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ICC-ES Evaluation Report

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DIVISION: 03 00 00—CONCRETE
Section: 03 16 00—Concrete Anchors

REPORT HOLDER:

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EVALUATION SUBJECT:

TITEN HD® SCREW ANCHOR AND TITEN HD® ROD HANGER FOR CRACKED AND UNCRACKED CONCRETE

1.0 EVALUATION SCOPE

Compliance with the following codes:

- 2012, 2009, 2006 and 2003 *International Building Code®* (IBC)
- 2012, 2009, 2006 and 2003 *International Residential Code®* (IRC)

Property evaluated:

Structural

2.0 USES

The Simpson Strong-Tie® Titen HD® Screw Anchor is used to resist static, wind and seismic tension and shear loads in cracked and uncracked normal-weight concrete and sand-lightweight concrete members having a specified compressive strength, f'_c, from 2,500 psi to 8,500 psi (17.2 MPa to 58.6 MPa); and cracked and uncracked sand-lightweight or normal-weight concrete over profile steel deck having a minimum specified compressive strength, f'_c, of 3,000 psi (20.7 MPa).

The Simpson Strong-Tie Titen HD® Rod Hanger is used to resist static, wind and seismic tension loads in cracked and uncracked normal-weight concrete and sand-lightweight concrete members having a specified compressive strength, f'_c, from 2,500 psi to 8,500 psi (17.2 MPa to 58.6 MPa); and cracked and uncracked sand-lightweight or normal-weight concrete over profile steel deck having a minimum specified compressive strength, f'_c, of 3,000 psi (20.7 MPa).

The Simpson Strong-Tie® Titen HD® Screw Anchors and Rod Hangers are alternatives to anchors described in Sections 1908 and 1909 of the 2012 IBC, Sections 1911 and 1912 of the 2009 and 2006 IBC and Sections 1912 and 1913 of the 2003 IBC. The anchors may also be used where an engineered design is submitted in accordance with Section R301.1.3 of the IRC.

3.0 DESCRIPTION

3.1 Titen HD® Screw Anchor:

The Titen HD® Screw Anchor is a carbon steel threaded anchor with a hex-washer head. The screw anchor is manufactured from heat-treated steel complying with SAE J403 Grade 10B21, and has an electrodeposited coating of zinc, minimum thickness 0.0002 inch (5 µm) in accordance with ASTM B 633, SC1, Type III. Titen HD® Screw Anchors are available with nominally $^3/_8$-, $^1/_2$-, $^5/_8$-, and $^3/_4$-inch (9.5, 12.7, 15.9, and 19.1 mm) shank diameters, and various lengths in each diameter. Figure 1A illustrates a typical Titen HD® Screw Anchor.

3.2 Titen HD® Rod Hanger:

The Titen HD® Rod Hanger is a carbon steel threaded anchor with an oversized hex-washer head that is internally threaded. The rod hanger is manufactured from heat-treated steel complying with SAE J403 Grade 10B21, and has an electrodeposited coating of zinc, minimum thickness 0.0002 inch (5 µm), in accordance with ASTM B633, SC1, Type III. The Titen HD® Rod Hanger is available with a nominally $^3/_8$-inch (9.5 mm) shank diameter and either $^3/_8$-inch- or $^1/_2$-inch-diameter (9.5 mm or 12.7 mm) internal threads. Figure 1B illustrates the Titen HD® Rod Hanger.

3.3 Concrete:

Normal-weight and sand-lightweight concrete must comply with Sections 1903 and 1905 of the IBC.

3.4 Profile Steel Deck:

The profile steel deck must comply with the configuration in Figures 3 and 4 and have a minimum base steel thickness of 0.035 inch (0.889 mm). Steel deck must comply with ASTM A 653/A 653M SS Grade 33, and have a minimum yield strength of 33 ksi (228 MPa).

4.0 DESIGN AND INSTALLATION

4.1 Strength Design:

4.1.1 General: Design strength of anchors complying with the 2012 and 2003 IBC, as well as Section R301.1.3 of the 2012 and 2003 IRC, must be determined in accordance with ACI 318-11 Appendix D and this report.

Design strength of anchors complying with the 2009 IBC, as well as Section R301.1.3 of the 2009 IRC, must be determined in accordance with ACI 318-08 Appendix D and this report.

Design strength of anchors complying with the 2006 IBC and 2006 IRC must be in accordance with ACI 318-05 Appendix D and this report.

