Torque-Controlled Adhesive Anchors

An Introduction to a New Type of Post-Installed Anchor

By Ryan Vuletic, P.E.

The structural design of concrete anchors has undergone many changes in the past few years, courtesy of the design precedents set by ACI 318 Appendix D.

Anchor Type	Tension Capacity Reduction
Cast-in-place Anchor	20%
Concrete Screws	15% to 30%
Expansion Anchors	20 to 40%
Adhesive Anchors	40 to 50%

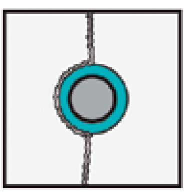
Table 1: Typical Capacity Loss for Anchors Loaded in Cracked Concrete.

Appendix D specifies complex ultimate strength design provisions for both cast-in-place and post-installed mechanical concrete anchors (such as wedge anchors & undercut anchors). Appendix D has many equations and provisions. However, the provision that has arguably the greatest impact upon anchorage design is the requirement that one consider the possibility of base material cracking and the effect that the cracking may have upon the anchorage. Laboratory tests and theory show that cracks that intersect anchors will reduce the capacity of the anchorage – even for those anchors that are specifically designed to exhibit better performance in cracked concrete. The magnitude of the reduction generally depends upon the anchor type. (*Table 1*)

Appendix D requires one to assume that cracks are present and that they intersect all anchors, if either: 1) The anchor is located in a concrete tension zone where cracks may occur at service load levels, or 2) the structure is located in an area of moderate to high seismicity – which is defined to be IBC seismic design categories C, D, E and F.

As can be seen in *Table 1*, the effect of base material cracking on the capacity of adhesive anchors is large. The approximately 40 to 50% loss can be more easily grasped when one understands that when a crack propagates through an anchor location it will theoretically cause about one half of the anchor's bond surface area to the concrete to be destroyed. (*Figure 1*) Since bonded anchors require contact with the base material in order to transfer load, and they have no ability to expand or re-engage the concrete after a crack forms, the performance reduction is roughly proportional to the percentage of bond area loss.

Recognition of this behavior has led to the development of a new anchor technology called a *torque-controlled adhesive anchor* (TCAA). This anchor type is meant to improve the performance of adhesives anchors through the use of a special insert, with cones or cone-like deformations on the embedded portion of the insert. (*Figure 2*).



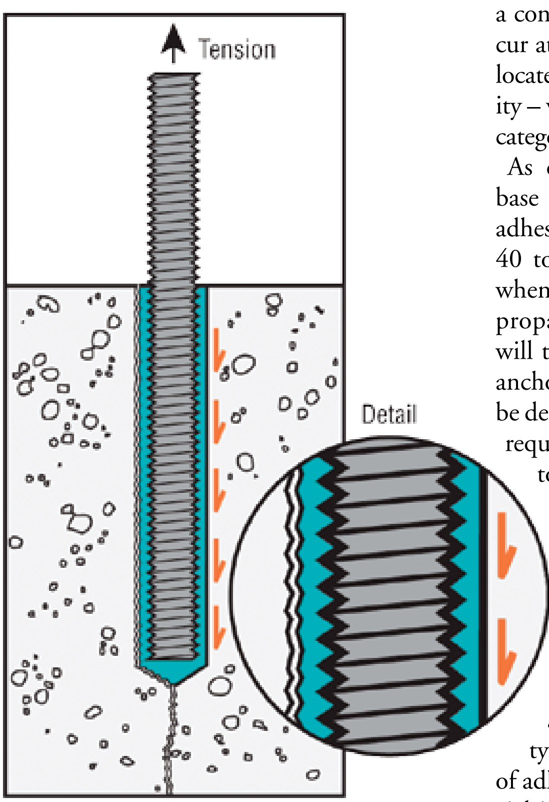


Figure 1: Adhesive Anchor Behavior in Cracked Concrete.

Installation Method & Anchor Function

TCAAs are installed into cylindrical holes drilled into concrete, just like traditional adhesive anchors that utilize threaded rods. However, unlike those anchors, a TCAA must be properly torqued to the manufacturer's specified installation torque after the adhesive fully cures. This setting torque induces sufficient pre-tension on the anchor to break any bond that exists between the insert and the adhesive. Destruction of the adhesive/insert bond is necessary for the TCAA to function as intended. When the bond is broken, a very small amount of slip occurs between the anchor and the adhesive, and the cones begin to exert expansion forces on the adhesive. The system then exhibits behavior similar to a steel wedge anchor with multiple adhesive expansion clips.

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Figure 2: Example of a Torque-Controlled Adhesive Anchor.

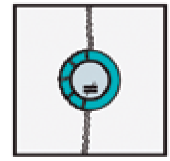
Benefits

The benefits of TCAAs are several. First, the geometry of the insert provides improved performance in cracked concrete. When a crack intersects the anchor location and tension is applied, the cured adhesive annulus will split and the expansion forces exerted by the insert's deformations will reduce loss of load transfer to the base material. (*Figure 3*) In fact, TCAAs generally only lose about 25 to 30% of their tension capacity in cracked concrete conditions. Some designs lose even less capacity.

In addition, due to the expansive forces exerted by the anchor, TCAAs are less sensitive to adverse hole conditions, such as the presence of loose drilling dust and/or moisture.

Design

Since TCAAs are not presently included within the scope of ACI 318 Appendix D, they are covered by IBC Section 104.11 – Alternative Materials, Design and Methods of Construction and Equipment. This is the same way that mechanical post-installed anchors were covered prior to the advent of ACI 318 Appendix D. When tested according to the provisions of ICC Evaluation Service's Acceptance Criteria AC308, design with TCAAs will follow ACI 318 Appendix D provisions, with only a few deviations that result from the fact that an adhesive is involved. For example, in-service temperature of the application must be considered.



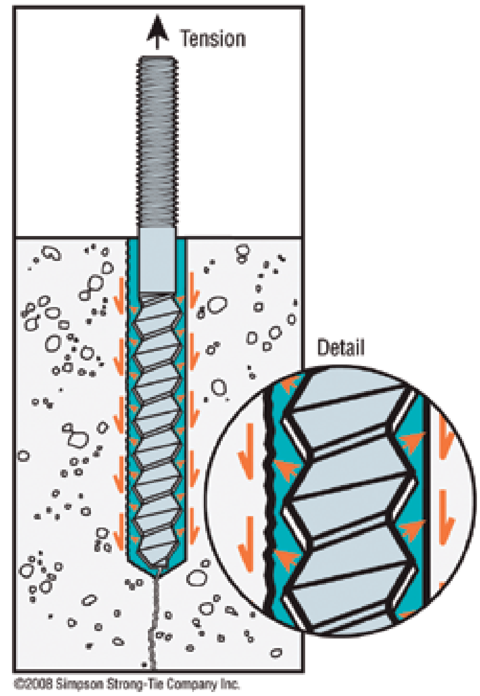


Figure 3: Torque-Controlled Adhesive Anchor Behavior in Cracked Concrete.

Applications

TCAAs are intended for use in applications where high load capacity is required and tension zone cracking of the concrete base material may occur. TCAAs are also suitable for resisting seismic forces.▪

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