February 2016 NJ-2016-002

New Jersey Department of Transportation
Bureau of Research
Technical Brief

Design and Fabrication of Orthotropic Deck Details

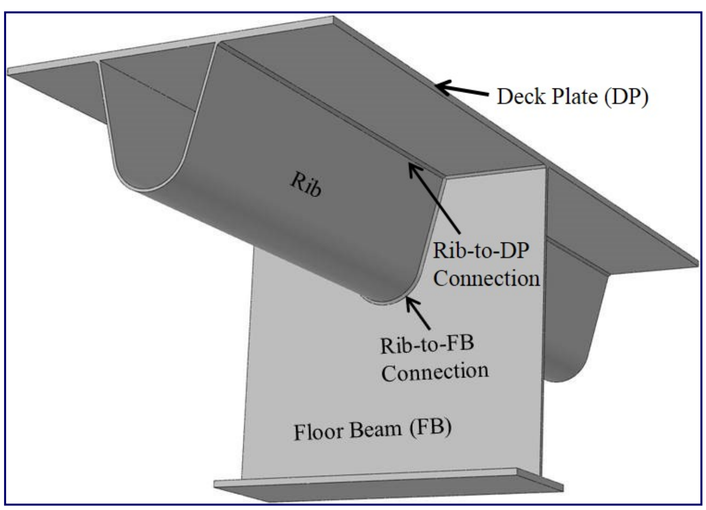
This research project investigated cost-effective design and fabrication of welded connection details for the proposed steel orthotropic deck for the Replacement Wittpenn Bridge, and verified the infinite life fatigue performance of the details by testing a full-scale prototype of the part bridge deck under simulated maximum AASHTO axle loading for fatigue design of orthotropic deck.

Background

A steel orthotropic deck integrated with steel box girders is proposed by designer for the replacement of the lift bridge. Contrary to the more conventional design, the design incorporated a thicker deck plate stiffened by round bottom ribs passing continuously through matching cutouts in the floor beams. To be cost-effective, the floor beams are fillet welded around the ribs without any additional cutout in the floor beam under the rib soffit. Although similar rib-to-floor beam connections have been implemented in service, their performance data is limited. The desired performance of the connection requires careful fit-up, which can incur additional fabrication efforts. In addition, the site-specific high Average Daily Truck Traffic is a concern for the fatigue performance of the orthotropic deck.

Research Objectives and Approach

The objectives of this research was to verify the design and simulate fabrication of the orthotropic deck details for infinite fatigue life, i.e., no in-service fatigue cracking during the design life of the bridge. Multi-level 3D linear elastic finite element analyses (FEA) of the proposed bridge deck were performed to determine the critical stresses at the connections, the corresponding load disposition, and the deck specimen. The design of rib-to-deck plate connection employed 80% partial joint penetration (PJP) weld with minimum 70% penetration, no joint preparation on the rib wall and a maximum fit-up gap of 0.020 in. (0.5 mm). The rib-to-floor beam connection required $^{5}/_{16}$ in. (8 mm) fillet weld with fit-up tolerance not exceeding $^{1}/_{16}$ in. (1.5 mm). To develop cost-effective connection details, three variations of rib-to-floor beam and rib-to-deck plate connection details, including the influence of different fabrication parameters, were



explored in full-scale small size mockups consisting of a single rib and one floor beam. Subsequently infinite life fatigue performance of the connection details were evaluated by laboratory testing of a full-scale prototype of the part bridge comprising 5 ribs and 3 floor beams in a unique setup that adequately replicated the boundary conditions. The prototype deck was fabricated in two panels, which were spliced (transverse to the ribs) in the laboratory by a complete joint penetration (CJP) weld at the deck plate and bolted splices at the ribs and the girder, simulating the field splice in the actual bridge construction. The fatigue testing was performed using a pair of above-deck hydraulic actuators simulating the rear tandem axles of the AASHTO fatigue truck. In addition, an under-deck actuator provided at the inner floor beam was cycled synchronously under displacement control to simulate the global displacement boundary condition. The deck was extensively instrumented with strain gauges and displacement transducers to evaluate the response of various connection details, with majority of the instrumentation concentrated at the critical connection between the inner floor beam and the rib adjacent to the girder.

Findings

The 3D FEA identified the rib-to-floor beam connection adjacent to a box girder as the most critically stressed region of the deck, when the rear tandem axle of the AASHTO fatigue design truck was symmetric with the floor beam and the rib was located in the shear span of the floor beam. The fatigue testing of the prototype deck was run out at 8 million cycles, without any detectable fatigue cracking in the deck. The measured stress ranges at all critical connections were less than the constant amplitude fatigue threshold (CAFT) of their respective detail categories. The test results indicated infinite life performance of the deck design, as long as the site specific overloads do not exceed the AASHTO Fatigue I limit state load more than 1 in 10000 occurrences. The research compared three different details with different fabrication parameters and verified cost-effective details for fitted rib-to-floor beam connections, and rib-to-deck plate connections for orthotropic bridge decks. In addition, the study provided critical information on issues related to fabrication and installation of the orthotropic deck design based on one fabricator's experience. The research also highlighted the need for developing rational tolerances for economic domestic fabrication of orthotropic decks.

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A final report is available online at: http://www.state.nj.us/transportation/refdata/research/
If you would like a copy of the full report, send an e-mail to: Research.Bureau@dot.nj.gov.

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NJDOT Research Report No: NJ-2016-002