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DIVISION: 03—CONCRETE
Section: 03151—Concrete Anchoring

REPORT HOLDER:

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EVALUATION SUBJECT:

ITW RED HEAD EPCON G5 ADHESIVE ANCHORING SYSTEM IN CONCRETE

1.0 EVALUATION SCOPE

Compliance with the following codes:

- 2006 *International Building Code*® (2006 IBC)
- 2006 *International Residential Code*® (2006 IRC)
- 2003 *International Building Code*® (2003 IBC)
- 2003 *International Residential Code*® (2003 IRC)
- 2000 *International Building Code*® (2000 IBC)
- 2000 *International Residential Code*® (2000 IRC)
- 1997 *Uniform Building Code*™ (UBC)

Property evaluated:

Structural

2.0 USES

The ITW Red Head EPCON G5 Adhesive Anchoring System is a post-installed anchorage system used to resist static tension, static shear and wind loads when installed in uncracked normal-weight concrete having a specified compressive strength, f'_c , of 2500 psi to 8,500 psi (17.2 MPa to 58.6 MPa). The anchoring system is an alternative to the cast-in-place anchors described in Section 1923 of the UBC, Sections 1912 and 1913 of the 2000 and 2003 IBC, and Sections 1911 and 1912 of the 2006 IBC. Engineered design is permitted in accordance with Section R301.1.2 of the 2000 IRC and Section R301.1.3 of the 2003 IRC and the 2006 IRC.

3.0 DESCRIPTION

3.1 General:

The ITW Red Head EPCON G5 Adhesive Anchoring System is a two-component structural epoxy adhesive with extended working time, used with stud-type threaded rods installed in normal-weight concrete.

Installation information and parameters are included with each adhesive unit package (cartridge, nozzle, and brushes) and are replicated in Figure 2 of this report. The adhesive system must be used with the threaded rods described in Section 3.2.2 of this report.

3.2 Materials:

3.2.1 Adhesive: The EPCON G5 adhesive has two components: an epoxy resin and an amine-based hardener. The components have an 18-month shelf life in the original, unopened containers when stored, transported, and used as noted in this report and the manufacturer's installation instructions. Adhesive is dual-component and comes in 22-fluid-ounce (0.6 L) cartridges. One side of the cartridge contains the resin and the other contains the hardener. The adhesive components are mixed to a 1:1 ratio by volume using the nozzle supplied by the adhesive manufacturer, ITW Red Head.

3.2.2 Threaded Rods: The stud-type continuously threaded rods range from $\frac{3}{8}$ inch through $1\frac{1}{4}$ inches (9.5 mm through 31.75 mm) in diameter. Carbon steel threaded rods must comply with minimum ASTM A 36 [minimum $F_u = 58,000$ psi (400 MPa)] or ASTM A 193, Grade B7 [minimum $F_u = 125,000$ psi (860 MPa)]. Stainless steel threaded rods must comply with ASTM F 593 (Alloy Type 300) [minimum $F_u = 75,000$ psi (517 MPa)].

3.2.3 Ductility: In accordance with Section D.3.3.4 of ACI 318-05 Appendix D, for the steel element to be considered ductile, the threaded rod elongation must be at least 14 percent and reduction of area must be at least 30 percent. Steel elements used for anchoring with an elongation of less than 14 percent or a reduction of area of less than 30 percent, or both, are considered brittle. Threaded rods complying with ASTM A 36 steel are considered to be ductile. The design professional must verify that the ASTM A 193 Grade B7 rod and stainless steel rods comply with this requirement. Table 3 notes steel properties for the threaded rods.

3.2.4 Concrete: Concrete in which the adhesive anchors are to be installed must be uncracked (see Condition of Use 5.9 in this report) normal-weight concrete with a minimum compressive strength at the time of anchor installation of 2,500 psi (17.2 MPa), but not less than that required by the applicable code, nor more than 8,500 psi (58.6 MPa). Concrete must comply with Sections 1903 and 1905 of the IBC and UBC.

3.2.5 Hole Clean Equipment: Hole cleaning equipment must comply with Table 5 and Figure 2.

3.2.6 Dispensers: EPCON G5 adhesive must be dispensed with the manual or pneumatic dispenser provided by ITW Red Head.

*Corrected October 2008

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4.0 DESIGN AND INSTALLATION

4.1 Strength Design:

4.1.1 General: Design strengths must be determined in accordance with ACI 318-05 Appendix D and this report. Design parameters including strength reduction factors, ϕ , corresponding to each limit state and anchor steel are provided in Table 3. Strength reduction factors, ϕ , as described in ACI 318 Section D.4.4, must be used for load combinations calculated in accordance with Section 1605.2 of the 2000, 2003 or 2006 IBC, or Section 1612.2 of the UBC. Strength reduction factors, ϕ , as described in ACI 318 Section D.4.5, must be used for load combinations calculated in accordance with Section 1909.2 of the UBC.

The concrete strength f'_c for calculation purposes must be limited to 2500 psi $\leq f'_c \leq$ 8000 psi (17.2 MPa $\leq f'_c \leq$ 55.1 MPa).

This section provides amendments to ACI 318 Appendix D as required for the strength design of adhesive anchors. In conformance with ACI 318, all equations are expressed in inch-pound units.

In lieu of ACI 318 Appendix D Section D.8.6, the critical edge distance (c_{cr}) has been determined from tests in accordance with Section 11.18 of the ICC-ES Acceptance Criteria for Post-installed Adhesive Anchors in Concrete Elements (AC308), and appropriate values are noted in Table 4 of this report. The actual edge distance and spacing cannot be less than the edge distance (c_{min}) and spacing (s_{min}) noted in Table 3 of this report.

Modify ACI 318 D.4.1.2 as follows:

D.4.1.2—In Eq. (D-1) and (D-2), ϕN_n and ϕV_n are the lowest design strengths determined from all appropriate failure modes. ϕN_n is the lowest design strength in tension of an anchor or group of anchors as determined from consideration of ϕN_{sa} , either ϕN_a or ϕN_{ag} , and either ϕN_{cb} or ϕN_{cbg} . ϕV_n is the lowest design strength in shear of an anchor or a group of anchors as determined from consideration of ϕV_{sa} , either ϕV_{cb} or ϕV_{cbg} , and either ϕV_{cp} or ϕV_{cpg} .

