



US 131 over Muskegon River

Harped external post-tensioning used to strengthen, rehabilitate bridge

by Corey E. Rogers, Michigan Department of Transportation

US 131 spans the Muskegon River on a northbound and southbound pair of 580-ft-long, concrete box-girder structures resting 55 ft above the river. The three-span bridges were constructed in 1982 and supported by a pair of fixed piers. Routine inspections by the Michigan Department of Transportation (MDOT) identified web shear cracking at pier locations and cracking in the bottom slab at post-tensioning (PT) anchorage locations.

Crack injection and structural monitoring were utilized until a 2013 structure study was completed. The shear reinforcement in the webs and diaphragms was found to be inadequate for the indirect support situation caused by the bearings not providing direct support to the webs of the box girders. Also, it was determined that the reinforcement around the anchorages was insufficient for the demands of the PT. A combination of harped external PT through the box girder, along with pier modifications to redistribute the shear forces, was recommended to strengthen the structure. MDOT proceeded immediately with a \$5 million rehabilitation project.

The design incorporated pier corbel construction to support grout-filled flat jacks, diaphragm modifications, deviator diaphragms, anchorage blocks, and external PT. The original steel corbel design was value-engineered to a cast-in-place concrete option utilizing high-performance, 6.5 ksi concrete



Northbound US 131 over Muskegon River bridge after project completion. Photo: Michigan Department of Transportation.

and transverse PT rods. The flat jacks were designed to accommodate a 1-in. stroke at 700 kips lock-off, and an ultimate load of 2100 kips.

The external PT comprised four full-length tendons and four additional tendons in the center span. The tendons were twelve 0.6-in.-diameter, 270 ksi, low-relaxation strands that were stressed to 560 kips. The diaphragm modifications, deviator diaphragms and anchorage blocks were designed for 6 ksi concrete and were attached to the structure with 1.25-in.-diameter PT rods.

In order to accommodate the 1.25-in.-diameter PT rods for the box girder modifications and tendon anchorages, approximately 400 holes were cored in the structures. To avoid damaging existing structural tendons and critical reinforcement during the coring process, ground penetrating radar, destructive testing (hand chipping and masonry drilling), and review of as-built plans were performed. Minor conflicts with existing tendons did occur initially, prompting process improvements such as early identification of reinforcement locations. Subsequent coring operations were successful. Much of the coring success is attributed to communication between MDOT inspectors, contractors, and designers.

Coordination with the city of Big Rapids, Mich., Ferris State University (Ferris), local businesses, and Michigan's notorious "up north" traffic was essential. US 131 is a major route to popular weekend destinations. Lane closures were permitted; however complete detours of 2- to 3-day durations were only allowed during Ferris's summer break. Diaphragm modifications, flat-jack inflation, and PT grouting were completed under structure closures to avoid locking in live-load stresses and effects from vibrations during grouting.

The project was completed in September 2015, ahead of schedule and under budget. The success of this project extends the service life of the structures and eliminates the need for complete structure replacements. **A**

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