Development of Reliability Based Design Procedures for FRP Composite Strengthening of Bridge Structures

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ABSTRACT

Fiber reinforced polymer composites are gaining acceptance as a strengthening mechanism for existing concrete structures. In order to effectively use these materials for restoring degraded infrastructure a design procedure considering the inherent variability of composites as well as the variations introduced during wet layup manufacture and environmental degradation is necessary. This paper outlines a research project intended to develop a reliability-based design procedure for FRP strengthening. The main challenges to be overcome are identified as the wide range of available composite materials, difficulty in predicting field properties of composites, uncertain degradation characteristics and the overall lack of data due to the novel nature of composites for civil engineering.

The design procedure under development is based on isolation of the material design value from the material variability. This eliminates difficulties identified with older design approaches and makes the design code applicable to many different composite systems. The characteristic value is defined as the predicted mean value of the composite property. Application Factors are defined to relate the characteristic value to the mean value witnessed in field manufacture. A factor for environmental degradation that depends on the length and type of environmental exposure is determined as the percent retention of composite properties. Both the application and environmental factors can be updated due to new research without having to recalibrate the reliability-based factors.

The target reliability will be set at a value between 2.5 and 3.5 depending on the judgment of design engineers on the calibrated factors. Calibration will be conducted with a hybrid reliability procedure combining Monte Carlo Simulation and First Order Reliability Methods. Current work is focused on T-beam RC bridge girders and slabs; a survey of approximately 100 California bridges is underway to determine member sizes for calibration. Remaining work includes modeling continued degradation of the bridge based on loss of reinforcement due to corrosion, consideration of limit states, and calibration of the final design factors.

KEY WORDS

FRP, rehabilitation, reliability, LRFD