FDOT

Project Number
BED28-977-02

Project Manager
Steven Nolan, P.E.
State Structures Design Office

Principal Investigator
Nakin Suksawang, Ph.D., P.E.
Florida Institute of Technology

Florida Department of Transportation Research

Confinement Effect of Narrow Baseplates or Reaction Area on Anchor Breakout, Part 3

March 2026

Background

The concrete parapet mockup specimen after breakout of two 5/8-in dia. galvanized screw anchors.

The American Concrete Institute (ACI) released the ACI CODE 318-19, which for the first time includes design rules for screw anchors in Chapter 17. The Florida Department of Transportation (FDOT) and American Association of State Highway and Transportation Officials (AASHTO) are considering adopting these provisions into the AASHTO Load and Resistance Factor Design (LRFD) Bridge Design Specifications because screw anchors can make construction faster, more reliable, and simpler than traditional adhesive anchors. However, past research—including FDOT's own project BDV28-977-06—shows that the current ACI code is overly conservative when predicting concrete breakout strength for narrow baseplate anchorages subject to flexural loading and near free edges. This conservatism could discourage the use of screw anchors in typical FDOT applications, preventing cost and time savings on projects.

Research Objectives

The research aimed to evaluate how screw anchors actually perform in real FDOT conditions, understand why the current ACI design approach is conservative, and develop improved FDOT design guidelines that safely allow screw anchors to be used more widely, without unnecessary restrictions.

Project Activities

The Florida Institute of Technology research team tested 3/4-in and 5/8-in stainless steel and galvanized screw anchors embedded in two classes of concrete and installed in realistic structural configurations (sidewalk slabs, gravity walls, and parapets). Researchers reviewed how confinement from concrete and baseplates increases strength, examined the effects of anchor spacing and group patterns, observed how anchors fail, and checked performance under repeated (cyclic) loads like those experienced by guiderails and railings.

Full-scale tests were run at the Marcus H. Ansley Structures Research Center using 35 specimens under steady pull until failure and 10 specimens under 1,000 cycles of realistic tension loads followed by pull-to-failure. An additional set of nine retrofitted specimens was also tested until failure.

Project Conclusions and Benefits

The tests showed that screw anchors are much stronger in practice than the ACI CODE-318-19 predictions—often more than double the nominal breakout capacity calculated by the code. Experimental capacities consistently exceeded the required design loads for all railings tested. Cyclic loading did not reduce screw anchor strength. Some lower strength results were observed in sidewalk specimens, but this was traced to yielding in the guiderail/baseplate, not the anchor itself.

Based on the data, the research team developed practical FDOT recommendations.

The project also validated the use of the confinement modification factor previously developed in FDOT project BDV28-977-06 and proposed a higher resistance factor (ϕ = 0.75) for design and testing instead of the current ACI value of 0.65. A new Section 1.6.4 for FDOT design guidance was also suggested.

Overall, this work supports safer, more economical use of screw anchors, improves FDOT structural design guidelines, and helps reduce installation time, costs, and inspection burdens while maintaining performance and safety.