Bridges & Structures

Technical Advisory

Use and Inspection of Adhesive Anchors in Federal-Aid Projects

January 16, 2018

T5140.34

Does this Technical Advisory supersede another Technical Advisory?
Yes. This Technical Advisory supersedes Technical Advisory T 5140.30, dated March 21, 2008, by updating the stance on the use of adhesive anchors. Technical Advisory T 5140.30 is herein canceled.

What is the purpose of this Technical Advisory?
This is the third issue of this technical advisory. The original (T 5140.26) was issued after the investigation into the ceiling panel collapse in the I-90 Seaport Connector Tunnel in Boston, MA was complete. The primary cause of that failure was the use of a "fast set" epoxy with inadequate creep resistance. A contributing factor was the irregular installation of the anchors due to the challenges associated with installing anchors overhead. The second issue of this technical advisory provided an expanded list of specific epoxies that were deemed to be "fast set." The first two technical advisories strongly discouraged the use of adhesive anchors, in particular those with "fast set" epoxies. At the time, FHWA had concerns with how the industry regulated itself in terms of design and qualification of adhesive anchor systems, and the qualification of installers or lack thereof. Since the original technical advisory was issued, two National Cooperative Highway Research Program (NCHRP) studies have been completed, and the industry and the American Concrete Institute (ACI) have made significant advancements on regulating adhesive anchor systems and installation. The FHWA has reevaluated its position on the use of adhesive anchor systems as a result.

What developments have occurred since T 5140.30 was published?

1. The ACI and Concrete Reinforcing Steel Institute (CRSI) have established an "Adhesive Anchor Installer" certification program. The purpose of the program is to ensure uniformity in the knowledge base of those that install anchors on the parameters that may affect anchor performance including hole drilling, hole cleaning, adhesive storage, adhesive mixing, and not following Manufacture's Printed Installation Instructions (MPII).

2. Pursuant to ACI 318-14, "*Installation of adhesive anchors shall be performed by personnel trained to install adhesive anchors*." In particular, ACI 318-14 states that "*Installation of adhesive anchors horizontally or upwardly inclined* (including vertically overhead) *to support sustained tension loads shall be performed by personnel certified by an applicable certification program*," such as the ACI/CRSI Adhesive Anchor Installer Certification program, or equivalent.

3. ACI 318-14 requires continuous inspection of adhesive anchors installed in horizontal or upwardly inclined orientations to resist sustained tension loads, but it is left up to the owner to establish the inspector qualifications.

4. The ACI 318-14 design requirements are consistent with ACI 355.4 "*Qualification of Post-Installed Adhesive Anchors in Concrete and Commentary*," which establishes evaluation requirements under various adverse loading conditions include sustained tension.

5. NCHRP Report 757 contains recommended language for consideration by the American Association of State and Highway Transportation Officials (AASHTO) for the design of post-installed adhesive anchors. This language is modeled after the requirements of ACI 318-14.

What are the recommendations for new Federal-aid projects and existing projects?

a. **New Federal-aid projects.** Where post-installed adhesive anchors are deemed a necessity, they should be designed using ACI 318-14 or later editions for the given loading condition (vertical, horizontal, or overhead) and use only adhesive anchor systems qualified per ACI 355.4-11 or later editions for the same loading condition.

b. **Existing projects.** Applications of post-installed adhesive anchors that are under permanent sustained tension where the adhesive anchor system was not specifically qualified for use under that loading per ACI 355.4-11 or later editions, the owner should either:

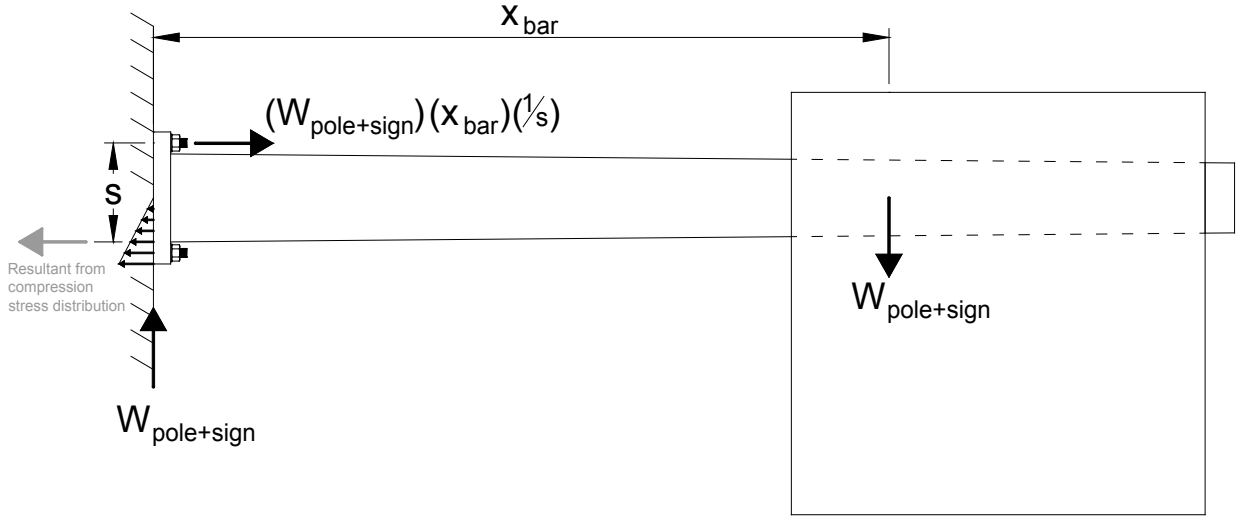
   - **I**nstitute a rigorous and regular inspection program that considers importance and redundancy to maintain an appropriate level of confidence in their long-term performance. This may require developing a testing protocol and program to determine the site specific ultimate capacities and creep characteristics of the adhesive over the expected life of the structure. Or,