Add the following requirements after ACI 318 Section D.4.1.3:

D.4.1.4—For adhesive anchors installed overhead and subjected to tension resulting from sustained loading, Eq. (D-1) must also be satisfied taking $\phi N_n = 0.75 \phi N_a$ for single anchors and $\phi N_n = 0.75 \phi N_{ag}$ for groups of anchors, whereby N_{ua} is determined from the sustained load alone, e.g., the dead load and that portion of the live load acting that may be considered as sustained. Where shear loads act concurrently with the sustained tension load, interaction of tension and shear shall be analyzed in accordance with ACI Section D.4.1.3.

The following is a simple guide to use to verify that a single anchor, loaded in tension only, complies with the code and this report. Other conditions may exist. The designer is responsible for ensuring that all conditions of ACI 318.05 Appendix D and this report are met. A similar approach could be used for an anchor loaded in shear.

1. Check the minimum edge distance, anchor spacing and member thickness. (Section 4.1.9 of this report)
2. Calculate steel strength ϕN_{sa} (Section 4.1.2 of this report)
3. Determine concrete breakout strength ϕN_{cb} (Section 4.1.3 of this report). This includes determining and using appropriate:

ψ factors (ACI 318-05, Appendix D - Section 5.2)

c_{min} (Table 3 of this report)

c_{cr} (Table 4 of this report—determined from test data)

N_b (Appendix D-5.2.2)

$\phi = 0.65$ (Appendix D-4.4 Condition B)

4. Determine bond strength ϕN_a (Section 4.1.4 of this report). This includes determining and using appropriate:

s_{cr} , N_a determined in accordance with equation D-14h

c_{cr} , N_a determined in accordance with equation D-14i

$\phi = 0.65$ (Appendix D-4.4 Condition B)

5. Determine controlling strength:

Steel strength ϕN_{sa}

Concrete breakout strength ϕN_{cb}

Bond strength ϕN_a

An additional factor 0.75 may also need to be applied in accordance with D.4.1.4 in this report.

6. Convert to ASD using factor provided in Section 4.2 (if appropriate)

$$N_{allow} ASD = \frac{\Phi N}{\omega}$$

ω determined in accordance with Section 4.2 of this report

- 4.1.2 Requirements for Steel Strength in Tension:** The nominal strength of an anchor in tension as governed by the steel, N_{sa} , in accordance with ACI 318 Section D.5.1.2, is given in Table 3 of this report for the corresponding anchor steel.

- 4.1.3 Requirements for Concrete Breakout Strength in Tension:** The nominal concrete breakout strength in tension in regions where analysis indicates no cracking must be calculated in accordance with ACI 318 Section D.5.2 with the following addition:

D.5.2.9—The limiting concrete strength of adhesive anchors in tension must be calculated in accordance with D.5.2.1 to D.5.2.7 where the value for k_c used in Eq. (D-7) is noted in Table 3 (k_{unscr}).

- 4.1.4 Requirements for Pullout Strength (Bond Strength) in Tension:** In lieu of determining the nominal pullout strength in accordance with ACI 318 Section D.5.3, nominal bond strength in tension must be calculated in accordance with the following sections added to ACI 318-05, Appendix D:

D.5.3.7—The nominal bond strength of an adhesive anchor, N_a , or group of adhesive anchors, N_{ag} , in tension shall not exceed

- (a) For a single anchor

$$N_a = \frac{A_{Na}}{A_{Na0}} \cdot \psi_{ed,Na} \cdot \psi_{p,Na} \cdot N_{a0} \quad (D-14a)$$

N_{a0} must be calculated according to equation (D-14j). Also see Table 3 in this report for N_{a0} values at a depth (h_{ef}) of 4d and 9d.

- (b) For a group of anchors

$$N_{ag} = \frac{A_{Na}}{A_{Na0}} \cdot \psi_{ed,Na} \cdot \psi_{g,Na} \cdot \psi_{ec,Na} \cdot \psi_{p,Na} \cdot N_{a0} \quad (D-14b)$$

where:

A_{na} is the projected area of the failure surface for the single anchor or group of anchors that must be approximated as the base of the rectilinear geometrical figure that results from projecting the failure surface outward a $C_{cr,Na}$ distance from the centerlines of the anchor, or in the case of a group of anchors, from a line through a row of adjacent anchors. A_{na} must not exceed nA_{na0} where n is the number of anchors in tension in the group. In ACI 318 Figures RD.5.2.1(a) and RD.5.2.1(b), the terms $1.5h_{ef}$ and $3.0h_{ef}$ must be replaced with $c_{cr,Na}$ and $s_{cr,Na}$, respectively.

A_{na0} is the projected area of the failure surface of a single anchor without the influence of proximate edges in accordance with Eq. (D-14c):

$$A_{na0} = (s_{cr,Na})^2 \quad (D-14c)$$

with

$$s_{cr,Na} = \text{as given by Eq. (D-14h)}$$

D.5.3.8—The critical spacing ($s_{cr,Na}$) and critical edge ($c_{cr,Na}$) distance shall be calculated as follows:

$$s_{cr,Na} = 20 \cdot d \cdot \sqrt{\frac{\tau_{k,uncr}}{1,450}} \quad (D-14h)$$

$$c_{cr,Na} = \frac{s_{cr,Na}}{2} \quad (D-14i)$$

D.5.3.9—The basic strength of a single adhesive anchor in tension in uncracked concrete shall not exceed

$$N_{a0} = \tau_{k,uncr} \cdot \pi \cdot d \cdot h_{ef} \quad (D-14j)$$

where $\tau_{k,uncr}$ is taken from Table 3 of this report.

