GLASS FIBER-REINFORCED POLYMER/STEEL HYBRID HONEYCOMB SANDWICH CONCEPT FOR BRIDGE DECK APPLICATIONS

Glass fiber-reinforced polymer (GFRP) materials possess inherently high strength-to-weight ratios, but their elastic moduli are low relative to civil engineering (CE) construction materials. As a result, serviceability issues are what govern GFRP material design in the CE bridge industry. Therefore, the study objective was to increase the stiffness of a commercial GFRP honeycomb sandwich panel through the inclusion of steel within the cross section.

GFRP-steel hybrid parametric studies were conducted to improve the GFRP honeycomb deck panel stiffness. The parametric studies included the embedment of steel plates within the face sheets, and the placement of steel tubes within the core. Core stiffness analyses were performed, which led to the development of the steel hexagonal honeycomb core concept. An experimental study, including small-scale component tests and large-scale beam tests was conducted. The small-scale objective was to characterize the core equivalent elastic moduli in an effort to simplify the modeling of the honeycomb core. The large-scale tests were conducted to assess the flexural stiffness, comparing the hybrid steel core concept and the current GFRP core design. Analysis methods and modeling techniques, including finite element (FE) models of a detailed steel honeycomb core and an equivalent solid core, were investigated. Strip method hand calculations were compared with the FE model results for accuracy. Finally, two bridge deck stiffness design examples were presented.

The steel core equivalent moduli experimental results were compared with theoretical hexagonal honeycomb elastic modulus equations from the literature, demonstrating the applicability of the theoretical equations to the steel honeycomb core. Core modulus design equations were then proposed to model and characterize the steel hexagonal honeycomb. From the large-scale test results, it was concluded that an overall core stiffness increase was observed. The solid equivalent core modeling technique was proven to work well both when applied to three-dimensional (3D) FE analysis and two-dimensional (2D) strip method hand calculations.