Design parameters provided in Table 1 through 4 and in Figures 2 through 4 of this report are based on the 2012 IBC (ACI 318-11) unless noted otherwise in Section 4.1.1 through 4.1.12 of this report.

The strength design of anchors must comply with ACI 318 D.4.1, except as required in ACI 318 D.3.3. Strength reduction factors, ϕ, as given in ACI 318-11 D.4.3, and noted in Tables 2 and 3 of this report, must be used for load combinations calculated in accordance with Section 1605.2.1 of the IBC and Section 9.2 of ACI 318. Strength reduction factors, ϕ, as given in ACI 318-11 D.4.4 must be used for load combinations calculated in accordance with ACI 318 Appendix C. The value of f'_c used in the calculations must be limited to a maximum of 8,000 psi (55.2 MPa), in accordance with ACI 318-11 D.3.7.

4.1.2 Requirements for Static Steel Strength in Tension: The nominal steel strength of a single screw anchor in tension, N_{sa}, calculated in accordance with ACI 318 D.5.1.2, is given in Table 2 of this report. The strength reduction factor, ϕ, corresponding to a brittle steel element must be used for all anchors, as given in Table 2.

4.1.3 Requirements for Static Concrete Breakout Strength in Tension: The nominal concrete breakout strength of a single screw anchor or a group of screw anchors in tension, N_{cb} or N_{cbg}, respectively, must be calculated in accordance with ACI 318 D.5.2, with modifications as described in this section. The basic concrete breakout strength of a single screw anchor in tension in cracked concrete, N_b, must be calculated in accordance with ACI 318 D.5.2.2 using the values of h_{ef} and k_{cr} as given in Table 2 of this report. The nominal concrete breakout strength in tension in regions where analysis indicates no cracking in accordance with ACI 318 D.5.2.6 must be calculated with the value of k_{uncr} as given in Table 2 of this report and with $\Psi_{c,N}$ = 1.0.

Determination of concrete breakout strength in accordance with ACI 318 D.5.2 is not required for anchors installed in the lower flute or upper flute of the soffit of profile steel deck floor and roof assemblies with sand-lightweight or normal-weight concrete fill as shown in Figure 3 or Figure 4, respectively.

4.1.4 Requirements for Static Pullout Strength in Tension: The nominal pullout strength of a single screw anchor or a group of screw anchors in tension in accordance with ACI 318 D.5.3.1 and D.5.3.2 in cracked and uncracked concrete, $N_{p,cr}$ and $N_{p,uncr}$, respectively, is given in Table 2 of this report and must be used in lieu of N_p. In regions of a concrete member where analysis indicates no cracking at service level loads in accordance with ACI 318 D.5.3.6, the nominal pullout strength in uncracked concrete, $N_{p,uncr}$, applies. Where values for $N_{p,cr}$ or $N_{p,uncr}$ are not provided in Table 2, the pullout strength does not need to be considered in design.

The nominal pullout strength in cracked concrete for anchors installed in the lower flute or upper flute of the soffit of sand-lightweight or normal-weight concrete filled profile steel deck floor and roof assemblies as shown in Figures 3 and 4, $N_{p,deck,cr}$, is given in Table 4. $N_{p,deck,cr}$ must be used in lieu of $N_{p,cr}$. In regions of a concrete member where analysis indicates no cracking in accordance with ACI 318 D.5.3.6, the nominal pullout strength in uncracked concrete $N_{p,deck,uncr}$ applies in lieu of $N_{p,uncr}$.

The value of $\Psi_{c,p}$ equals 1.0 for all design cases.

4.1.5 Requirements for Static Steel Strength in Shear: The nominal steel strength in shear, V_{sa}, of a single screw anchor in accordance with ACI 318 D.6.1.2, is given in Table 3 of this report and must be used in lieu of the values derived by calculation from ACI 318-11 Eq. D-29. The strength reduction factor, ϕ, corresponding to a brittle steel element must be used for all anchors, as described in Table 3.

The nominal shear strength, $V_{sa,deck}$, of a single screw anchor installed in the lower flute or upper flute of the soffit of sand-lightweight or normal-weight concrete filled profile steel deck floor and roof assemblies, as shown in Figures 3 and 4, is given in Table 4.