D.5.3.10—The modification factor for the influence of the failure surface of a group of adhesive anchors is

$$\psi_{g,Na} = \psi_{g,Na0} + \left[\left(\frac{s}{s_{cr,Na}} \right)^{0.5} \cdot (1 - \psi_{g,Na0}) \right] \geq 1.0 \quad (D-14k)$$

where:

s = spacing of anchors (see Table 3 for s_{min} requirements)

$$\psi_{g,Na0} = \sqrt{n} - \left[(\sqrt{n} - 1) \cdot \left(\frac{\tau_{k,uncr}}{\tau_{k,max,uncr}} \right)^{1.5} \right] \geq 1.0 \quad (D-14l)$$

where:

n = the number of tension-loaded adhesive anchors in a group.

$$\tau_{k,max,uncr} = \frac{k_{uncr}}{\pi \cdot d} \sqrt{h_{ef} \cdot f'_c} \quad (D-14m)$$

$\tau_{k,uncr}$ and k_{uncr} are from Table 3 of this report

D.5.3.11—The modification factor for eccentrically loaded adhesive anchor groups is

$$\psi_{ec,Na} = \frac{1}{1 + \frac{2e'_N}{s_{cr,Na}}} \leq 1.0 \quad (D-14n)$$

$$\text{Eq. (D-14n) is valid for } e'_N \leq \frac{s}{2}$$

If the loading on an anchor group is such that only certain anchors are in tension, only those anchors that are in tension shall be considered when determining the eccentricity, e'_N , for use in Eq. (D-14n).

In the case where eccentric loading exists about two orthogonal axes, the modification factor $\psi_{ec,Na}$ shall be computed for each axis individually and the product of these factors used as $\psi_{ec,Na}$ in Eq. (D-14b).

D.5.3.12—The modification factor for the edge effects for single adhesive anchors or anchor groups loaded in tension is:

$$\text{for } c_{a,min} \geq c_{cr,Na} \quad (D-14o)$$

$$\psi_{ed,Na} = 1.0$$

or

$$\text{for } c_{a,min} < c_{cr,Na} \quad (D-14p)$$

$$\psi_{ed,Na} = \left(0.7 + 0.3 \cdot \frac{c_{a,min}}{c_{cr,Na}} \right) \leq 1.0$$

D.5.3.13—Since this anchor can only be used in uncracked concrete, the modification factor shall be taken as

$$\psi_{p,Na} = 1.0 \text{ when } c_{a,m} \geq c_{ac}$$

$$\psi_{p,Na} = \frac{\max\{c_{a,m}; c_{cr,Na}\}}{c_{ac}} \text{ when } c_{a,m} < c_{ac}$$

Additional information for the determination of nominal bond strength in tension is given in Section 4.1.8.

4.1.5 Steel Strength in Shear: The nominal static strength of an anchor in shear as governed by the steel, V_{sa} , in accordance with ACI 318 D.6.1.2, is given in Table 3 of this report for the corresponding anchor steel.

4.1.6 Concrete Breakout Strength in Shear: The nominal concrete breakout strength in shear, V_{cb} or V_{cbg} , must be calculated in accordance with ACI 318 D.6.2 based on information given in Table 3 of this report.

4.1.7 Concrete Pryout Strength in Shear: In lieu of determining the nominal pryout strength in accordance with ACI 318 D.6.3.1, nominal pryout strength in shear must be calculated in accordance with the following sections added to ACI 318 Appendix D:

D.6.3.2—The nominal pryout strength of an adhesive anchor or group of adhesive anchors shall not exceed:

(a) for a single adhesive anchor:

$$V_{cp} = \min\{k_{cp} \cdot N_a; k_{cp} \cdot N_{cb}\} \quad (D-28a)$$

(b) for a group of adhesive anchors:

$$V_{cpg} = \min\{k_{cp} \cdot N_{ag}; k_{cp} \cdot N_{cbg}\} \quad (D-28b)$$

where:

$$k_{cp} = 1.0 \text{ for } h_{ef} < 2.5 \text{ in. (64 mm)}$$

$$k_{cp} = 2.0 \text{ for } h_{ef} \geq 2.5 \text{ in. (64 mm)}$$

N_a shall be calculated in accordance with Eq. (D-14a)

N_{ag} shall be calculated in accordance with Eq. (D-14b)

N_{cb}, N_{cbg} are determined in accordance with D.5.2.1

4.1.8 Bond Strength Determination: Bond strength values are a function of concrete condition (cracked, uncracked), drilling method (hammer drill, core drill) and installation

conditions (dry, water-saturated, etc.). The G5 adhesive system has been tested in uncracked concrete using a hammer drill. Therefore no reduction factors regarding installation conditions need to be applied to the bond strength value.

4.1.9 Requirements for Minimum Member Thickness, Minimum Anchor Spacing and Minimum Edge Distance:

In lieu of ACI 318 Section D.8.3, values of c_{min} and s_{min} , as given in Table 3 of this report, must be used. In lieu of ACI 318 Section D.8.5, minimum member thicknesses h_{min} as given in Tables 2 and 3 of this report must be used.

For adhesive anchors that will remain untorqued, the minimum edge distance shall be based on the minimum cover requirements of reinforcement in 7.7 of ACI 318-05. For adhesive anchors that will be torqued the minimum edge distance (c_{min}) and spacing (s_{min}) noted in Table 3 of this report shall be used, provided the anchors during installation are not torqued beyond the maximum torque noted in Table 3.

4.2 Allowable Stress Design (Optional):

For anchors designed using load combinations in accordance with IBC Section 1605.3 (Allowable Stress Design), allowable loads shall be established using the equations below.

$$T_{allowable,ASD} = \frac{\Phi N_n}{\alpha}$$

and

$$V_{allowable,ASD} = \frac{\Phi V_n}{\alpha}$$

where:

$T_{allowable,ASD}$ = Allowable tension load (lbf or kN)

$V_{allowable,ASD}$ = Allowable shear load (lbf or kN)

ΦN_n = Lowest design strength of an anchor or anchor group in tension as determined in accordance with Section 4.1 of this criteria and ACI 318, D.4.1.1 and D.4.1.2.

