ABSTRACT

Sim, Chungwook. Ph.D., Purdue University, May 2014. Structural and Corrosion Performance of Concrete Bridge Decks Reinforced with Corrosion-Resistant Reinforcing Steel. Major Professor: Robert J. Frosch.

Deterioration of bridge decks is a primary factor limiting the lifespan of bridges especially in cold climates where deicing salts are commonly used. While controlling deck cracking or decreasing the permeability and porosity of concrete can improve performance and service life, chloride and moisture ingress as well as cracking cannot be eliminated. Full-depth cracks which are caused by restrained shrinkage allow for corrosive conditions at early ages for both the top and bottom reinforcement mats. Therefore, the use of corrosion-resistant reinforcement is essential to mitigate deterioration of bridge decks. The objective of this research program is to evaluate both the structural and corrosion performance of concrete bridge decks reinforced with corrosion-resistant reinforcement. To achieve this objective, a three phase experimental investigation was conducted considering a wide range of corrosion-resistant reinforcing materials. These materials included stainless steel (316LN, Duplex 2205, Duplex 2304, and XM-28), MMFX II microcomposite steel, and coated steel (epoxy, hot-dip galvanized, zinc-clad, and dual-coated zinc and epoxy (Zbar)). Forty-five beam specimens with tension lap splices were tested in the first phase to evaluate the bond between corrosion-resistant reinforcement and concrete. The test data was combined with other data available in literature to construct a simple model for development and splice length considering the range of corrosion resistant bar types as well as unconfined and confined conditions. Twelve slab specimens were tested in the second phase to evaluate the cracking behavior of slabs reinforced with corrosion-resistant reinforcement.

Finally, one hundred and twelve modified macrocells were constructed in the third phase to evaluate corrosion resistance under uncracked and cracked conditions. Transverse steel was also tied to the longitudinal steel to simulate actual bridge deck conditions. Based on the results of this study, a simple model is recommended for the calculation of development and splice lengths for both conventional black and corrosion-resistant reinforcing steel with and without confinement. Test results indicate that stainless steel, MMFX II, galvanized, and dual-coated bar have bond strengths comparable with black bars. Modification factors were developed for development and splice length calculations when other bar type are used. Recommendations are also provided for the control of crack widths. Considering corrosion resistance, identical reinforcing materials should be used in the top and bottom reinforcing mats while inert ties or ties made of the same material as the reinforcing bars should be used to avoid galvanic coupling. Finally, to assist in the selection of corrosion-resistant reinforcement, a ranking of the corrosion performance of various corrosion-resistant bars is provided based on test results and a visual examination after 503 days of exposure.