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Experimental investigation on behavior of FRP-concrete-steel composite bridge decks with perfobond ribs

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Abstract

The ultimate behavior of a steel- GFRP- concrete composite bridge deck with perfobond rib shear connectors was experimentally and numerically investigated. The composite construction consists of multiple steel box cells as a core, GFRP layer as a tension zone and a concrete slab for the compression zone. To provide longitudinal shear resistance between the steel core and the concrete slab, perfobond ribs were used. Structural performance of the deck under static loading was evaluated. The load-displacement relationship, ultimate flexural resistance, and failure of the specimen were measured during the test. It was found that the ultimate failure of the composite deck occurs by longitudinal cracking at the concrete slab and no debonding take place at the interface between concrete slab and steel boxes, so perfobond ribs can be effectively used for shear connection in proposed composite decks. The bridge deck is cost effective and meets the stiffness requirement and has significant strength.

Keywords: Composite bridge decks, concrete, Steel, FRP, Perfobond rib, Experiment.

1. INTRODUCTION

The bridge deck performs a vital role in a bridge system and its durability affects the whole structural health of the bridge system. Several of structural defects in bridges are due to the bridge deck geometry and deck condition. Thus, it is essential to design a bridge deck systems that have long-term durability and require less maintenance [1]. In the early 1980's, Exodermic bridge deck that consist of steel profiles and concrete was developed by Neal Bettigole [2], a consulting bridge engineer in New Jersey. The ultimate behavior of a steel-concrete composite deck with profiled steel plate and perfobond rib shear connectors was experimentally investigated by Kim and Jeong [3]. Typically, the weight and thickness of the steel-concrete deck is less than conventional reinforced concrete decks, so they can be implemented in a longer span, but their resistance against corrosion is low and they have high maintenance costs. Fiber reinforced polymers (FRP) composites have introduced a promising solution to solve prevalent problems in steel-concrete decks. The FRP composites have superior material properties such as high stiffness, high strength, corrosion resistance, light weight, and durability. In recent years, the interest in using FRP in construction field has significantly increased worldwide [4].

Gan et al. [5] evaluated several cellular deck panels with different cross-sectional profiles based on finite element analysis. The specimens consist of hexagonal, triangle and rectangular. Their numerical assessment covers the global and local stiffness, the maximum stresses, and buckling strength. The panels with 3-cell rectangular section can provide better properties in local stiffness and buckling strength than the hexagonal and triangle section panels.

Reising et al. [6] tested four different fiber-reinforced polymer decks. They examines whether four composite deck are able to realize many of the expected benefits of using FRP composites instead of conventional reinforced concrete bridge decks. Installation matter, connection details, and specific construction techniques for each deck are explained. They showed that FRP deck systems could significantly reduce the installation time, and avoid lane closures in comparison to standard reinforced concrete decks.

Zi et al. [7] experimentally investigated the behavior of an orthotropic bridge deck made of GFRP and polyurethane foam. The bridge deck composed of GFRP cells with rectangular holes filled with foam to improve the structural behavior in the transverse direction. Result shows when the GFRP bridge deck was