ΦV_n = Lowest design strength of an anchor or anchor group in shear as determined in accordance with Section 4.1 of this criteria and ACI 318, D.4.1.1 and D.4.1.2.

α = Conversion factor calculated as a weighted average of the load factors for the controlling load combination. In addition, α shall include all applicable factors to account for non-ductile failure modes and required over-strength.

Example calculation for the determination of the factor α :

For 800 lbs dead load and 1700 lbs live load, the controlling combination would be:

$$1.2D + 1.6L$$

the total load is 2500 lbs and consists of:

$$800/2500 = 32\% D$$

and

$$1700/2500 = 68\% L$$

α is determined from the controlling load combination as follows:

$$1.2D + 1.6L$$

$$\alpha = 1.2 (0.32) + 1.6 (0.68) = 1.47$$

Interaction shall be calculated consistent with ACI 318 Appendix D.7 as follows:

For shear loads $V \leq 0.2V_{allowable}$, the full allowable load in tension shall be permitted.

For tension loads $T \leq 0.2V_{allowable}$, the full allowable load in shear shall be permitted.

For all other cases:

$$\frac{T}{T_{allowable}} + \frac{V}{V_{allowable}} \leq 1.2$$

Table 6 contains an example for a specific ASD.

4.3 Installation:

4.3.1 General: The anchors must be installed in accordance with the ITW Red Head published installation instructions (Figure 2), the installation drawings and the requirements of this report. The nozzle and brushes supplied by ITW Red Head must be used along with the adhesive cartridge. See Table 5 for brush specification.

The anchors must be installed in locations where the maximum short-term concrete temperature does not exceed 110°F (43°C) and the maximum long-term concrete temperature does not exceed 70°F (21°C) during the service life of the anchor. Short-term elevated concrete temperatures are those that occur over brief intervals, e.g., as a result of diurnal cycling. Long-term concrete temperatures are roughly constant over significant periods of time.

The adhesive anchoring system may be used for floor, wall and overhead applications. However, overhead applications are limited to use with the $\frac{3}{8}$ -inch- (9.5 mm) and $\frac{1}{2}$ -inch-diameter (12.7 mm) threaded rods.

The ITW Red Head working and cure times are shown in Table 1.

4.3.2 Special Inspection: Special inspection in accordance with Section 1704 of the IBC must be provided for all anchor installations, and periodically thereafter. The code official must be provided with a report, from an approved special inspector, which includes the following details:

1. Adhesive anchor description, including the adhesive product name and expiration date; and anchor bolt or rod material, grade, diameter, length and cleanliness.
2. Hole description, including verification of drill bit compliance with ANSI B212.15-1994, hole depth and cleanliness.
3. Installation description, including verification of concrete compressive strength by ASTM C 42 methods, and installation and location (spacing and edge distance) in accordance with ITW Red Head published installation instructions and this report.

5.0 CONDITIONS OF USE

The ITW Red Head EPCON G5 Adhesive Anchoring System described in this report complies with, or is a suitable alternative to what is specified in, those codes listed in Section 1.0 of this report, subject to the following conditions:

- 5.1** The anchors must be installed in uncracked normal-weight concrete having a specified compressive strength of $f'_c = 2500$ psi to 8500 psi (17.2 MPa to 58.6 MPa) in accordance with the ITW Red Head installation instructions and this report. In the event of a conflict between the instructions of ITW Red Head and the requirements of this report, this report governs.
- 5.2** Anchors must be installed in holes predrilled into concrete using a carbide-tipped masonry drill bit manufactured within the range of the maximum and minimum drill-tip dimensions of ANSI B212.15-1994.

- 5.3** Special inspection in accordance with Section 4.3.2 must be provided for all anchor installations.
- 5.4** Strength design values must be established in accordance with Section 4.1 of this report. Allowable stress design values (if used) must be established in accordance with Section 4.2 of this report.
- 5.5** Calculations and details demonstrating compliance with this report must be submitted to the code official for approval. The calculations and installation drawings must be prepared by a registered design professional where required by the statutes of the jurisdiction in which the project is constructed.
- 5.6** Since an ICC-ES acceptance criteria for evaluating data to determine the performance of adhesive anchors subjected to fatigue or shock loading is unavailable at this time, the use of these anchors under these conditions is outside the scope of this report.
- 5.7** Adhesive anchors may be used to resist tension and shear forces in floor, overhead or wall installations only if installation is within base material having a temperature between 50°F and 110°F after installation. Additionally, overhead installations are limited to $\frac{3}{8}$ -inch (9.5 mm) and $\frac{1}{2}$ -inch-diameter (12.7 mm) threaded rods
- 5.8** Where not otherwise prohibited in the code, anchors are permitted for use with fire-resistance-rated construction provided at least one of the following conditions is fulfilled:
- Anchors resist static and wind loading only.
 - Anchors that support gravity load-bearing structural elements are within a fire-resistance-rated envelope or a fire-resistance-rated membrane, are protected by approved fire-resistance-rated materials, or have been evaluated for resistance to fire exposure in accordance with recognized standards.
 - Anchors are used to support nonstructural elements.
- 5.9** The use of the anchors is limited to installation in uncracked concrete over the service life of the anchor. Cracking occurs when $f_t > f_r$ due to service loads or deformations.
- 5.10** The anchors are limited to interior use. See Section 4.3.1 of this report for specific installation details.
- 5.11** Anchors may be installed in dry holes, damp holes, saturated holes, water-filled holes, or submerged holes.
- 5.12** Use of the anchors is limited to static tension, static shear and wind loading as noted in Section 2.0 of this report.
- 5.13** Steel anchoring materials in contact with preservative-treated wood or fire-retardant-treated wood must be stainless steel.
- 5.14** Minimum anchor spacing and edge distance as well as minimum member thickness must comply with this report.
- 5.15** The adhesive must be manufactured by ITW Red Head, in Elk Grove Village, Illinois, under a quality control program with inspections by PFS Corporation (AA-652).
- 6.0 EVIDENCE SUBMITTED**
- Data in accordance with the ICC-ES Acceptance Criteria for Post-installed Adhesive Anchors in Concrete Elements (AC308), dated January 2008.
- 7.0 IDENTIFICATION**
- The ITW Red Head adhesive is identified by labels on the adhesive cartridges bearing the adhesive manufacturer's name (ITW Red Head) and address (Addison, Illinois), the product name (EPCON G5), best-used-by expiration date, the evaluation report number (ESR-1137), and the name of the inspection agency (PFS Corporation).

