ACI 355.4 Modifications

Modify ACI 355.4-11 as follows in the underlined text:

1.2.3 This standard does not address the following systems and use conditions:
1. Bulk adhesives mixed in open containers without automatically controlled metering and mixing of adhesive components.
2. Adhesives to adhere structural elements to concrete surfaces outside of a drilled hole.
3. Adhesive anchors in aggressive environments not specifically considered in this standard.
4. Adhesive anchors to resist fatigue or shock loading.
5. Injection-type adhesive anchor systems for horizontal and upwardly inclined installations that do not employ a piston plug or similar device to provide back pressure during the adhesive injection process.

R1.2.3 Correct proportioning (metering) and mixing of adhesive components is critical to their performance. Bulk mixing and delivery of adhesives (for example, those with paddle mixers in buckets), while appropriate for some applications, may not provide anchor performance consistent with the assumptions of this standard. These systems are not considered to provide controlled metering of adhesive components. Bulk dispensing equipment that provides automatic metering and mixing of the adhesive components is included; however, ongoing monitoring is required to check that the equipment is operating within tolerances in accordance with the Manufacturer’s Printed Installation Instructions (MPII), particularly with respect to mixture ratios, leak tightness, and dwell time.

This standard is not appropriate for assessing the use of adhesives to adhere structural elements to the concrete surface. Examples include bonded steel plates or external carbon fiber reinforcement. Other standards exist for these purposes. This standard includes tests to assess the sensitivity of adhesive anchor systems to a limited range of aggressive environments, including moisture, highly alkaline fluids, and sulfur dioxide. While it is believed that these exposure environments envelop a range of possible exposures, specific environments (for example, radiation exposure and chemical production environments) may require unique assessment.

Due to the variety of possible loading conditions associated with fatigue and shock loading, this standard does not include tests for these loading variants. Fatigue and shock loading may result in reductions in bond strength, steel strength, and concrete strength, and these effects are not addressed by this standard. Caution should be exercised in the determination of whether cyclic loading should be explicitly considered. These conditions may be evaluated separately for specific systems using generally accepted principles. Fatigue is generally less of a problem for the adhesive than for the anchor element; provisions of preload in the anchor to reduce the level of stress fluctuation in the anchor element is only effective if sufficient unbonded length is provided to ensure a reasonable degree of elastic stretch.

Void-free injection of adhesive is critical for the performance of adhesive anchors, particularly for cases involving sustained tension load. This standard includes several criteria for assessing the effectiveness of the adhesive anchor injection system. Nevertheless, the injection of adhesive into horizontal and upwardly inclined holes presents special challenges. The collapse of a tunnel ceiling in Boston, Massachusetts in 2006 highlights this issue. NTSB (2006) documented improper installation of the adhesive based on observation of failed anchors and anchors adjacent to the collapsed section. Subsequent laboratory investigations confirmed these findings, see Ocel and Hartmann (2007). The piston plug was developed to minimize injected air voids (see Fig. 2.2). Laboratory investigations (Silva 2016) indicate that injection of adhesive with only an extension tube, i.e., without the use of a device such as a piston plug to provide back pressure during the injection process, does not result in a sufficient degree of reliability in the installation process. The use of a piston plug during the injection process consistently results in good installation. For small hole diameters (1/4-in. to 3/8-in.), the same effect is accomplished when the extension tube diameter equals the hole diameter.

Consequently, the injection of adhesive in the horizontal or upwardly inclined direction without the use of a piston plug or similar back-pressure device to avoid air voids is no longer included in the scope of this Standard. It is also important to note that the use of the piston plug for proper injection is not limited to embeddings of large diameter or depth.
2.2 – Definitions

Add the following

**piston plug** – a device on the end of a flexible injection tube equaling the hole diameter, which facilitates injection of liquid adhesive into a drilled hole. See Fig. 2.2.

**piston plug** – The function of the piston plug is to a) minimize introduction of air bubbles (voids) into the injected adhesive mass and b) provide the operator of the injection equipment with haptic feedback based on the sense of touch during injection regarding the progress of the injection process. The piston plug facilitates backpressure in the installation process, to control the rate of tube or nozzle withdrawal.

Add a new Fig. 2.2 as follows

![Fig. 2.2 – Use of piston plug for adhesive injection](image)

7.18.1 **Purpose** – These optional reliability tests are performed to evaluate the performance of adhesive anchors installed horizontally and overhead, that is, vertically up. See Section 1.2.3 (5.) for restrictions on adhesive anchor systems to be qualified for these installation conditions.

Add the following to 10.12.3

10.12.3 Where testing and assessment to address sensitivity to installation direction in accordance with this standard is not conducted, or where the requirement of Section 1.2.3 (5.) is not met, the product shall be limited to down-hole installation only and the product labeling will include the notification shown in Fig. 7.2.
14.2 – Cited references

Add the following

