COHESIVE ZONE MODEL OF FRP-CONCRETE INTERFACE UNDER THERMAL AND MECHANICAL STRESSES

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Abstract
Adhesively bonded structures, usually composed of different materials, have been widely used in aerospace and civil engineering. Successful application of these structures relies primarily on the interface between the different materials. Extensive research has been conducted in this area, mainly focused on mechanical stresses caused by mode I, mode II or mix-mode loading, and less attention has been devoted to the interface under thermal stresses. This issue becomes significant if the differences between the coefficients of thermal expansions for different materials are large. For example, for FRP-concrete structure as shown in Fig. 1, FRP has a typical thermal coefficient of expansion in the range of 1.6 to 2.7×10⁻⁴/°C, which is different from 1.2×10⁻⁵/°C for concrete. This difference may induce significant thermal stresses at the interface leading to possible premature debonding failures. Therefore, it is the objective of this paper to study the FRP-concrete interface under combined thermal and mechanical stresses, based on a combination of analytical model, Finite Element (FE) analysis, and experimental investigation.

The Cohesive Zone Model (CZM) pioneered by Dugdale [1] and Barenblatt [2] has been successfully applied to study FRP-concrete interface under mechanical stresses by Wang [3-5], based on various types of traction-separation laws. This paper will first extend the existing CZM to incorporate thermal stresses, based on the FRP-concrete structure under mode II loading, as shown in Fig. 1, and bi-beam model as shown in Fig. 2.

Fig 1 Single shear FRP-concrete beam
To assess the accuracy of the proposed CZM, FE analysis will be carried out using ABAQUS. Discretized mesh will be built to model the interface; and duplicated nodes will be created at the interface between FRP-concrete. Four-node cohesive elements with zero thickness in the direction normal to the interface, which are provided by ABAQUS, will be used to model the interface.

Mode II fracture single shear test will further be conducted to correlate with analytical and FE results. Concrete prisms with nominal dimensions of $13 \times 5 \times 4$ in$^3$ will be casted against a FRP plate of $6.3 \times 1.8$ in$^2$ as shown in Fig. 1. A predefined notch will be introduced at one end of the concrete prism by placing a wax paper over that area before pouring concrete. The FRP will be extended beyond the concrete prism to apply the load. Five temperatures will be considered to study the thermal expansion between FRP and concrete covering the typical range for a building, namely, $T_1 = 0°C$, $T_2 = 15°C$, $T_3 = 30°C$, $T_4 = 45°C$, and $T_5 = 60°C$, by using an environmental chamber attached to the loading machine. Strain gages will be bonded on FRP plate and embedded into concrete to measure the strain differences between FRP and concrete due to temperature change, and subsequent mode II loading.

REFERENCES