4.1.6 Requirements for Static Concrete Breakout Strength in Shear: The nominal concrete breakout strength in shear of a single screw anchor or group of screw anchors, V_{cb} or V_{cbg}, respectively, must be calculated in accordance with ACI 318 D.6.2, with modifications as described in this section. The basic concrete breakout strength in shear of a single screw anchor in cracked concrete, V_b, must be calculated in accordance with ACI 318 D.6.2.2 using the values of l_e and d_a as given in Table 3 of this report. The modification factors in ACI 318 D.6.2.4, D.6.2.5, D.6.2.6 and D.6.2.7 must be applied to the basic breakout strength in shear, V_b, as applicable.

Calculation of the concrete breakout strength in accordance with ACI 318 D.6.2 is not required for screw anchors installed in the lower flute or upper flute of the soffit of sand-lightweight or normal-weight concrete filled profile steel deck floor and roof assemblies, as shown in Figures 3 and 4.

4.1.7 Requirements for Static Concrete Pryout Strength in Shear: The nominal concrete pryout strength for a single screw anchor or group of screw anchors, V_{cp} or V_{cpg}, respectively, must be calculated in accordance with ACI 318 D.6.3, using the coefficient for pryout strength, k_{cp}, provided in Table 3 of this report and the value of nominal breakout strength in tension of a single screw anchor or group screw anchors, N_{cb} or N_{cbg}, as calculated in Section 4.1.3 of this report.

For anchors installed in the lower flute or upper flute of the soffit of sand-lightweight or normal-weight concrete filled profile steel deck floor and roof assemblies, as shown in Figure 3 or Figure 4, respectively, calculation of the concrete pryout strength in accordance with ACI 318 D.6.3 is not required.

4.1.8 Requirements for Seismic Design:

4.1.8.1 General: When the screw anchor design includes seismic loads, the design must be performed in accordance with ACI 318 D.3.3. For the 2012 IBC, Section 1905.1.9 shall be omitted. Modifications to ACI 318 D.3.3 shall be applied under Section 1908.1.9 of the 2009 IBC, Section 1908.1.16 of the 2006 IBC, or the following:

CODE	ACI 318 D.3.3 SEISMIC REGION	CODE EQUIVALENT DESIGNATION
2003 IBC & 2003 IRC	Moderate or high seismic risk	Seismic Design Categories C, D, E and F

Except for use in Seismic Design Category A or B of the IBC, design strengths must be determined presuming the concrete is cracked unless it can be demonstrated that the concrete remains uncracked.

The nominal steel strength and nominal concrete breakout strength of anchors in tension, and the nominal concrete breakout strength and pryout strength of anchors in shear, must be calculated according to ACI 318 D.5 and D.6, respectively, taking into account the corresponding values in Tables 1 through 4.

The screw anchors comply with ACI 318 D.1 as brittle steel elements and must be designed in accordance with ACI 318-08 D.3.3.5 or D.3.3.6 or ACI 318-05 D.3.3.5, as applicable.

4.1.8.2 Seismic Tension: The nominal steel strength and concrete breakout strength in tension must be determined in accordance with ACI 318 D.5.1 and D.5.2, as described in Sections 4.1.2 and 4.1.3 of this report. In accordance with ACI 318 D.5.3.2, the appropriate value for nominal pullout strength in tension for seismic loads, $N_{p,eq}$ or $N_{p,deck,cr}$, described in Tables 2 and 4 of this report, must be used in lieu of N_p.

4.1.8.3 Seismic Shear: The nominal concrete breakout and concrete pryout strength in shear must be determined in accordance with ACI 318 D.6.2 and D.6.3, as described in Sections 4.1.6 and 4.1.7 of this report. In accordance with ACI 318 D.6.1.2, the appropriate value for nominal steel strength in shear for seismic loads, $V_{sa,eq}$, or $V_{sa,deck,eq}$ described in Tables 3 and 4 of this report, must be used in lieu of V_{sa}.

4.1.9 Interaction of Tensile and Shear Forces: Screw anchors or groups of screw anchors that are subjected to combined axial (tensile) and shear loadings must be designed in accordance with ACI 318 D.7.

4.1.10 Requirements for Minimum Member Thickness, Minimum Anchor Spacing and Minimum Edge Distance: In lieu of ACI 318 D.8.1 and D.8.3, values of c_{min} and s_{min} provided in Table 1 of this report must be used. In lieu of ACI 318 D.8.5, minimum member thickness, h_{min}, must comply with Table 1 of this report.

For anchors installed in the lower flute or upper flute of the soffit of sand-lightweight or normal-weight concrete filled profile steel deck floor and roof assemblies, details in Figures 3 and 4 must be observed. The minimum anchor spacing along the flute must be the greater of $3h_{ef}$ or 1.5 times the flute width.

