

## ABSTRACT

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Title: Anchoring to Lightweight Concrete: Concrete Breakout Strength of Cast-In, Expansion, and Screw Anchors in Tension

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The use of lightweight concrete in the concrete industry provides economical and practical advantages. Structural anchors are commonly used in the industry for various structural applications. In *ACI 318-19: Building Code Requirements for Structural Concrete and Commentary*, a modification factor,  $\lambda_a$ , is specified for the calculated design strengths of anchors installed in lightweight concrete that experience concrete or bond failure. The modification factor consists of the general lightweight concrete modification factor,  $\lambda$ , specified in the code multiplied by an additional reduction factor dependent on the anchor and failure type. For the concrete breakout strength of expansion and screw anchors in lightweight concrete, the value of  $\lambda_a$  is specified as  $0.8\lambda$ . For the concrete breakout strength of cast-in anchors in lightweight concrete, the value of  $\lambda_a$  is  $1.0\lambda$ . In both cases, however, the specified value of  $\lambda_a$  is based on limited test data. A research program was therefore conducted to provide the data needed for more appropriate lightweight modification factors. A primary objective of the research was to evaluate the concrete breakout strengths of cast-in, expansion, and screw anchors installed in lightweight concrete by conducting a systematic experimental program that included various types of lightweight concrete. More specifically, the experimental program included tension tests on torque-controlled expansion anchors, displacement-controlled expansion anchors, and screw anchors from four manufacturers in addition to tension tests on cast-in headed stud anchors. A total of seven concrete types were included in the research: one normalweight concrete mixture and six lightweight concrete

mixtures. The lightweight concrete included sand-lightweight and all-lightweight mixtures composed of expanded shale, clay, and slate aggregates. The results of the experimental program are compared to limited data available from previous tension tests on anchors in lightweight concrete. Based on the results of the research, revised lightweight concrete modification factors for the concrete breakout design strengths of the anchor types included in the test program are recommended.