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CALTRANS DIVISION OF RESEARCH, INNOVATION AND SYSTEM INFORMATION

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Research Notes

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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Task Manager:

Colman Cronin
Senior Technical Engineer
colman.cronin@dot.ca.gov

WHAT IS THE NEED?

This proposal 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 ARE WE DOING?

The research work was performed in three phases. The first phase of the research work included the development of a hybrid anchor for the anchor-profiled FRP jacket system. The hybrid anchor consist of a carbon fiber anchor with an anchor dowel and an anchor fan. The system was constructed by drilling holes in a column, filling the holes with structural adhesive, and inserting the anchor dowels. Subsequently, the FRP jacket is directly wrapped around the concrete corners and the hybrid anchors using wet layup, forming a bulged cross-sectional profile. The effectiveness of the anchor-profiled FRP system depends on the optimal design of the anchor array

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pattern and spacing, anchor diameter, anchor insert depth and extrusion height, and FRP thickness and mechanical properties.

In phase 2 of the research work, a testing plan including the specimen design, loading protocol, and instrumentation setup was developed. Scaled rectangular concrete column specimens were designed based on the geometry, internal steel reinforcement, and concrete materials representing typical rectangular concrete columns in the California Transportation System. Five groups of nominally identical rectangular concrete columns were fabricated and strengthened with different configurations, as shown in Table 1.

Table 1 Test matrix

Group	Strengthening configuration	Number of specimens
1	Control	2
2	FRP jacketing	2
3	Through FRP anchor strengthening	2
4	Part-through FRP anchor strengthening	2
5	Anchor-profiled FRP jacketing	2
	Anchor-profiled FRP jacketing with expansive grout	2

All columns were tested under the same loading protocol designed based on the geometry of the specimens to test the effectiveness of the different confining configurations. The instrumentation collected data on the columns to facilitate understanding both the global structural behavior and local mechanisms.

In phase 3 of the research work, a comprehensive experimental database of FRP-strengthened rectangular columns was compiled based on previous studies. The experimental data from Phase 2 was analyzed comparatively against this database by examining the global and local behavior of the five groups of columns to understand the effectiveness of the developed system in retrofitting rectangular concrete columns. This comparative analysis helped determine the effectiveness of the approach proposed here in comparison to conventional and other methods proposed in the literature. A journal paper and final report will be prepared by the Principal Investigator documenting the experimental testing, findings, and suggestions based on the comparative analysis.

WHAT IS 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 IS THE BENEFIT?

The research will benefit 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.

WHAT IS THE PROGRESS TO DATE?

The contract for this task order was executed on March 13, 2024, and the kick-off meeting was held on April 10, 2024. The design details of the anchored FRP jacket systems have been completed and the five groups of RC column test specimens have been cast. All specimens were load tested in December 2024. The final report has been published on the research projects page of the METRANS website.