4.1.11 Requirements for Critical Edge Distance: In applications where $c < c_{ac}$ and supplemental reinforcement to control splitting of the concrete is not present, the concrete breakout strength in tension for uncracked concrete, calculated according to ACI 318 D.5.2, must be further multiplied by the factor $\psi_{cp,N}$ given by Eq-1:

$$\psi_{cp,N} = \frac{c}{c_{ac}} \qquad \text{(Eq-1)}$$

whereby the factor $\psi_{cp,N}$ need not be taken less than $\frac{1.5h_{ef}}{c_{ac}}$.
For all other cases, $\psi_{cp,N}$ = 1.0. In lieu of using ACI 318 D.8.6, values of c_{ac} provided in Table 1 of this report must be used.

4.1.12 Requirements for Sand-lightweight Concrete: For ACI 318-11 and ACI 318-08, when anchors are used in sand-lightweight concrete, the modification factor λ_a or λ, respectively, for concrete breakout strength must be taken as 0.6 in lieu of ACI 318-11 D.3.6 (2012 IBC) or ACI 318-08 D.3.4 (2009 IBC). In addition, the pullout strength $N_{p,uncr}$, $N_{p,cr}$, and $N_{p,eq}$ must be multiplied by 0.6, as applicable.

For ACI 318-05, the values N_b, $N_{p,eq}$, $N_{p,uncr}$, $N_{p,cr}$, and V_b determined in accordance with this report must be multiplied by 0.60, in lieu of ACI 318 D.3.4.

For anchors installed in the lower flute or upper flute of the soffit of sand-lightweight concrete filled profile steel deck floor and roof assemblies, this reduction is not required.

4.2 Allowable Stress Design (ASD):

4.2.1 General: Design values for use with allowable stress design load combinations calculated in accordance with Sections 1605.3 of the IBC must be established using the following equations:

$$T_{allowable,ASD} = \frac{\phi N_n}{\alpha} \qquad \text{(Eq-2)}$$

and

$$V_{allowable,ASD} = \frac{\phi V_n}{\alpha} \qquad \text{(Eq-3)}$$

where:

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

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

ϕN_n = The lowest design strength of an anchor or anchor group in tension as determined in accordance with ACI 318 Appendix D, Section 4.1 of this report, and either 2009 IBC Section 1908.1.9 or 2006 IBC Section 1908.1.16, as applicable (lbf or N).

ϕV_n = The lowest design strength of an anchor or anchor group in shear as determined in accordance with ACI 318 Appendix D, Section 4.1 of this report, and either 2009 IBC Section 1908.1.9 or 2006 IBC Section 1908.1.16, as applicable (lbf or N).

α = A conversion factor calculated as a weighted average of the load factors for the controlling load combination. In addition, α must include all applicable factors to account for nonductile failure modes and required over-strength.

An example calculation for the derivation of allowable stress design tension values is presented in Table 5.

The requirements for member thickness, edge distance and spacing, described in Table 1 of this report, must apply.

4.2.2 Interaction of Tensile and Shear Forces: The interaction of tension and shear loads must be consistent with ACI 318 D.7, as follows:

If $T_{applied} \leq 0.2T_{allowable,ASD}$, then the full allowable strength in shear, $V_{allowable,ASD}$, shall be permitted.

If $V_{applied} \leq 0.2V_{allowable,ASD}$, then the full allowable strength in tension, $T_{allowable,ASD}$, shall be permitted.

For all other cases:

$$\frac{T_{applied}}{T_{allowable,ASD}} + \frac{V_{applied}}{V_{allowable,ASD}} \leq 1.2 \qquad \text{(Eq-4)}$$

4.3 Installation:

Installation parameters are provided in Table 1 and Figures 2, 3, and 4. Anchor locations must comply with this report and the plans and specifications approved by the code official. The Titen HD® Screw Anchors and Rod Hangers must be installed in accordance with the manufacturer's published instructions and this report. Anchors must be installed by drilling a pilot hole into the concrete using a handheld electro-pneumatic rotary hammer drill with a carbide-tipped drill bit conforming to ANSI B212.15-1994. The pilot hole must have the same nominal diameter as the nominal diameter of the anchor. For $^3/_8$-inch (9.5 mm) Titen HD® Screw Anchors and Rod Hangers, the hole is drilled to the specified nominal embedment depth plus $^1/_4$

