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A new concrete-filled hollow FRP composite column

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An effective use of fiber reinforced plastic (FRP) shapes in infrastructure is in the form of composite construction with reinforced concrete. A novel composite column is proposed that is similar to the classic concrete-filled steel tubes, except that steel has been replaced with a hollow FRP shell. The FRP shell, while an integral part of the structure, is also the pour form for concrete. The shell may be a filament-wound or a multi-layer FRP pipe with a layer of longitudinal fibers sandwiched between two piles of circumferential fibers. The proposed column offers high strength and ductility in addition to excellent durability. Behavior of the proposed column is studied by developing two analytical tools; a new passive confinement model for externally reinforced concrete columns, and a composite action model that evaluates the lateral stiffening effect of the jacket. Results are compared with recent studies of fiber-wrapped columns.

(Keywords: columns; composite; concrete; ductility; fibers; reinforcement)

INTRODUCTION

Deterioration of the nation's infrastructure has been well documented and publicized[1]. FRP composites have emerged as a potential solution to the problems associated with the infrastructure. An economic application of FRP materials is in the form of composite construction with concrete, such that FRP could act as load-carrying partner and protective measure for the structural members. One such application has been demonstrated in fiber jacketing technique, which is now considered an effective retrofitting tool for existing columns. Using the principles of fiber-wrapping and steel-jacketing practice[2,3], classic steel-concrete composite columns[4], FRP pressure vessels[5], and steel-encased plastic piles[6], a novel type of composite column is proposed that consists of a reinforced concrete core confined in a FRP tubular jacket (*Figure 1*). The main advantage of FRP-concrete composite construction is the optimal use of materials based on their mechanical properties and resistance to corrosive environments. Moreover, it results in composite members with pseudo-ductile characteristics and high stiffness and strength properties.

The composite shell may be a multi-layer FRP tube that consists of at least two plies; an inner ply of longitudinal fibers and an outer ply of circumferential fibers. The longitudinal fibers are inhibited from outward buckling by the outer circumferentially oriented fiber ply, and from inward buckling by the concrete core. Similar tubes have been made with a center ply of longitudinal fibers sandwiched between two plies of circumferential fibers. The FRP shell plays several important roles in the composite column as follows:

1. It is the pour form for concrete, thereby reducing the cost and time for formwork and removal of the forms[7];
2. It acts as protective jacket and sealer for concrete and the embedded reinforcing steel in corrosive environments. Glass fiber jackets have been used as insulators in severe conditions. In a hot oil pipeline project that ran over the water on the Gulf of Mexico, a glass fiber jacket was chosen over aluminium and stainless steel alternatives. After eleven years, reports indicate that the jacket has withstood a harsh, salty environment with over 140° F internal temperature, direct sunlight, moisture, vapor, and seawater[8];