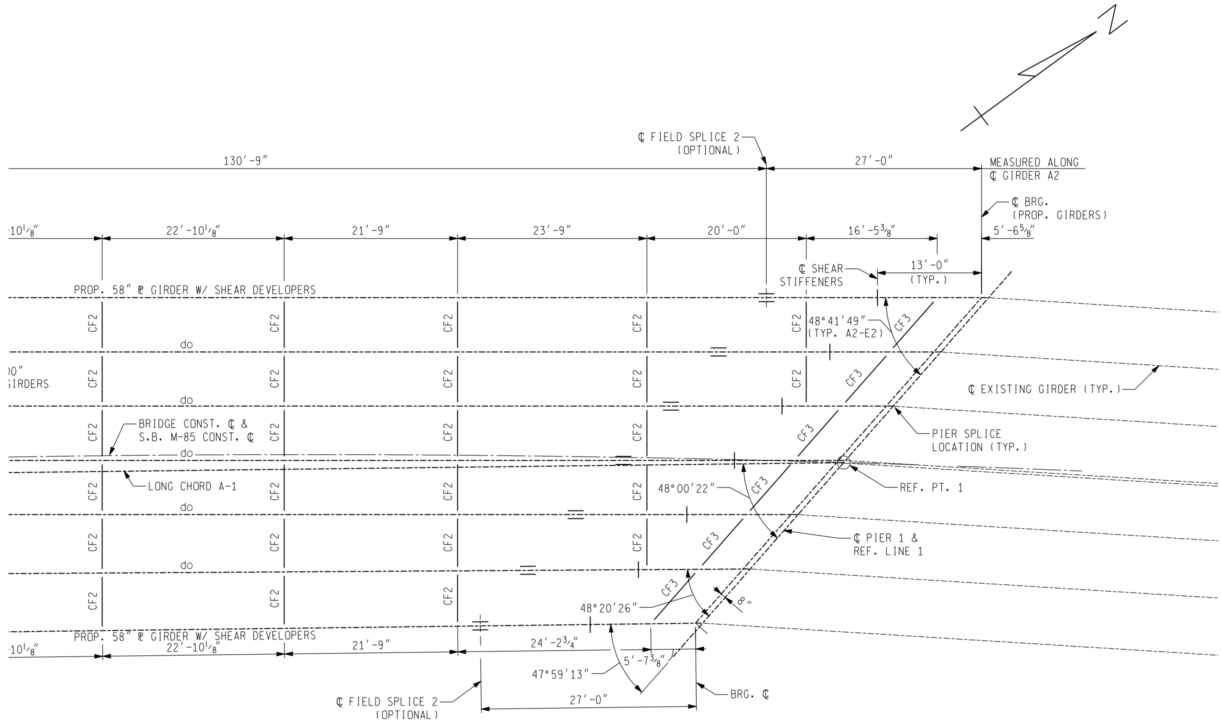

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Fig. 1: Partial view of the erection diagram showing the orientation of the new girders relative to the existing girders.

The pier splice prior to pier diaphragm and negative moment deck concrete placement.

was used for analysis in conjunction with spreadsheets to evaluate forces and deflections of both existing and proposed girders in both span configurations. DESCUS I software performs a 2D grid analysis, accounting for torsion effects in addition to typical shear and moment forces on the girders. This structure also was one of the first in the state to be designed with AASHTO LRFD design specifications, and HL-93 live load.

The new superstructure consists of seven plate girders fabricated using ASTM A709 (Grade 50 ksi) steel. The new girder required a ½-in.-thick web and a depth of 58 in., 2 in. deeper than the existing girders. Due to the longer span and loading sequence, the flanges are substantially larger than those of the existing girders. Top flanges for the new girders are either 1¾ in. or 2 in. thick and 22 in. wide. The bottom flanges are 2¼ in. thick and 24 in. wide.