inch (6.3mm). For $^1/_2$-, $^5/_8$- and $^3/_4$-inch (12.7, 15.9 and 19.1 mm) Titen HD® Screw Anchors, the hole is drilled to the specified nominal embedment depth plus $^1/_2$ inch (12.7mm). Dust and debris in the hole must be removed by using oil-free compressed air. The Titen HD® Screw Anchors and Rod Hangers must be installed into the hole to the specified embedment depth using a socket wrench or powered impact wrench. The maximum installation torque and maximum impact wrench torque rating requirements for the Titen HD® Screw Anchor and Rod Hangers are detailed in Table 1. Titen HD® Screw Anchors and Rod Hangers may be loosened by a maximum one turn and reinstalled with a socket wrench or powered impact wrench to facilitate fixture attachment or realignment.

For anchors installed in the lower flute or upper flute of the soffit of sand-lightweight or normal-weight concrete over profile steel deck floor and roof assemblies, the hole diameter in the steel deck must not exceed the diameter of the hole in the concrete by more than $^1/_8$ inch (3.2 mm).

4.4 Special Inspection:

Periodic special inspection is required in accordance with Section 1704.15 of the 2009 IBC or Section 1704.13 of the 2006 or 2003 IBC. The special inspector must make periodic inspections during anchor installation to verify anchor type, anchor dimensions, hole cleaning procedure, embedment depth, concrete type, concrete compressive strength, concrete member thickness, hole dimensions, anchor spacing, edge distance, installation torque, maximum impact wrench torque rating, and adherence to the manufacturer's published installation instructions. The special inspector must be present as often as required in accordance with the "statement of special inspection."

Under the IBC, additional requirements as set forth in Section 1705, 1706 or 1707 must be observed, where applicable.

5.0 CONDITIONS OF USE

The Simpson Strong-Tie® Titen HD® Screw Anchors and Rod Hangers described in this report comply with, or are suitable alternatives 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 accordance with the manufacturer's published installation instructions and this report. In case of conflict, this report governs.

5.2 Anchor sizes, dimensions and minimum embedment depths are set forth in the tables of this report.

5.3 The anchor must be installed in accordance with Section 4.3 of this report in cracked and uncracked normal-weight and sand-lightweight concrete having a compressive strength, f'_c, of 2,500 psi to 8,500 psi (17.2 MPa to 58.6 MPa); and cracked and uncracked sand-lightweight or normal-weight concrete over profile steel deck having a minimum specified compressive strength, f'_c, of 3,000 psi (20.7 MPa).

5.4 The value of f'_c used for calculation purposes must not exceed 8,000 psi (55.2 MPa).

5.5 Strength design values must be established in accordance with Section 4.1 of this report.

5.6 Allowable stress design values must be established in accordance with Section 4.2 of this report.

5.7 Anchor spacing(s) and edge distance(s), as well as minimum member thickness, must comply with Tables 1 and 4, and Figures 3 and 4 of this report.

5.8 Reported values for the Titen HD® Rod Hanger do not consider the steel insert element which must be verified by the design professional.

5.9 Prior to installation, calculations and details demonstrating compliance with this report must be submitted to the code official. The calculations and details must be prepared by a registered design professional where required by the statutes of the jurisdiction in which the project is to be constructed.

5.10 Since an ICC-ES acceptance criteria for evaluating data to determine the performance of screw anchors subjected to fatigue or shock loading is unavailable at this time, the use of these anchors under such conditions is beyond the scope of this report.

5.11 Anchors may be installed in regions of concrete where cracking has occurred or where analysis indicates cracking may occur ($f_t > f_r$), subject to the conditions of this report.

5.12 Anchors may be used to resist short-term loading due to wind or seismic forces, subject to the conditions of this report.

5.13 Anchors are not permitted to support fire-resistance-rated construction. Where not otherwise prohibited by the code, Titen HD® Screw Anchors and Rod Hangers are permitted for installation in fire-resistance-rated construction provided that at least one of the following conditions is fulfilled:

- Anchors are used to resist wind or seismic forces 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.

5.14 Anchors have been evaluated for reliability against brittle failure and found to be not significantly sensitive to stress-induced hydrogen embrittlement.

5.15 Use of anchors is limited to dry, interior locations.

5.16 Special inspection must be provided in accordance with Section 4.4.

5.17 The anchors are manufactured by Simpson Strong-Tie® Company, Inc., under a quality control program with inspections by CEL Consulting (AA-639.)

