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Anchor Bolt Design per ACI 318-11

Crane beam design

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Gauge Length in ASCE 7-10 15.7.5 = Stretch Length in ACI 318-11,D.3.3.4.3 (a) -3

From ACI 318-11 Appendix D

CODE

D.3.3.4.3 — Anchors and their attachments shall satisfy one of options (a) through (d):

(a) For single anchors, the concrete-governed strength shall be greater than the steel strength of the anchor. For anchor groups, the ratio of the tensile load on the most highly stressed anchor to the steel strength of that anchor shall be equal to or greater than the ratio of the tensile load on tension-loaded anchors to the concrete-governed strength of those anchors. In each case:

1. The steel strength shall be taken as 1.2 times the nominal steel strength of the anchor.

2. The concrete-governed strength shall be taken as the nominal strength considering pullout, side-face blowout, concrete breakout, and bond strength as applicable. For consideration of pullout in groups, the ratio shall be calculated for the most highly stressed anchor.

In addition, the following shall be satisfied:

3. Anchors shall transmit tensile loads via a ductile steel element with a stretch length of at least eight anchor diameters unless otherwise determined by analysis.

4. Where anchors are subject to load reversals, the anchor shall be protected against buckling.

COMMENTARY

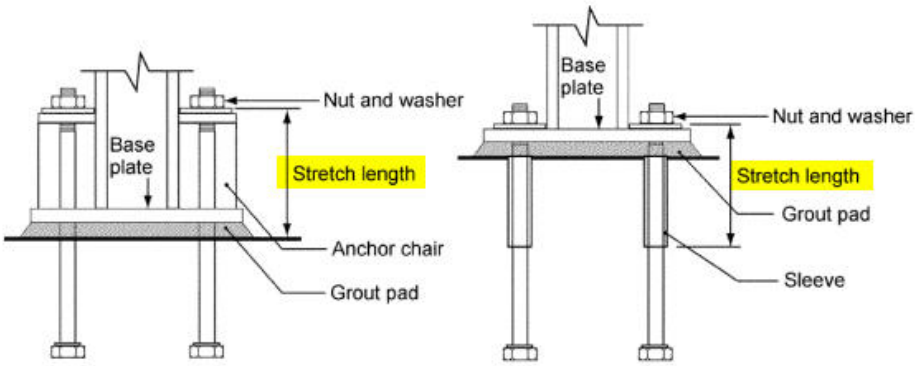
RD.3.3.4.3 — Four options are provided for determining the required anchor or attachment strength to protect against nonductile tension failure:

In option (a), anchor ductility requirements are imposed and the required anchor strength is that determined using strength-level earthquake forces acting on the structure. Research[D.7,D.8] has shown that if the steel of the anchor yields before the concrete anchorage fails, no reduction in the anchor tensile strength is needed for earthquake loadings. Ductile steel anchors should satisfy the definition for ductile steel elements in D.1. To facilitate comparison between steel strength, which is based on the most highly-stressed anchor, and concrete strength based on group behavior, the design is performed on the basis of the ratio of applied load to strength for the steel and concrete, respectively.

For some structures, anchors provide the best locations for energy dissipation in the nonlinear range of response. The stretch length of the anchor affects the lateral displacement capacity of the structure and therefore that length needs to be sufficient such that the displacement associated with the design-basis earthquake can be achieved.[D.9] Observations from earthquakes indicate that the provision of a stretch length of eight anchor diameters results in good structural performance. Where the required stretch length is calculated, the relative stiffness of the connected elements needs to be considered. When an anchor is subject to load reversals, and its yielding length outside the concrete exceeds six anchor diameters, buckling of the anchor in compression is likely

CODE

COMMENTARY



(a) Anchor chair (b) Sleeve

Fig. RD.1.3—Illustrations of stretch length (see D.3.3.4.3(a)).

Stretch length — Length of anchor, extending beyond concrete in which it is anchored, subject to full tensile load applied to anchor, and for which cross-sectional area is minimum and constant.

Supplementary reinforcement — Reinforcement that acts to restrain the potential concrete breakout but is

Stretch length — Length of an anchor over which inelastic elongations are designed to occur for earthquake loadings. Examples illustrating stretch length are shown in Fig. RD.1.3.

Supplementary reinforcement — Supplementary reinforcement has a configuration and placement similar to anchor

From ASCE Significant Changes to the Seismic Load Provisions of ASCE 7-10 An Illustrated Guide

for designing the embedment for the minimum published yield strength of the anchor bolt with the terminology "tensile or shear strength of steel element," which is similar to that of ACI 318, ensures that anchor reinforcement is provided and that the anchor bolt will yield. Hooked anchor bolts are also deleted. Historically these bolts have performed poorly in seismic events. The Seismic Subcommittee of ASCE 7 decided to eliminate the use of these bolts.

Anchors in concrete used for nonbuilding structure anchorage in Chile
Courtesy of J. Silva, ASCE/SEI 2010 Chile Earthquake Reconnaissance Team