

CODE

D.2.2 — This appendix applies to cast-in anchors and to post-installed expansion (torque-controlled and displacement-controlled), undercut, and adhesive anchors. Adhesive anchors shall be installed in concrete having a minimum age of 21 days at time of anchor installation. Specialty inserts, through-bolts, multiple anchors connected to a single steel plate at the embedded end of the anchors, grouted anchors, and direct anchors such as powder or pneumatic actuated nails or bolts are not included in the provisions of Appendix D. Reinforcement used as part of the embedment shall be designed in accordance with other parts of this Code.

D.2.3 — Design provisions are included for the following types of anchors:

- (a) Headed studs and headed bolts having a geometry that has been demonstrated to result in a pullout strength in uncracked concrete equal to or exceeding $1.4N_p$, where N_p is given in Eq. (D-14);
- (b) Hooked bolts having a geometry that has been demonstrated to result in a pullout strength without the benefit of friction in uncracked concrete equal to or exceeding $1.4N_p$, where N_p is given in Eq. (D-15);
- (c) Post-installed expansion and undercut anchors that meet the assessment criteria of ACI 355.2; and
- (d) Adhesive anchors that meet the assessment criteria of ACI 355.4.

D.2.4 — Load applications that are predominantly high cycle fatigue or impact loads are not covered by this appendix.

D.3 — General requirements

D.3.1 — Anchors and anchor groups shall be designed for critical effects of factored loads as determined by elastic analysis. Plastic analysis approaches are permitted where nominal strength is controlled by ductile steel elements, provided that deformational compatibility is taken into account.

COMMENTARY

RD.2.2 — Provisions for design of adhesive anchors were added in the 2011 Code. Adhesive anchors are particularly sensitive to a number of factors including installation direction and loading type. Where adhesive anchors are used to resist sustained tension, the provisions include testing requirements for horizontal and upwardly inclined installations in D.3.4 and design and certification requirements for sustained tension load cases in D.3.5 and D.9.2.2 through D.9.2.4, respectively. Adhesive anchors qualified in accordance with ACI 355.4 are tested in concrete with compressive strengths within two ranges: 2500 to 4000 psi and 6500 to 8500 psi. Bond strength is in general not highly sensitive to concrete compressive strength. The design performance of adhesive anchors cannot be ensured by establishing a minimum concrete compressive strength at the time of installation in early-age concrete. Therefore, a minimum concrete age of 21 days at the time of adhesive anchor installation was adopted.

The wide variety of shapes and configurations of specialty inserts precludes prescription of generalized tests and design equations. Specialty inserts are not covered by Appendix D provisions.

RD.2.3 — Typical cast-in headed studs and headed bolts with geometries consistent with ANSI/ASME B1.1,^{D.1} B18.2.1,^{D.2} and B18.2.6^{D.3} have been tested and proven to behave predictably, so calculated pullout strengths are acceptable.

Post-installed anchors do not have predictable pullout strengths, and therefore qualification tests to establish the pullout strengths per ACI 355.2 are required. For a post-installed anchor to be used in conjunction with the requirements of this appendix, the results of the ACI 355.2 tests have to indicate that pullout failures exhibit an acceptable load-displacement characteristic or that pullout failures are precluded by another failure mode. For adhesive anchors, the characteristic bond stress and suitability for structural applications are established by testing in accordance with ACI 355.4.

RD.2.4 — The exclusion from the scope of load applications producing high cycle fatigue or extremely short duration impact (such as blast or shock wave) are not meant to exclude seismic load effects. D.3.3 presents additional requirements for design when seismic loads are included.

RD.3 — General requirements

RD.3.1 — When the strength of an anchor group is governed by breakage of the concrete, the behavior is brittle and there is limited redistribution of the forces between the highly stressed and less stressed anchors. In this case, the theory of elasticity is required to be used assuming the attachment that distributes loads to the anchors is sufficiently