6.0 EVIDENCE SUBMITTED

Data in accordance with the ICC-ES Acceptance Criteria for Mechanical Anchors in Concrete Elements (AC193), dated March 2012, including an optional suitability test for seismic tension and shear; profile steel deck soffit tests; mechanical properties tests; calculations; and quality control documentation.

7.0 IDENTIFICATION

The Titen HD® Screw Anchor and Rod Hanger packaging is marked with the Simpson Strong-Tie® Company name; product name (Titen HD®); anchor diameter and length; catalog number corresponding to Table 6 of this report; the name or logo of the inspection agency (CEL Consulting); and the evaluation report number (ESR-2713). In addition, the ≠ symbol and the anchor length (in inches) are stamped on the head of each screw anchor.

TABLE 1—TITEN HD® SCREW ANCHORS AND ROD HANGERS INSTALLATION INFORMATION[1]

Characteristic	Symbol	Units	Nominal Anchor Diameter / Threaded Coupler Diameter (inch)									
			$^{3}/_{8}$		$^{1}/_{2}$		$^{5}/_{8}$		$^{3}/_{4}$		$^{3}/_{8}$ Rod Hanger	$^{1}/_{2}$ Rod Hanger
Installation Information												
Nominal Diameter	d_a (d_o)[5]	in.	$^{3}/_{8}$		$^{1}/_{2}$		$^{5}/_{8}$		$^{3}/_{4}$		$^{3}/_{8}$	$^{3}/_{8}$
Drill Bit Diameter	d_{bit}	in.	$^{3}/_{8}$		$^{1}/_{2}$		$^{5}/_{8}$		$^{3}/_{4}$		$^{3}/_{8}$	$^{3}/_{8}$
Minimum Baseplate Clearance Hole Diameter[2]	d_c	in.	$^{1}/_{2}$		$^{5}/_{8}$		$^{3}/_{4}$		$^{7}/_{8}$		N/A[3]	N/A[3]
Maximum Installation Torque[4]	$T_{inst,max}$	ft-lbf	50		65		100		150		50	50
Maximum Impact Wrench Torque Rating	$T_{impact,max}$	ft-lbf	150		340		340		385		150	150
Minimum Hole Depth	h_{hole}	in.	$2^{3}/_{4}$	$3^{1}/_{2}$	$3^{3}/_{4}$	$4^{1}/_{2}$	$4^{1}/_{2}$	6	6	$6^{3}/_{4}$	$2^{3}/_{4}$	3
Nominal Embedment Depth	h_{nom}	in.	$2^{1}/_{2}$	$3^{1}/_{4}$	$3^{1}/_{4}$	4	4	$5^{1}/_{2}$	$5^{1}/_{2}$	$6^{1}/_{4}$	$2^{1}/_{2}$	$2^{1}/_{2}$
Effective Embedment Depth	h_{ef}	in.	1.77	2.40	2.35	2.99	2.97	4.24	4.22	4.86	1.77	1.77
Critical Edge Distance	c_{ac}	in.	$2^{11}/_{16}$	$3^{5}/_{8}$	$3^{9}/_{16}$	$4^{1}/_{2}$	$4^{1}/_{2}$	$6^{3}/_{8}$	$6^{3}/_{8}$	$7^{5}/_{16}$	$2^{11}/_{16}$	$2^{11}/_{16}$
Minimum Edge Distance	c_{min}	in.	$1^{3}/_{4}$									
Minimum Spacing	s_{min}	in.	3									
Minimum Concrete Thickness	h_{min}	in.	4	5	5	$6^{1}/_{4}$	6	$8^{1}/_{2}$	$8^{3}/_{4}$	10	4	$4^{1}/_{4}$
Anchor Data												
Yield Strength	f_{ya}	psi	97,000									
Tensile Strength	f_{uta}[6]	psi	110,000									
Minimum Tensile & Shear Stress Area	A_{se}[7]	in^2	0.099		0.183		0.276		0.414		0.099	0.099
Axial Stiffness in Service Load Range - Uncracked Concrete	β_{uncr}	lb/in.	715,000									
Axial Stiffness in Service Load Range - Cracked Concrete	β_{cr}	lb/in.	345,000									

For **SI:** 1 inch = 25.4 mm, 1 ft-lbf = 1.356 N-m, 1 psi = 6.89 kPa, 1 in^2 = 645 mm^2, 1 lb/in = 0.175 N/mm.

