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ANALYTICAL AND EXPERIMENTAL INVESTIGATION OF REINFORCED CONCRETE COLUMNS ENCASED IN FIBERGLASS TUBULAR JACKET AND USE OF FIBER JACKET FOR PILE SPLICING

PROBLEM STATEMENT

Environmental effects on concrete bridge pier columns could significantly deteriorate the long-term durability and structural integrity of concrete. The two key problems are permeability of concrete and corrosion of the embedded reinforcement. Although use of Fiber Reinforced Plastics (FRP) rods and prestressing tendons in lieu of steel re-bars and tendons has also been suggested in the past, insulating the exposed concrete could potentially increase life expectancy of pier columns. To achieve this purpose, one can envision casting concrete in a permanent formwork made of a filament-wound tube. A fully composite FRP-concrete column was proposed that consists of FRP tube with a concrete core. The benefits of the encased FRP composite concrete are two fold; protection of concrete against harsh environmental effects in marine and coastal areas, and increasing the strength of column due to the confinement of concrete. Additional cost savings are also realized by reducing the cross sectional area required for the same design load.

OBJECTIVES

The main objectives of this study were to evaluate the feasibility of using hybrid columns made of FRP and concrete in the construction of bridge pier columns, develop a confinement model that quantifies the benefits of FRP as a confining measure, performing experimental investigation into eliminating reinforcements from the construct of hybrid columns, and to develop mechanical methods of composite action between FRP and concrete.

FINDINGS

The experimental component of the project included several series of uniaxial compression tests, uniaxial cyclic tests, split tension tests, beam column tests, slenderness tests, and square column tests. From the results of the tests on 54 cylindrical specimens and 5 long beam columns, the following conclusions can be made:

1. Depending upon the degree of confinement, ultimate axial strengths and strains were increased by 2-3 and 15-20 times those of unconfined concrete, respectfully.
2. FRP jacket keeps concrete from expanding at stresses higher than the unconfined peak stress. Generally, after an initial period of volume expansion due to the cracking of concrete, the FRP jacket becomes fully activated and continuously reduces the volume until failure occurs.
3. It was confirmed that existing confinement models which are calibrated for steel jacketing, do not accurately represent the confinement characteristics for the FRP material.
4. Internal ribs ensured full composite action. No slippage or loss of bond was noticed.
5. Both long and short columns, and both axial and axial-flexural loadings indicated considerable ductility for the proposed hybrid system.

The analytical component of the study included a critical review of existing confinement models. Comparing experimental results with theoretical models demonstrated the need for development of a special confinement model for fiber composites. A parametric study of concrete columns confined by FRP jackets with cross-piles indicated that:

1. Increase in the thickness of the jacket increases pure axial strength, balanced axial capacity, and balanced moment capacity of the composite column. In the presence of full composite action, the pure flexural strength of the column increases , as well.
2. Increase in the fiber widening angle of FRP jacket will decrease the pure axial strength, balanced axial capacity, and balanced moment capacity. In the presence of full composite action, the maximum pure flexural capacity occurs at =45.

The nonlinear finite element analysis of hybrid columns further confirmed the need for developing a new confinement model. Upon a detailed mechanical analysis of FRP composite tubes, a complete confinement model was proposed. The model predicts stress-strain response both in the axial and lateral directions. It also predicts the cyclic response of hybrid columns. Comparison of the model with experimental results and those of other researchers has confirmed its validity.

CONCLUSION

The present study has determined the concept of hybrid columns to be feasible and efficient. The future of concrete filled FRP tubes appears to be very promising. There is much however, still to be learned. Shear strengthening term effects including creep and fatigue, cyclic response, optimization of thickness and winding angle, design procedure, and full-scale testing are of great importance. Some of these topics are included in Phase II and III of this project.

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