Summary of Final Report, BC 354-48
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DESIGN GUIDELINES AND SPECIFICATIONS FOR ENGINEERED GROUTS

PROBLEM STATEMENT

Frequently, FDOT installations require dowel bars or headed anchors for attaching structural members to existing concrete. Current FDOT Design Guidelines and Specifications permit the use of polymer adhesives that are only approved for installation in drilled holes less than one and one half times the anchor diameter. This hole size limitation currently precludes the use of headed anchors that have been shown to exhibit a higher strength for the same embedment length than unheaded anchors due to mechanical anchorage at the anchor head. Grouted anchors permit larger diameter hole sizes due to the engineered fill in the grout, which allows for the use of either unheaded or headed anchors. Additionally, the large hole size provides an increased construction tolerance due to the oversized hole. In addition to anchorage applications, precast concrete piles are frequently spliced together for deep installations. Current FDOT requirements specify structural polymer adhesives for these installations. Problems associated with the relatively short cure times of polymer adhesives have led to construction problems since multiple large diameter and depth holes need to be filled with a bonding agent prior to installation of the new pile. Engineered grouts appear to be easier and more economical to install than structural adhesives for these types of applications. For use of engineered grouts, the FDOT Specifications need to include appropriate product approval requirements.

OBJECTIVES

The objectives of this project were (1) to provide recommendations for extending the FDOT Design Guidelines to cover grouted anchors in addition to adhesive anchors; and (2) to provide recommendations for extending the FDOT Specifications to permit the use of engineered grout products for both anchorage and pile splice installations. The work to accomplish these objectives included the following:

- A thorough review of published information related to the use of grouts for anchorage applications and information obtained from manufacturers of engineered grouts was performed.
- Based on results of the information acquired in the review process, a testing program was developed and performed to acquire the data necessary to establish recommendations for product approval of grouts and to develop design guidelines for grouted anchorages.
- Using previous research data and test data from this project, design and product approval recommendations for grouted anchors were developed and draft changes were prepared for incorporation into the FDOT Design Guidelines and Specifications.

FINDINGS AND CONCLUSIONS

Grouted anchor behavior varies depending on the product used for installation; on whether the anchor is installed as unheaded or headed, installed near an edge, or installed in an anchor group; and on the installation and service conditions to which the anchor is exposed.

Four different failure modes exist for grouted anchors: bond failure at the steel/grout interface, bond failure at the grout/concrete interface, concrete breakout failure, and steel failure. Assuming steel failure does not control, unheaded grouted anchors predominantly experience a bond failure at the steel/grout interface, but a bond failure at the grout/concrete interface has also been observed. Again, assuming steel failure does not control, headed grouted anchors may experience either a bond failure at the grout/concrete interface or a concrete cone breakout. For each of these potential failure modes, the report provides, for incorporation into the FDOT Design Guidelines, design equations for both single anchors and groups of anchors with or without edge conditions.

This research also includes an analysis of tests of installation and service conditions. The tests performed in the test program associated with this project and in previous testing programs led to conclusions regarding the types of tests to be incorporated into the FDOT Specifications for approval of grouted anchor products. The following represents some of these conclusions:

- Products develop strength at different rates. In general, polymer grouts develop a significant portion of strength more rapidly than cementitious grouts.
- The type of grout product used to install the anchor can greatly influence the anchor strength.
- The moisture condition of the hole affects the bond strength of anchors installed with polymer grouts.
- Polymer grouts are believed to be sensitive to elevated temperatures since they are similar in composition to adhesives, which have been shown to possess this sensitivity.

Appendices to the report provide suggested revisions to the FDOT Design Guidelines and Specifications for the design of grouted anchors and product approval of engineered grouts.

BENEFITS

This project improved the basic understanding of the effective use of cementitious grouts. The predominant themes of the study were safety and reliability, and the results of this project will allow for a safer and more reliable use of cementitious grouts. One specific finding is that cementitious grout is usable with a nut to make a headed anchor, and this will allow for shallower embedments. Because of the difficulties associated with drilling deeper holes—increased labor and the use of different equipment (i.e., utilizing the right bits), not to mention the possibility of encountering rebar—shallower embedments, beyond safety and reliability concerns, should result in cost savings. Recommended revisions to the FDOT Design Guidelines and to the FDOT Specifications are provided in the final report.

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