Doctoral Dissertation Defense Announcement

EVALUATION OF PRESTRESS LOSSES, TRANSFER LENGTH AND HARPING CHARACTERISTICS OF CFRP TENDONS

Hamidreza Tahsiri

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ABSTRACT

Different types of fiber reinforced plastic (FRP) materials have been developed to replace steel in areas where corrosion is a problem. Among these materials, carbon fiber reinforced plastics (CFRP) stand out as a primary prestressing reinforcement to replace steel and provide corrosion free prestressed bridge girders. This dissertation presents the results of an experimental and analytical study regarding the evaluation of prestress losses, transfer length and harping characteristics of prestressing CFRP systems for prestressed bridge beams.

Several prestressing CFRP cable and bar specimens with different lengths and different initial prestressing levels were monitored under constant strain condition at room temperature for over one year to determine their relaxation behavior. Based on the experimental results and by considering the effect of anchorage system on the total prestress loss of the relaxation specimens, prestress relaxation equations for both pre-tensioning and post-tensioning applications were developed. Additionally, scanning electron microscopy (SEM) observations were conducted on relaxation test specimens to examine the microstructure of the CFRP specimens after exposure to the long-term loading.

Furthermore, a total of 54 CFRP pre-tensioned prisms with different jacking stress levels were cast and instrumented to evaluate the associated long-term prestress losses. After one year from prestress transfer, the specimens were subjected to thermal fluctuation cycles ranging between 0 ºF to 140 ºF. The effects of thermal cyclic loading on transfer length and prestressing force were investigated. Experimental results suggest degradation of the bond between prestressing CFRP tendon and concrete after subjection to the thermal fluctuation cycles due to the thermal mismatch between CFRP and concrete. Additionally, a Finite Element (FE) model was developed to study the temperature effect on the interface between the prestressing CFRP and concrete in CFRP prestressed prisms. Different jacking stress levels and concrete clear cover thicknesses were examined in numerical simulations.

Finally, prestressing CFRP specimens were tested in various harping angles with the use of different harping devices to evaluate the tensile capacity retention of the harped CFRP tendons. New harping devices with large diameters and contact surfaces were developed and fabricated by the author to maximize the harping tensile capacity retention in CFRP systems. Also, an FE model was developed to investigate the harping induced stresses in a prestressing CFRP bar in different harping configurations. The FE model was calibrated based on the test results. Then, a parametric study was conducted to evaluate the harping characteristics of the CFRP bars in a broader range of harping angles.