TABLE 1—MANUFACTURER’S RECOMMENDED MINIMUM INITIAL WORKING TIME AND CURE TIME FOR EPCON G5 ADHESIVE

MINIMUM CONCRETE TEMP. (°F) ¹	WORKING TIME (minutes) ²	CURE TIME (hours) ³
50	15	24
70	15	24
90	9	24
110	9	24

For SI: $c^{\circ} = (^{\circ}F - 32) \times \frac{5}{9}$.

¹Adhesives must be installed in substrates at temperatures of at least 50°F to 110°F. Installations in substrates at temperatures below 50°F or above 110°F must be conditioned to proper temperatures during working time.

²Working time is the maximum time from the end of mixing to when the insertion of the anchor into the adhesive shall be completed.

³Cure time is the minimum time from the end of working time to when the anchor may be torqued or loaded. Anchors are to be undisturbed during the cure time.

TABLE 2—SPECIFICATIONS AND DETAILS FOR INSTALLATION OF ANCHORS IN CONCRETE WITH EPCON G5 ADHESIVE

PROPERTY	THREADED ROD DIAMETER (d)														
		$\frac{3}{8}$ "		$\frac{1}{2}$ "		$\frac{5}{8}$ "		$\frac{3}{4}$ "		$\frac{7}{8}$ "		1"		1 $\frac{1}{4}$ "	
Tensile stress area of rod (in ²)		0.078		0.142		0.226		0.335		0.462		0.606		0.969	
Nominal bit diameter size (in)	d_o	$\frac{7}{16}$		$\frac{9}{16}$		$\frac{3}{4}$		$\frac{7}{8}$		1		1 $\frac{1}{8}$		1 $\frac{3}{8}$	
Effective embedment depth (in) ¹	h_{ef}	1 $\frac{1}{2}$	3 $\frac{3}{8}$	2	4 $\frac{1}{2}$	2 $\frac{1}{2}$	5 $\frac{5}{8}$	3	6 $\frac{3}{4}$	3 $\frac{1}{2}$	7 $\frac{7}{8}$	4	9	5	11 $\frac{1}{4}$
Minimum hole depth (in)	h_o	1 $\frac{11}{16}$	3 $\frac{9}{16}$	2 $\frac{3}{16}$	4 $\frac{11}{16}$	2 $\frac{11}{16}$	5 $\frac{13}{16}$	3 $\frac{3}{16}$	6 $\frac{15}{16}$	3 $\frac{3}{4}$	8 $\frac{1}{8}$	4 $\frac{1}{4}$	9 $\frac{1}{4}$	5 $\frac{1}{4}$	11 $\frac{1}{2}$
Minimum slab thickness (in)	h_{min}	4	5	4	6	4	7	5	8 $\frac{1}{4}$	8	10	8	11	10	14
Maximum tightening torque for pretention (ft.lbs)	T_{inst}	9		16		47		90		145		170		370	

For SI: 1 inch = 25.4 mm, 1 lbf = 4.45N, 1ft-lbf = 1.356 N-M, 1 psi = 0.00690 MPa.

¹Minimum and maximum depths are noted.

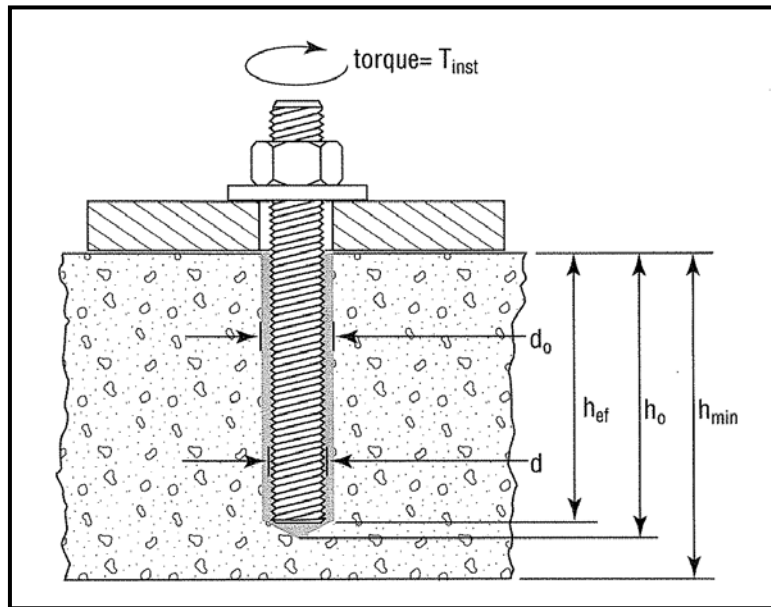


FIGURE 1—ANCHOR INSTALLATION

TABLE 3—G5 ANCHOR SYSTEM IS QUALIFIED FOR USE IN UNCRACKED CONCRETE IN ACCORDANCE WITH STEEL, CONCRETE BREAKOUT, AND BOND RESISTANCE DESIGN VALUES^{1, 2, 3, 4}

