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FIBER REINFORCED POLYMER TUBE ENCASED CONCRETE CONFINEMENT MODEL

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ABSTRACT

Fiber Reinforced Polymers (FRP) are made of reinforcing fibers (glass, carbon, aramid) and resins (epoxy, polyester, phenolics). Due to its high strength, low weight, corrosion-resistance, and high durability, FRP provides more advantages than the conventionally used materials in structural applications. FRP is now being used for repair, rehabilitation and strengthening of engineering structures, including reinforced concrete columns. In engineering structures, for instance high-rise buildings, offshore platforms, waterfront fenders, bridges, ports, etc., concrete columns are the fundamental structural elements. Concrete jacketing, steel jacketing, and FRP–wrapping are the common methods for repair and retrofitting of these columns. In FRP jacketed concrete columns, the FRP shell confines the lateral expansion of the concrete core and thus transforms the concrete core to a 3-D compressive stress condition. As a result, the compressive strength and ductility of the confined concrete column are increased significantly; see Fig. 1. The ideal combination of FRP and concrete, i.e., the high tensile strength and durability of FRP and the high compressive strength of concrete may form a column that is strong, ductile, and reliable.

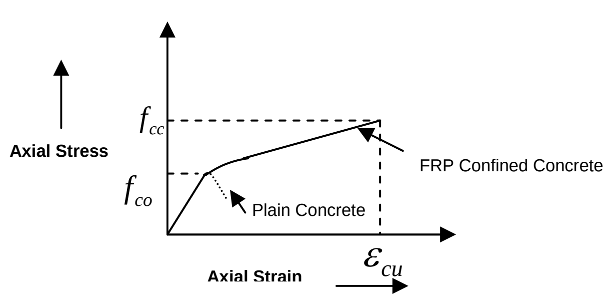

Fig.1. Axial Stress-Strain Response of FRP Confined Concrete versus Plain Concrete [3].

Recently, FRP tube-encased concrete columns have been developed for new construction and rebuilding of concrete piers/piles in engineering structures. In this structure, the steel rebar is replaced by a lamented FRP tube. The FRP tube serves as a stay-in-place formwork during construction and a confinement device during service. It has been demonstrated that this type of structure has many advantages over traditional concrete construction. It has a foreseeable potential to be used in various engineering structures.

To design an FRP tube-encased concrete column, the key is to develop a confinement model – a model predicting its strength and ductility. Currently, design-oriented models have been developed for FRP repaired concrete columns. The general design-oriented model has the form:

$$\frac{f_{cc}}{f_{co}} = 1 + k_1\left(\frac{f_l}{f_{co}}\right)^m \qquad (1)$$

where f_{co} is the unconfined concrete strength, f_{cc} is the confined concrete strength, f_l is the lateral pressure provided by the FRP jacket, k and m are constants determined from experimental results through curving fitting. Although this model is very successful for FRP repaired concrete columns, there is a need to develop a design-oriented confinement model for FRP tube-encased concrete columns. The reasons may be summarized as:

(1) In FRP repaired concrete columns, the FRP jacket is subjected to 1-D stress condition, tension in hoop direction; for the FRP tube, it is subjected to both hoop tension and axial compression stress condition. As shown in Fig. 2, the lateral pressure by the FRP jacket is determined by a 1-D equilibrium equation:

$$f_l = \frac{2tf_{FRP}}{D} \quad (2)$$

in which t is the wall thickness of the FRP jacket and D is the diameter of the concrete core. f_{FRP}, is the hoop tensile strength of the FRP.

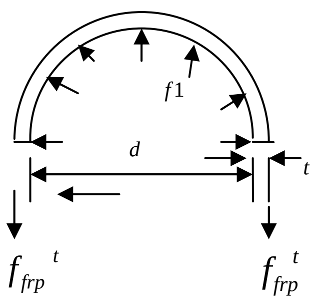

Fig.2. Confining action of FRP [6].

(2) The model is developed for fibers mainly oriented toward hoop direction; for FRP tubes, fibers are mainly oriented in a direction other than hoop.

(3) The model cannot explicitly consider the stiffness and ply stacking sequence of the FRP shell.

(4) The model was developed based on a limited database. A larger database is desired.

In developing the FRP-confined concrete models, the models should also consider the hoop modulus of the FRP, the continuous effect provided by the FRP on the expansion of concrete when subjected to different loadings and the interfacial bonding between the FRP and the concrete. The main objective of this study is to develop an analytical and a finite element model for FRP tube encased concrete column including all the parameters which affect the strength of the confined concrete. It is also planned to develop a large test database for wider applicability of the model. There is not sufficient work done on studying the interfacial bonding between the FRP and the concrete which holds a key role in determining the failure of the column. Therefore, the study of failure mechanisms of the FRP confined concrete is also a part of this research.

ANSYS, FEM software is used to develop the model and to perform the required analysis. The modeling results will be compared and validated using the experimental data.

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