ABSTRACT

Machado, Marcelo Augusto da Silva. Ph.D., Purdue University, August, 2006.
Alternative Serviceability Criterion for Honeycomb FRP Deck-to-Steel Girder Bridges.
Major Professors: Elisa D. Sotelino and Judy Liu.

The objective of this work is to develop an alternative serviceability criterion for honeycomb FRP deck-on-steel girder bridges. The existing AASHTO static deflection criteria are not applicable to honeycomb FRP decks due to their inherent characteristics, such as low mass and stiffness, and the discrete deck-to-girder connections which do not provide full composite action. The proposed alternative serviceability criterion is based on the bridge vertical acceleration response to traffic and human tolerance to vibrations.

The first step in the development of this serviceability criterion is the creation of a simplified three-dimensional finite element modeling technique for the complex geometry of the honeycomb FRP deck. The modeling technique includes the use of the eccentric beam model from the commercial finite element (FE) program ANSYS for the steel girders, the steel guardrails, and the pier supports. The simplified honeycomb deck geometry preserves the same mass and stiffness of the original complex cross-section. This is essential to obtaining an accurate vibration response.

The second step in the development of this serviceability criterion is a parametric study, used to examine the acceleration response of a matrix of FRP deck-on-steel girder bridge configurations to moving traffic loads. The developed FE modeling technique is used in the parametric study. The obtained acceleration responses are properly filtered to

capture the first bending and first torsional modal frequencies of the bridges. The resulting filtered peak accelerations are directly compared to limits of human tolerance.

The last step in the development of this serviceability criterion includes recommendations for future design of honeycomb FRP deck-on-steel girder bridges. The recommendations are based on results of the parametric study and include values such as deck thickness, girder spacing, and bridge first bending and first torsional modal frequencies. Empirical formulations for predicting the first bending and the first torsional modal frequencies of FRP deck-on-steel-girder bridges are also proposed. The results of the parametric study show that the proposed recommendations would lead to more economical designs than those following the current AASHTO static deflection serviceability criteria. This makes honeycomb FRP decks more competitive with respect to traditional materials.