DEVELOPMENT AND TESTING OF A NOVEL ANCHOR-PROFILED FRP JACKET SYSTEM FOR EFFECTIVE CONFINEMENT OF RECTANGULAR CONCRETE COLUMNS

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Project Objective

The goal of this project is to find a more effective method to repair and retrofit rectangular concrete columns using FRP materials. There were two main objectives:

1) Develop an Improved FRP System: create a cost-effective and easy-to-apply FRP jacket and anchor system that can provide more uniform confinement in rectangular columns.

2) Demonstrate the Effectiveness of the Proposed System: conduct experiments on concrete columns to determine how well the new FRP system improves the strength and ductility of rectangular columns.

By achieving these objectives, the project aims to improve the safety and performance of concrete columns commonly used in bridges and civil infrastructure.

Problem Statement

Fiber-reinforced polymer (FRP) jacketing has become a popular method for strengthening concrete columns because it is easier to apply than traditional methods, such as adding more concrete or installing steel jacketing. While this method works well for square and circular columns, it is much less effective for rectangular ones. This is because the support provided by FRP jacketing is uneven in rectangular columns, making it harder to strengthen them properly. Most of the concrete in these columns does not receive enough confinement, especially in the middle of each side, which reduces the overall performance.

Research Methodology

The research methodology for this project involved a combination of experimental testing and comparative analysis to evaluate the effectiveness of different FRP strengthening systems for rectangular reinforced concrete (RC) columns. Six groups of scaled concrete columns were fabricated and subjected to uniaxial compression tests to simulate real-world loading conditions. Two key strategies were investigated: FRP anchoring systems (including both part-through and through-anchor configurations), and innovative FRP profiling systems using geofoam and steel tubes.

The testing program included six groups, each with two identical columns, totaling 12 scaled concrete columns, as shown in Table 1. Group 1 served as the control group without any confinement. Group 2 used direct FRP jacketing. Groups 3 and 4 involved anchoring systems: Group 3 employed part-through anchors, while Group 4 used through anchors. Groups 5 and 6 focused on profiling methods: Group 5 used geofoam for FRP profiling, and Group 6 used steel tubes for the same purpose. All columns were tested under uniaxial compression until failure.

Table 1. Test matrix.

Group	Confinement	Number of columns
1	Control	2
2	Direct FRP	2
3	FRP with part-through anchors	2
4	FRP with through anchors	2
5	FRP with geofoam profiling	2
6	FRP with steel-tube profiling	2

Results

The peak loads for all columns are summarized in a bar chart comparison in Figure 1 below. Based on the peak loads of Groups 2, 3, and 4, no significant enhancement was observed from the use of FRP anchors. For the geofoam-profiled Group 5 columns, the peak loads were lower than those of the Group 2 columns but slightly higher than those of the control group columns.

In contrast, the Group 6 steel tube-profiled columns exhibited substantial variation in performance. Column 1 showed the highest enhancement, with a 16.5% increase in peak load, while Column 2 showed only 2.1% increase, primarily due to fabrication flaws. These results suggest that combining geofoam and steel tubes offers a promising approach to enhancing the effectiveness of FRP confinement. The geofoam provides a solid surface for the FRP to be flat and tightly wrapped around the column, while the steel tube offers sufficient stiffness to engage the FRP in confining the concrete rather than deforming under the low-modulus geofoam.

In summary, direct FRP jacketing increased the columns' load-carrying capacity by an average of 11.7%, demonstrating its effectiveness. However, adding FRP anchors and using geofoam-based profiling systems did not significantly improve performance, with the geofoam system even reducing capacity due to its low stiffness. In contrast, the steel tube profiling system showed promising results, with one column achieving a 16.6% capacity increase, though installation issues affected consistency. Based on these findings, a hybrid system combining geofoam for surface flatness and steel tubes for structural support is recommended for future research.

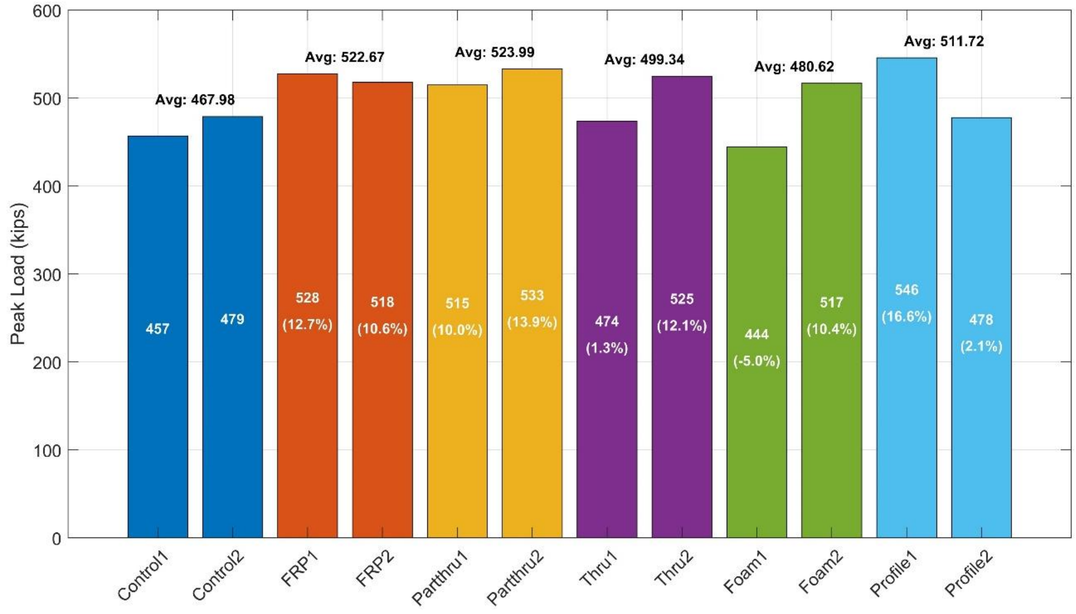

Figure 1 Summary of peak load of all columns.