[1]The information presented in this table is to be used in conjunction with the design criteria of ACI 318 Appendix D.
[2]The clearance must comply with applicable code requirements for the connected element.
[3]The Titen HD® Rod Hanger version is driven directly to the supporting member surface.
[4]$T_{inst,max}$ applies to installations using a calibrated torque wrench.
[5]For the 2006 IBC d_o replaces d_a
[6]For the 2003 IBC f_{ut} replaces f_{uta}
[7]$A_{se,N} = A_{se,V} = A_{se}$

TABLE 2—TITEN HD® SCREW ANCHOR AND ROD HANGER CHARACTERISTIC TENSION STRENGTH DESIGN VALUES[1]

Characteristic	Symbol	Units	Nominal Anchor Diameter / Threaded Coupler Diameter (inch)									
			$^3/_8$		$^1/_2$		$^5/_8$		$^3/_4$		$^3/_8$ Rod Hanger	$^1/_2$ Rod Hanger
Anchor Category	1, 2 or 3	-	1									
Nominal Embedment Depth	h_{nom}	in.	$2^1/_2$	$3^1/_4$	$3^1/_4$	4	4	$5^1/_2$	$5^1/_2$	$6^1/_4$	$2^1/_2$	$2^1/_2$
Steel Strength in Tension (ACI 318 Section D.5.1)												
Tension Resistance of Steel	N_{sa}[8]	lbf	10,890		20,130		30,360		45,540		10,890	10,890
Strength Reduction Factor - Steel Failure[2]	ϕ_{sa}	-	0.65									
Concrete Breakout Strength in Tension (ACI 318 Section D.5.2)												
Effective Embedment Depth	h_{ef}	in.	1.77	2.40	2.35	2.99	2.97	4.24	4.22	4.86	1.77	1.77
Critical Edge Distance	c_{ac}	in.	$2^{11}/_{16}$	$3^5/_8$	$3^9/_{16}$	$4^1/_2$	$4^1/_2$	$6^3/_8$	$6^3/_8$	$7^5/_{16}$	$2^{11}/_{16}$	$2^{11}/_{16}$
Effectiveness Factor - Uncracked Concrete	k_{uncr}	-	24									
Effectiveness Factor - Cracked Concrete	k_{cr}	-	17									
Modification factor	$\Psi_{c,N}$[7]	-	1.0									
Strength Reduction Factor - Concrete Breakout Failure[3]	ϕ_{cb}	-	0.65									
Pullout Strength in Tension (ACI 318 Section D.5.3)												
Pullout Resistance Uncracked Concrete (f'_c=2,500 psi)	$N_{p,uncr}$	lbf	2,700[5]	N/A[4]	N/A[4]	N/A[4]	N/A[4]	9,810[5]	N/A[4]	N/A[4]	2,025[5]	2,025[5]
Pullout Resistance Cracked Concrete (f'_c=2,500 psi)	$N_{p,cr}$	lbf	1,235[5]	2,700[5]	N/A[4]	N/A[4]	3,040[5]	5,570[5]	6,070[5]	7,195[5]	1,235[5]	1,235[5]
Strength Reduction Factor - Pullout Failure[6]	ϕ_p	-	0.65									
Tension Strength for Seismic Applications (ACI 318 Section D.3.3.3)												
Nominal Pullout Strength for Seismic Loads (f'_c=2,500 psi)	$N_{p,eq}$	lbf	1,235[5]	2,700[5]	N/A[4]	N/A[4]	3,040[5]	5,570[5]	6,070[5]	7,195[5]	1,235[5]	1,235[5]
Strength Reduction Factor for Pullout Failure[6]	ϕ_{eq}	-	0.65									

For **SI:** 1 inch = 25.4 mm, 1 ft-lbf = 1.356 N-m, 1 psi = 6.89 kPa, 1 in^2 = 645 mm^2, 1 lb/in = 0.175 N/mm.

