ABSTRACT

Several truck fires have occurred in recent years involving bridges with reinforced and prestressed concrete components. If the fire burns for a significant period of time (15 minutes or more), bridge inspectors and engineers must determine if the exposure to elevated temperature has reduced the strength and serviceability of the concrete components. Little guidance is available, however, correlating the results of field inspections with the actual condition of the reinforced/prestressed concrete elements. This dissertation presents the results of a research program conducted to develop rational guidance for inspectors and engineers to evaluate concrete bridge elements after a fire event and help them make informed decisions regarding the future status of the bridge.

The research program includes tests on portions of a reinforced concrete deck and three full-scaled AASHTO Type I prestressed girders acquired from a decommissioned highway bridge. In addition, six pretensioned concrete prismatic beam specimens with varying levels of prestress were fabricated and tested. The specimens had cross-sectional dimensions of 8 in. by 8 in. and were designed to simulate the bottom flanges of common I-shaped prestressed concrete bridge girders. The deck specimens and four (of the six) concrete beam specimens were subjected to elevated temperatures using radiation-based heaters. Two (of the six) prismatic specimens built in the laboratory were subjected to a hydrocarbon pool fire test conducted in the field for using approximately 135 gallons of kerosene. The concrete temperature profiles and the deformations of the specimens were measured using thermocouple trees and displacement transducers, respectively. Concrete samples were also cored and examined using various methods (DSC and SEM) to correlate microstructure degradation (microcracking, dehydration of C-S-H, decomposition of calcium hydroxide, etc.) with the measured temperatures through the depth of the specimens.

To evaluate the residual loading-carrying capacities of prestressed concrete girders after being subjected to fire, a hydrocarbon pool fire test was performed on two decommissioned AASHTO Type I girders in the field. Load tests were then conducted on the prestressed girders under both ambient and post-fire conditions. After structural testing, material tests were also conducted on

concrete cores taken from the girders to evaluate the post-fire concrete microstructure alteration. Furthermore, three-dimensional finite element models were developed to predict the residual load-carrying capacities and overall structural responses of prestressed concrete bridge girders after being exposed to fire. Results from the numerical models generally agree favorably with experimental observations and provide insights into the behavior of the specimens.

Based on the results from this research, guidelines for the post-fire assessment of prestressed concrete bridges are included in this dissertation along with a step-by-step checklist. Bridge inspectors can infer the extent of damage to prestressed concrete bridge girders in the event of a fire and develop a post-fire assessment plan cognizant of the findings. In most cases, no more than 1.0 in. of the concrete from the exposed surface undergoes material damage / deterioration due to loss of CH, cracking, and spalling. The impact on the strength of prestressed concrete girders is relatively minor based on experimental results. Their initial stiffness, however, will likely be reduced.