   - Retrofit and/or replace the existing adhesive anchors with a post-installed mechanical anchor, or post-installed adhesive anchor meeting the requirements of ACI 318-14/ACI 355.4-11 or later editions

What is sustained tension?
We have seen misinterpretations of loading scenarios that cause sustained tension, and misunderstanding of what loads contribute to sustained tension. The FHWA is aware of three scenarios which result in sustained tension:

- Overhead applications in which an anchor is loaded in direct tension due to sustained loads. In this situation, the anchor is oriented vertically or inclined overhead, and the force (likely from gravity) has a vertical downward component.

- Application where the tension component of a force couple is developed in an anchor as a result of sustained load in a structure. This is illustrated with the figure below of a sign structure that is cantilevered off a wall. In this case, the self-weight of the structure is in the vertical direction, however the adhesive anchors are oriented in the horizontal direction. The weight of the structure resolves itself into a vertical shear force on the anchor pattern, and an axial force couple between the upper anchor and the wall to resist the overturning moment. In this situation, the upper anchor is horizontally oriented, but still under a sustained tension load from self-weight of the structure.



- Any application that requires a preload to the anchor (slip critical joint design, or vibrational support). If the preload is assumed to be around the yield strength of the steel rod, it is highly likely that a large portion of the preload will eventually creep away. Designs requiring preload need to understand that the allowable bond stress on the adhesive will control preload that can be developed, not the strength of the rod.

The term "sustained load" is meant to represent loads that remain static and do not change significantly with time. Dead load is a perfect example of a sustained load. Transient loads are those that occur sporadically, and/or are highly variable. Examples of these would be live load (i.e. a truck driving on/off a bridge, a wind event occurring for a few minutes, etc.). Adhesive anchors are essentially metal bonded to concrete with plastic. Plastics creep under constant loads. In a general sense for transportation structures, the creep we are concerned about occurs over months to years, so any load that remains constant over those time periods should be considered a "sustained load." Using a bridge as an example, construction loads are often thought of as "live loads," but it's feasible for construction equipment to remain on a bridge for a period of months and if an adhesive anchor resists that long-term construction loading, it may be prudent to consider that a "sustained load." Likewise, ice loads could feasibly remain in place for an entire winter season and could be considered a "sustained load." Wind would not likely be called a "sustained load" because at most it is only sustained for hours, not days. Each Owner will have to develop their own guidance as to what loads engineers should consider transient or sustained over identified time frames. The table below reproduces all the load types considered in the AASHTO LRFD Bridge Design Specifications, and indicates if each is, is not, or possibly could be a "sustained load."

	Load Type	**Considered sustained?**
AASHTO Permanent Loads	*CR* = force effects due to creep	Yes
	DD = downdrag force	Maybe
	DC = dead load of structural components and nonstructural attachments	Yes
	DW = dead load of wearing surfaces and utilities	Yes
	EH = horizontal earth pressure load	Yes
	EL = miscellaneous locked-in force effects from construction	Yes
	ES = earth surcharge load	Maybe
	EV = vertical pressure from dead load of earth fill	Maybe
	PS = secondary forces from post-tensioning for strength limit states	Yes
	SH = force effects due to shrinkage	Yes
AASHTO Transient Loads	*BL* = blast loading	No
	BR = vehicular braking force	No
	CE = vehicular centrifugal force	No
	CT = vehicular collision force	No
	CV = vessel collision force	No
	EQ = earthquake load	No
	FR = friction load	Maybe
	IC = ice load	Maybe

	IM = vehicular dynamic load allowance	No
	LL = vehicular live load	No
	LS = live load surcharge	Maybe
	PL = pedestrian live load	No
	SE = force effect due to settlement	Yes
	TG = force effect due to temperature gradient	Maybe (if seasonal)
	TU = force effect due to uniform temperature	Maybe (if seasonal)
	WA = water load and stream pressure	Yes
	WL = wind on live load	No
	WS = wind load on structure	No