Characteristic		Symbol	Units	Anchor nominal diameter (d)							
				$\frac{3}{8}$ "	$\frac{1}{2}$ "	$\frac{5}{8}$ "	$\frac{3}{4}$ "	$\frac{7}{8}$ "	1"	1 $\frac{1}{4}$ "	
Maximum Installation torque		T_{inst}	ft-lb	9	16	47	90	145	170	370	
Effective bolt tension area		A_{se}	in. ²	0.078	0.142	0.226	0.335	0.462	0.606	0.969	
Strength reduction factor for tension, steel failure modes		ϕ	-	0.70 ¹	0.70 ¹	0.70 ¹	0.70 ¹	0.70 ¹	0.70 ¹	0.70 ¹	
Strength reduction factor for shear, steel failure modes		ϕ	-	0.65 ¹	0.65 ¹	0.65 ¹	0.65 ¹	0.65 ¹	0.65 ¹	0.65 ¹	
Carbon Steel A36	Min. specified yield strength	f_y	psi	36000	36000	36000	36000	36000	36000	36000	
	Min. specified ultimate strength	f_{ut}	psi	58000	58000	58000	58000	58000	58000	58000	
	Nominal steel strength in tension	N_{sa}	lb	4500	8230	13110	19400	26780	35130	56210	
	Nominal steel strength in shear	V_{sa}	lb	2700	4940	7870	11640	16070	21080	33730	
Carbon Steel A193 B7	Min. specified yield strength	f_y	psi	105,000	105,000	105,000	105,000	105,000	105,000	105,000	
	Min. specified ultimate strength	f_{ut}	psi	125,000	125,000	125,000	125,000	125,000	125,000	125,000	
	Nominal steel strength in tension	N_{sa}	lb	9,690	17,740	28,250	41,810	57,710	75,710	121,140	
	Nominal steel strength in shear	V_{sa}	lb	5,810	10,640	16,950	25,090	34,630	45,430	72,680	
Stainless Steel F593	Min. specified yield strength	f_y	psi	30000	30000	30000	30000	30000	30000	30000	
	Min. specified ultimate strength	f_{ut}	psi	75000	75000	75000	75000	75000	75000	75000	
	Nominal steel strength in tension	N_{sa}	lb	5810	10640	16950	25090	34630	45430	72680	
	Nominal steel strength in shear	V_{sa}	lb	3490	6390	10170	15050	20780	27260	43610	
Embedment depth(min. to max) ²		h_{ef}	in.	See Table 2 in this report							
Anchor category periodic inspection				1	1	1	1	1	1	1	
N_{ao} (for 4d/ for 9d) ³				1460/3280	Note ³	Note ³	Note ³	Note ³	Note ³	Note ³	
Effectiveness factor for uncracked concrete, used for ACI 318 design		k_{uncr}	-	24	27	30	30	30	30	30	
Characteristic bond resistance in uncracked concrete ⁴		ϕk_{uncr}	psi	825	1495	1495	1495	1495	1495	1360	
Strength reduction factor for tension, concrete failure modes ¹		ϕ	Cond A	NA	NA	NA	NA	NA	NA	NA	
			Cond B	0.65	0.65	0.65	0.65	0.65	0.65	0.65	
Strength reduction factor for shear, concrete failure modes ¹		ϕ	Cond A	NA	NA	NA	NA	NA	NA	NA	
			Cond B	0.70	0.70	0.70	0.70	0.70	0.70	0.70	
Minimum concrete thickness	$h_{ef}=4d$	h_{min}	in.	4	4	4	5	8	8	10	
	$h_{ef}=9d$	h_{min}	in.	5	6	7	8 $\frac{1}{2}$	10	11 $\frac{1}{2}$	14	
Minimum spacing		s_{min}		See Footnote 5 below						4	5
Minimum edge distance		c_{min}	in.	$\frac{15}{16}$	1	2 $\frac{1}{2}$	6	3 $\frac{1}{2}$	4	5	

For SI: 1 inch = 25.4mm, 1 lbf = 4.45N, 1ft-lbf = 1.356N-m, 1psi = 0.006895MPa.

¹ Strength reduction factors are given for load combination determined according to ACI318 Appendix D D.4.4

² For intermediate embedment depth the value of N_{ao} may be interpolated

³ N_{ao} is calculated according to Equation (D-14j) in this report.

⁴ The bond resistance is not affected by installation conditions such as water-saturated or water-filled hole. Therefore no reduction factors need to be applied for these types of conditions.

⁵ Minimum spacing shall be calculated using the value obtain from Equation (D-14h).

TABLE 4—CRITICAL EDGE DISTANCE C_{ac}

h_{ef}/d	D	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1	$1\frac{1}{4}$
4	Hef	$1\frac{1}{2}$	2	$2\frac{1}{2}$	3	$3\frac{1}{2}$	4	5
	C_{ac}	$2\frac{1}{2}$	4	5	6	7	8	10
5	Hef	2	$2\frac{1}{2}$	3	4	$4\frac{1}{2}$	5	$6\frac{1}{2}$
	C_{ac}	$3\frac{1}{2}$	$5\frac{1}{2}$	$6\frac{1}{2}$	$8\frac{1}{2}$	10	$11\frac{1}{2}$	15
6	Hef	$2\frac{1}{2}$	3	4	$4\frac{1}{2}$	$5\frac{1}{2}$	6	$7\frac{1}{2}$
	C_{ac}	$4\frac{1}{2}$	$6\frac{1}{2}$	$8\frac{1}{2}$	11	13	$15\frac{1}{2}$	21
7	Hef	$2\frac{1}{2}$	$3\frac{1}{2}$	$4\frac{1}{2}$	$5\frac{1}{2}$	6	7	9
	C_{ac}	$5\frac{1}{2}$	8	$10\frac{1}{2}$	$13\frac{1}{2}$	17	$20\frac{1}{2}$	28
8	Hef	3	4	5	6	7	8	10
	C_{ac}	$6\frac{1}{2}$	$9\frac{1}{2}$	13	17	21	$25\frac{1}{2}$	36
9	Hef	$3\frac{3}{8}$	$4\frac{1}{2}$	$5\frac{5}{8}$	$6\frac{3}{4}$	$7\frac{7}{8}$	9	$11\frac{1}{4}$
	C_{ac}	$7\frac{1}{2}$	$11\frac{1}{2}$	$15\frac{1}{2}$	$20\frac{1}{2}$	$25\frac{1}{2}$	$31\frac{1}{2}$	45

For SI: 1 inch = 25.4mm.

