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Confinement Effect of Metal Railing Narrow Baseplates on Adhesive Anchor Breakout

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Current Situation

The words “transportation engineering” very likely conjure images of great bridges and sweeping elevated highways. But even engineering on the grand scale often depends on small-scale details. This is the case for metal railings that serve as a safety barrier between walkways and vehicular traffic or drop-offs. These railings are often attached using bolts anchored in concrete with an adhesive (usually epoxy or vinyl ester). The size and depth of these anchors is governed by engineering design standards to help assure that under expected loads and over years of service, the anchors will not yield or break out of the concrete. A recent adoption of ACI design standards by AASHTO requires that the anchors be set deeper than before; even though no performance issues have been observed in practice. This may seem like a small change, but it could mean increased concrete thickness for sidewalks and top widths of retaining walls and increased drilled hole depths and adhesive quantities, resulting in increased costs. However, the new AASHTO/ACI design standard does not take into account how the baseplate reaction increases the pullout/breakout capacity of the concrete: the confinement effect.

Research Objectives

Florida Institute of Technology researchers examined the confinement effect of a narrow baseplate on adhesive anchor breakout resistance and developed a new confinement modification factor.

Project Activities

The researchers reviewed the literature concerning the failure mechanism and appropriate confinement modification factor of adhesive anchors used for metal railing. Based on the review, they designed an experimental program to evaluate the confinement effect of a narrow baseplate configuration on adhesive anchors, including designs for standard metal railings with reduced edge distance and embedment for sidewalks and gravity walls to be used in tests.

The first of three experimental schemes used concrete block specimens to evaluate the confinement effect and embedment length for adhesive anchor breakout resistance on slabs without the influence of edge distance. The second scheme investigated the anchors on top of standard concrete gravity wall specimens. In the third scheme, concrete block specimens were used to examine how reduced edge distances affected adhesive anchor breakout resistance.

Results indicated that the confinement effect of narrow metal baseplates increased the adhesive anchor breakout resistance by as much 182%, compared to the updated standard. This was especially true for specimens with reduced edge distances. Based on this and other observations, the researchers made recommendations for the construction of anchors that are well within the new standard’s requirements, yet use reduced embedment lengths, resulting in solid installations that require less time and money to construct.

Project Benefits

This project provided recommendations that assure the strength and service life of pedestrian and bicyclist railings while reducing installation costs.

For more information, please see www.fdot.gov/research/.



This railing protects pedestrians and cyclists from a steep drop onto a parking lot.