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Research Results

Development and testing of a novel anchor-profiled FRP jacket system for effective confinement of rectangular concrete columns

Develop and evaluate an innovative anchor-profiled FRP jacket system, which has the potential to directly provide effective confinement to rectangular concrete columns without the need for concrete casting.

Geotechnical/ Structures

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Project Title: Development and testing of a novel anchor-profiled FRP jacket system for effective confinement of rectangular concrete columns

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WHAT WAS THE NEED?

The research project addressed a common need to retrofit rectangular concrete columns in transportation structures. The direct fiber-reinforced polymer (FRP) jacketing technique, while effective and economical for retrofitting circular columns, is less efficacious for retrofitting rectangular columns. This limitation is a result of the inability of FRP to effectively confine the flat sides of rectangular columns, thus requiring a time-consuming and costly process of transforming the section from rectangular into elliptical via concrete casting prior to FRP jacketing. The goal of this research is to develop and evaluate an innovative anchor-profiled FRP jacket system, which has the potential to directly provide effective confinement to rectangular concrete columns without the need for concrete casting.

WHAT WAS OUR GOAL?

The goal of this research is to develop an effective, straightforward, and economical approach to directly provide effective confinement to rectangular concrete columns, utilizing an anchor-profiled FRP jacket system as an alternative to current practices of using reinforced concrete or steel jackets.

WHAT DID WE DO?

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

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(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

WHAT WAS THE OUTCOME?

The application of direct FRP jacketing led to an average capacity increase of 11.7% for the columns tested in this study. This increase demonstrates the effectiveness of FRP jacketing in enhancing the load-carrying capacity of rectangular concrete columns. The following is a summary of the performance of each FRP strengthening systems:

Ineffectiveness of FRP Anchoring Systems: contrary to expectations, the incorporation of both part-through and FRP anchoring systems did not result in a significant capacity improvement beyond those achieved with direct FRP jacketing alone. This suggests that FRP anchoring systems may be ineffective for column configurations with large aspect ratios and traditional jacketing methods.

Geofoam Profiling System: the geofoam-based profiling system did not show any notable improvement compared to the direct FRP group. In fact, it resulted in an average capacity decrease. This outcome is primarily attributed to the low stiffness of the geofoam, which failed to provide adequate support for improving the confinement of the concrete by the FRP jacket.

Steel Tube Profiling System: the steel tube profiling system exhibited large variability between the two columns tested. One specimen demonstrated an increase in capacity of 16.6%, surpassing the average improvement observed with direct FRP jacketing. The variability was largely due to a slack in the FRP jacket that occurred during installation, which critically affected the effectiveness of the confinement. Notably, even for the specimen with a 16.6% increase in capacity, the FRP jacket was not perfectly flat, indicating potential for further improvement if flatness is controlled.

WHAT IS THE BENEFIT?

The research could benefit California Department of Transportation (Caltrans) as well as other state transportation agencies by offering time and cost savings associated with the retrofitting of rectangular columns, increasing safety, and extending the service life of transportation infrastructure.

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Final Report Title

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