TABLE 5—BRUSH SPECIFICATIONS

Brush color	Part #	(d) Anchor diameter (in)	(d ₀) Drill bit diameter (in)	(d _{brush}) Brush diameter (in)
Grey	SB038	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{5}{8}$
Brown	SB012	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{3}{4}$
Green	SB058	$\frac{5}{8}$	$\frac{3}{4}$	1
Yellow	SB034	$\frac{3}{4}$	$\frac{7}{8}$	$1\frac{1}{4}$
Red	SB078	$\frac{7}{8}$	1	$1\frac{1}{2}$
Purple	SB010	1	$1\frac{1}{8}$	$1\frac{5}{8}$
Blue	SB125	$1\frac{1}{4}$	$1\frac{3}{8}$	$1\frac{3}{4}$

For SI: 1 inch = 25.4mm.

TABLE 6—CHARACTERISTIC BOND STRENGTH AND ALLOWABLE STRESS DESIGN (ASD) FOR TENSION LOADS FOR AN A36 THREADED ROD ANCHORS INSTALLED IN $f'_c = 2,500$ psi CONCRETE WITH EPCON G5 ADHESIVE

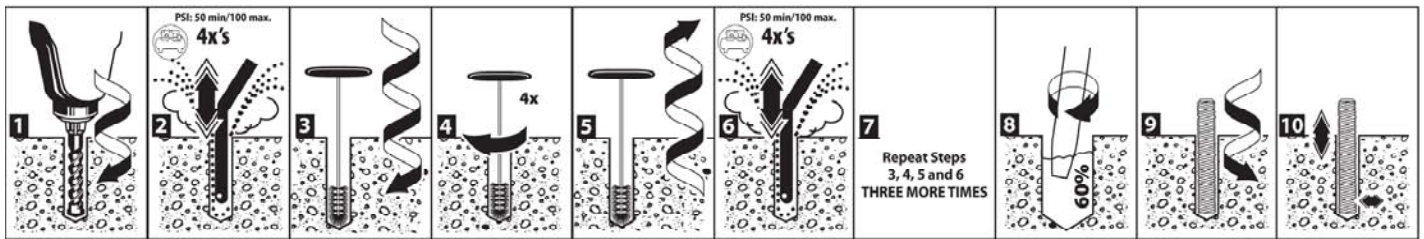
Anchor Diameter (d)	Embedment Depth, h_{ef} (in) (min. / max.)	Maximum Tightening torque for pretension, T_{inst} (ft-lb)	Char. Bond Strength $\tau_{k,uncr}$ (psi)	Allowable Load (lb) 2500psi- 8000psi
				Tension
$\frac{3}{8}$	$1\frac{1}{2}$	9	825	640
	$3\frac{3}{8}$			1440
$\frac{1}{2}$	2	16	1495	1680
	$4\frac{1}{2}$			4170
$\frac{5}{8}$	$2\frac{1}{2}$	47	1495	2605
	$5\frac{5}{8}$			6645
$\frac{3}{4}$	3	90	1495	3425
	$6\frac{3}{4}$			9830
$\frac{7}{8}$	$3\frac{1}{2}$	145	1495	4315
	$7\frac{7}{8}$			13570
1	4	170	1495	5270
	9			17780
$1\frac{1}{4}$	5	370	1360	7365
	$11\frac{1}{4}$			4860

For SI: 1 inch = 25.4mm, 1 lbf = 4.45N, 1ft-lbf = 1.356 N-M, 1 psi = 0.006895 MPa.

This table was developed based on the following conditions:

¹Single anchor with static tension load only.²Vertical downward or horizontal installation direction.³Inspection regimen = Periodic.⁴Installation temperature = 50°F to 110°F.⁵Long term temperature = 70°F.⁶Short term temperature = 110°F.⁷Dry and wet hole condition (carbide drilled hole).⁸Embedment = h_{ef} (min/max for each diameter).⁹Concrete determined to remain uncracked for the life of the anchorage.¹⁰Load combinations from ACI 318 Section 9.2 (no seismic loading).¹¹30% dead load and 70% live load, controlling load combination 1.2D + 1.6L.¹²Calculation of weighted average for $\alpha = 0.3*1.2 + 0.7*1.6 = 1.48$.¹³ $f'_c = 2,500$ psi (normal weight concrete).¹⁴ $C_{a1} = C_{a2} \geq C_{ac}$.¹⁵ $h \geq h_{min}$.

