# Verification of Infinite Life Fatigue Performance of a Cost-Effective Steel Orthotropic Deck Design by Full Scale Laboratory Testing

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## Abstract

Recently the infinite life fatigue performance of a steel orthotropic deck employing fillet-welded fitted floor beams was evaluated at the ATLSS Engineering Research Centre of Lehigh University by testing a full-scale prototype of a part bridge deck under simulated AASHTO fatigue loading. The test setup was developed based on multi-level 3D finite element analyses (FEA) to reproduce the boundary conditions and the critical stresses in the part deck specimen consistent with the full bridge deck. The fatigue test was run-out after 8 million cycles without any detectable fatigue cracking demonstrating infinite life under site-specific loading. The study provided the foundation for a standardized cost-effective orthotropic deck design that can provide 100 years' service life.

**Keywords:** infinite life, orthotropic deck, cost-effective, full-scale prototype, round bottom ribs, fitted floor beams, 100 years' service life.

## 1 Introduction

An orthotropic deck integrated with steel box girders was proposed for a lift bridge that included fitted fillet welded rib-to-floor beam connections without any additional cut-out under the rib soffit, which was perceived to be a cost-effective design. Although, no adverse performance of this detail used in earlier bridge decks has been reported, limited published information on fabrication [1] and laboratory testing [2, 3] raises questions about its success. In modern orthotropic decks, additional cut-out under the rib soffit are more commonly used at rib-to-floor beam connections for better fit-up and fatigue performance; however, these connections require expensive fabrication. For suppressing fatigue crack growth from the weld root, the proposed detail requires fit-up to tight tolerances between the floor beam and the rib, which can significantly increase the fabrication effort. In addition, being located on a portway corridor the bridge was expected to experience high average daily truck traffic (ADTT). Accordingly, the infinite life fatigue performance of the proposed orthotropic deck design was evaluated by testing a full scale prototype of a part bridge deck.

## 2 Prototype Deck Specimen

Multi-level 3D FEA was performed to design the prototype part deck specimen and a fatigue test setup that reproduced the boundary conditions and the critical stresses consistent with the full bride deck. A 3D FEA of the entire bridge deck using shell model (global model) identified the rib-to-floor connection adjacent to one of the box girders as the most critically stressed region, when the AASHTO tandem axle was symmetric about the floor beam in the longitudinal direction, and the wheels nearest to the box girder placed centrally between the adjacent pair of the ribs. The deformation of the deck was localized and contained within three floor beams in the longitudinal direction, and a few ribs locally



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