Development of Advanced Grid Stiffened FRP Tube-Encased Concrete Columns

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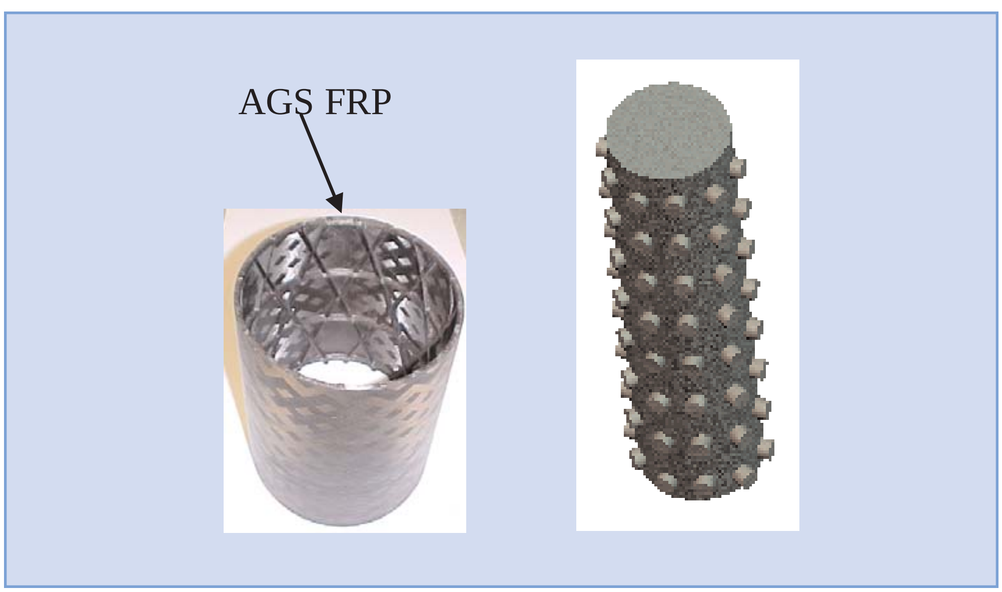
Problem

Recently, fiber reinforced polymer tube-encased concrete columns (FRP ECCs) have been developed as a formwork-free, steel-free, and maintenance-free alternative for new construction of bridge piers/piles in corrosive environments.

However, FRP ECCs have inherent disadvantages and limitations. Because the interfacial bonding strength is not sufficient, the desired composite action between the FRP shell and the concrete core cannot be developed. The FRP tube cannot effectively distribute an applied load and contain or arrest concrete cracks, resulting in excessive interfacial slippage and the inability to carry eccentric axial load or bending moment. These limitations can be circumvented by advanced grid stiffened FRP tube-encased concrete column (AGS ECC) technology.

Objective

This study's objective is to develop formwork-free, steel-free, maintenance-free, high compressive strength, high bending strength, and high ductility AGS ECCs for bridge pier/pile construction in corrosive environments. A systematic theoretical



Advanced Grid Stiffened (AGS) FRP Tube (left) and a schematic of concrete core (right) analysis and lab-scale experimentation will be conducted to validate and fine-tune the new concept, followed by field-level construction and monitoring. To achieve the study's objective, a two-phase study will be conducted. Phase I will include (1) raw materials selection and development of construction technology, (2) structural analysis and design, (3) experimental validation, and (4) new construction. Structural monitoring of full-scale AGS ECC installations will be performed in Phase II.

Description

To achieve this project's objective, eight inter-related tasks have been identified as essential: 1) literature survey, 2) selection and characterization of raw materials, 3) development of construction technology, 4) evaluation of interfacial bonding strength, 5) development of confinement model 6) experimental tests, 7) preparation and installation of full-scale AGS ECCs, and 8) structural monitoring.

This project will use normal strength concrete made from Type I Portland cement, limestone, and river sand. Materials characterization will control the quality of the concrete and provide physical/mechanical properties for theoretical modeling. The FRP skin will be prepared with E-glass fiber and vinyl ester resin, and coupon testing will control the quality of the FRP grids. FRP grid stiffened composite tubes will be manufactured using filament wound technology, allowing the research team to establish guidelines for full-scale production of these tubes.

The tube structure is innovative because it will insure composite action through mechanical interlocking of the concrete teeth with the FRP grids. Theoretical modeling is desired so that the concrete teeth will be designed to have sufficient strength. Stress-strain distributions will be determined from a push-out test, which simulates the most critical loading condition for the concrete teeth.

The ultimate strength of the confined columns is a key element in the structural design of AGS ECCs. FRP ECCs currently use two types of confinement models-design oriented and analysis oriented. In this project, researchers will use a finite element modeling analysis to develop the confinement model.

Experimental study is necessary to validate the proposed concept, the selected raw materials, the developed construction technology, the interfacial bonding evaluation method, and the proposed confinement model. The coaxial compression test, flexural strength test, and push-out test are all considered essential.

Two full-scale AGS FRP tubes will be manufactured according to the procedure used in lab-scale tests; these tubes will then replace two bridge timber piers. This construction will establish guidelines for the preparation, transportation, and installation of AGS ECC piers. The FRP system's efficiency will be measured through structural monitoring of the bridge before and after the FRP installations. The two piers will then be monitored for one year after installation.

Implementation Potential

Once this project proves successful, a new generation of durable, reliable, and long-term cost-effective hybrid FRP/concrete columns will be available for design engineers to consider in the construction of bridge piers/piles. The success of this project may lead to economic benefits and greatly affect bridge design and construction in Louisiana and the nation as a whole.