Making the Splices

The final continuous configuration meant that precise erection of the new girders relative to the existing girders was critical to successful field splicing. Figure 1 shows the new span erection dia-

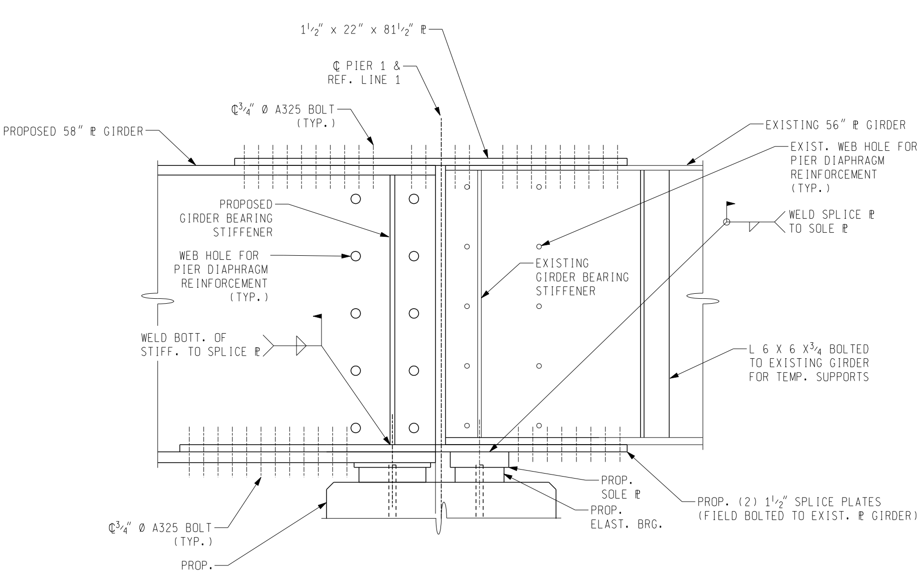

Fig. 2: Elevation view of the new-to-existing steel girder splice at the pier.

The completed structure showing the new span to the left of the new median pier.

gram with the new girders skewed to the existing. The girder skew and difference in depth between the spans required an unconventional splice. It was proposed to match the top elevation of the existing girder with the new plate girders and use a single splice plate across both top flanges. That would result in a constant haunch depth, but also would cause a misalignment in elevation of the bottom flanges. In the end the splices were accomplished using dual bottom flange splice plates above the new girder bottom flange and below the existing girder bottom flange (See Figure 2).

Due to the skewed alignment between girders, much of the field bolting included field drilling. The top and bottom splice plates were shop drilled for the proposed girders, but field drilled for the existing girder side of the splice. This fabrication procedure ensured proper alignment and edge clearance for holes in the existing girder flanges regardless of minor erection skew deviations of the new girders.

The construction sequence for the pier splice was a multi-step process.

1. The bottom flange splice plates were field bolted to both the new and existing girders.
2. The deck was placed in the positive moment area of the new span, which could deflect independent of the existing span.
3. The existing girders were lowered onto new bearings at the pier and temporary supports were removed.
4. The top flange splice plates were field bolted to the new and existing girder top flanges.
5. Concrete was placed for the pier diaphragm and negative moment deck area at the pier. Following that the final barrier pours were cast, completing the transformation from a single-span to a two-span continuous structure.

The use of structural steel for this project was invaluable given the site geometric constraints as a result of saving the existing span. Steel's design and construction flexibility led to an efficient two-span continuous structure. The Route 85 over I-75 structure was completed in July of 2009, with 301 tons of structural steel going into the new bridge superstructure and 138 tons for the abutment and pier piles. MSC

The opinions expressed in this article are those of URS and do not necessarily represent the views of MDOT. The author would like to acknowledge and express his sincere appreciation to Sam Guerrazzi (MDOT), Mike Szumigala (CA Hull), Laura Aylsworth-Bonzelet (URS), and Mike Tarazi (URS) for their contributions to this project.

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Structural Software
DESCUS I