G5 Adhesive Anchor Installation Instructions



- 1**
 - Use a rotary hammer drill or pneumatic air drilling machine with a drill bit complying with ANSI B212.15.1994 tolerance standards.
 - Drill depth is a minimum four times rod diameter thru maximum nine times rod diameter. See attached tables for general guidelines and construction specifications for specific requirements.
 - Use a drill bit equal to the rod diameter plus $\frac{1}{16}$ " (for $\frac{3}{8}$ " \varnothing and $\frac{1}{2}$ " \varnothing) and $\frac{1}{8}$ " (for $\frac{5}{8}$ " \varnothing and above).
 - The $\frac{3}{8}$ " \varnothing and $\frac{1}{2}$ " \varnothing are acceptable for overhead, horizontal, and floor installation direction. The $\frac{5}{8}$ " \varnothing and above permitted for horizontal and floor installation direction only.
 - Per construction specification, adhere to minimum spacing, minimum edge distance, and minimum member thickness.
- 2**
 - Oscillate a clean air nozzle in and out of the hole four times, for a total of four seconds, starting at the bottom, with contaminant free compressed air exhausting hole until visually clean (i.e., no trace oils, antifreeze, et cetera).
 - If hole is water filled or contains sludge/debris; the hole can be clean with pressured clean water for optimum cleaning method verse compressed air.
- 3**
 - Select and insert an appropriately sized Red Head brush from part no. SB038, SB012, SB058, SB034, SB078, SB010, SB125, or match color to anchor diameter. See attached brush specifications table.
 - Insert brush into the hole with a clockwise motion, while completing one full turn for every $\frac{1}{2}$ " forward advancement further until bottom is reached. For faster and more suitable cleaning, attach the brush to a drill.
- 4**
 - Twist/Spin the brush four full turns at bottom of the hole.
- 5**
 - Using a clockwise motion, for every full turn of the brush, pull the brush $\frac{1}{2}$ " out of the hole.
 - Air clean the dust or water clean the slurry off of brush to prevent clogging of brush.
- 6**
 - Oscillate a clean air nozzle in and out of the hole four times, for a total of four seconds, starting at the bottom with contaminant free compressed air exhausting hole until visually clean.
 - Or, use pressure clean water to clean.
- 7**
 - Repeat steps 3, 4, 5, and 6 (brushing and blowing) three more times before proceeding to step 8.
 - Leave no dust, slurry, in the hole.
- 8**
 - Assemble Red Head supplied cartridge and nozzle.
 - Place assembly into a hand or pneumatic injection tool. Dispense mixed adhesive outside of hole until uniform color is achieved.
 - Insert the nozzle tip to the far end of the hole, inject the adhesive at an angle from the bottom into the hole and leave the nozzle tip always slightly below the fill level working, in a slow circular direction, work the adhesive into the side of the hole, filling slowly to prevent air entrapment, until the hole is filled 60% full. After installing the anchor the gap between the rod and the concrete must be completely filled with adhesive.
 - If the working time has not expired the rod can be removed from an under filled holes and additional adhesives can be injected into the hole. Otherwise the installation shall be rejected. For flush application trowel off excess.
 - For holes that contain water, keep injecting below the water and the adhesive will displace the water upward and prevent drawing water into the adhesive.
 - During installation, concrete must be between 50°F to 110°F or artificially maintained.
- 9**
 - Insert rod with a counterclockwise motion to prevent air entrapment.
 - Install rod into adhesive without delay after adhesive is injected into hole during working time of the adhesive.
 - Insure that the adhesive fills voids, crevices and uniformly coats rod and concrete.
 - Carefully work out the air pockets with an oil, rust and scale free rod, pushing to bottom of the hole while twisting and jiggling to ensure coverage.
- 10**
 - Jiggle rod slightly, immediately after installation, and do not disturb during working time.
 - Cure time is 24 hours.

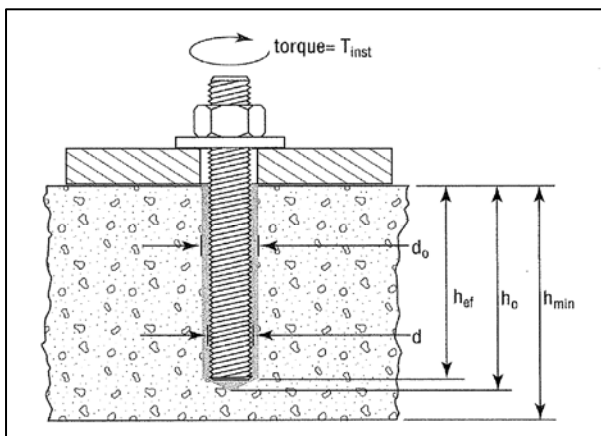
FIGURE 2—ANCHOR INSTALLATION INSTRUCTIONS

Specifications and details for installation of anchors in concrete with Epcon G5 Adhesive

PROPERTY		THREADED ROD DIAMETER (d)													
		3/8"		1/2"		5/8"		3/4"		7/8"		1"		1 1/4"	
Tensile stress area of rod (in ²)	A_{se}	0.078		.142		.226		.335		.462		.606		.969	
Nominal carbide bit diameter size (in.)	d_o	7/16		9/16		3/4		7/8		1		1 1/8		1 3/8	
Effective embedment depth (in.)	h_{ef} min/max	1 1/2	3 3/8	2	4 1/2	2 1/2	5 5/8	3	6 3/4	3 1/2	7 7/8	4	9	5	11 1/4
Min./Max Hole depth (in.)	h_o min/max	1 11/16	3 9/16	2 3/16	4 11/16	2 11/16	5 13/16	3 3/16	6 15/16	3 3/4	8 1/8	4 1/8	9 1/4	5 1/4	11 1/2
Minimum Slab thickness (in.)	h_{min}	4	5	4	6	4	7	5	8 1/4	8	10	8	11	10	14
Maximum Tightening Torque for pretension Clamping (ft-lb)	T_{inst}	9		16		47		90		145		170		370	

For SI: 1 inch = 25.4mm, 1 lbf = 4.45N, 1ft-lbf = 1.356N-m, 1psi = 0.006895MPa.

Anchor Installation



Brush Specification

Brush color	Part #	(d) Anchor diameter (in)	(d _o) Drill bit diameter (in)	(d _{brushφ}) Brush diameter (in)
Grey	SB038	3/8	7/16	5/8
Brown	SB012	1/2	9/16	3/4
Green	SB058	5/8	3/4	1
Yellow	SB034	3/4	7/8	1 1/4
Red	SB078	7/8	1	1 1/2
Purple	SB010	1	1 1/8	1 5/8
Blue	SB125	1 1/4	1 3/8	1 3/4

Manufacturer's Recommended Minimum Initial Working Time and Cure Time for EPCON G5 Adhesive

Minimum Concrete Temp. (°F) ¹	Working Time (minutes) ²	Cure Time (hours) ³
50	15	24
70	15	24
90	9	24
110	9	24

For SI: t° (°F-32) X .555 = °C.

¹Adhesives must be installed in substrates at temperatures of at least 50°F to 110°F. Installations in substrates at temperatures below 50°F or above 110°F must be conditioned to proper temperatures during working time.

²Working time is the maximum time from the end of mixing to when the insertion of the anchor into the adhesive shall be completed.

³Cure time is the minimum time from the end of working time to when the anchor may be torque or loaded. Anchors are to be undisturbed during the cure time.

FIGURE 2 (Continued)