[1]The information presented in this table is to be used in conjunction with the design criteria of ACI 318 Appendix D.
[2]The tabulated value of ϕ_{sa} applies when the load combinations of Section 1605.2.1 of the IBC, or ACI 318 Section 9.2 are used. If the load combinations of ACI 318 Appendix C are used, the appropriate value of ϕ must be determined in accordance with ACI 318 D.4.5(b).
[3]The tabulated values of ϕ_{cb} applies when both the load combinations of Section 1605.2.1 of the IBC or ACI 318 Section 9.2 are used and the requirements of ACI 318 D.4.4(c) for Condition B are met. If the load combinations of ACI 318 Appendix C are used, the appropriate value of ϕ must be determined in accordance with ACI 318 D.4.5(c) for Condition B.
[4]As described in this report, N/A denotes that pullout resistance does not govern and does not need to be considered.
[5]The characteristic pullout resistance for greater compressive strengths may be increased by multiplying the tabular value by $(f'_c/2.500)^{0.5}$.
[6]The tabulated values of ϕ_p or ϕ_{eq} applies when both the load combinations of ACI 318 Section 9.2 are used and the requirements of ACI 318 D.4.4(c) for Condition B are met. If the load combinations of ACI 318 Appendix C are used, the appropriate value of ϕ must be determined in accordance with ACI 318 D.4.5(c) for Condition B.
[7]For the 2003 IBC, Ψ_3 replaces $\Psi_{c,N}$
[8] For the 2003 IBC, N_s replaces N_{sa}

TABLE 3—TITEN HD® SCREW ANCHOR CHARACTERISTIC SHEAR STRENGTH DESIGN VALUES[1]

Characteristic	Symbol	Units	Nominal Anchor Diameter (inch)							
			$^3/_8$		$^1/_2$		$^5/_8$		$^3/_4$	
Anchor Category	1, 2 or 3	-	1							
Nominal Embedment Depth	h_{nom}	in.	$2^1/_2$	$3^1/_4$	$3^1/_4$	4	4	$5^1/_2$	$5^1/_2$	$6^1/_4$
Steel Strength in Shear (ACI Section D.6.1)										
Shear Resistance of Steel	V_{sa}^{5}	lbf	4,460		7,455		10,000		16,840	
Strength Reduction Factor - Steel Failure[2]	ϕ_{sa}	-	0.60							
Concrete Breakout Strength in Shear (ACI 318 Section D.6.2)										
Nominal Diameter	d_a $(d_o)^4$	in.	0.375		0.500		0.625		0.750	
Load Bearing Length of Anchor in Shear	l_e^{6}	in.	1.77	2.40	2.35	2.99	2.97	4.24	4.22	4.86
Strength Reduction Factor - Concrete Breakout Failure[3]	ϕ_{cb}	-	0.70							
Concrete Pryout Strength in Shear (ACI 318 Section D.6.3)										
Coefficient for Pryout Strength	k_{cp}	-	1.0			2.0				
Strength Reduction Factor - Concrete Pryout Failure[3]	ϕ_{cp}	-	0.70							
Shear Strength for Seismic Applications (ACI 318 Section D.3.3.3)										
Shear Resistance of Single Anchor for Seismic Loads (f'_c=2,500 psi)	$V_{sa,eq}$	lbf	2,855		4,790		8,000		9,350	
Strength Reduction Factor - Steel Failure[2]	ϕ_{eq}	-	0.60							

For **SI:** 1 inch = 25.4mm, 1 lbf = 4.45N.

[1]The information presented in this table is to be used in conjunction with the design criteria of ACI 318 Appendix D.
[2]The tabulated value of ϕ_{sa} and ϕ_{eq} applies when the load combinations of Section 1605.2.1 of the IBC or ACI 318 Section 9.2 are used. If the load combinations of ACI 318 Appendix C are used, the appropriate value of ϕ must be determined in accordance with ACI 318 D.4.5(b).
[3]The tabulated values of ϕ_{cb} and ϕ_{cp} applies when both the load combinations of Section 1605.2.1 of the IBC or ACI 318 Section 9.2 are used and the requirements of ACI 318 D.4.4(c) for Condition B are met. If the load combinations of ACI 318 Appendix C are used, the appropriate value of ϕ must be determined in accordance with ACI 318 D.4.5(c) for Condition B.
[4]The notation in parenthesis is for the 2006 IBC.
[5]For the 2003 IBC, V_s replaces V_{sa}.
[6]For the 2003 IBC, l replaces l_e.

TABLE 4—TITEN HD® SCREW ANCHOR AND ROD HANGER CHARACTERISTIC TENSION AND SHEAR DESIGN VALUES FOR THE SOFFIT OF CONCRETE-FILLED PROFILE STEEL DECK ASSEMBLIES[1,5,6]

Characteristic	Symbol	Units	Nominal Anchor Diameter / Threaded Coupler Diameter (inch)							
			Lower Flute						Upper Flute	
			$^{3}/_{8}$		$^{1}/_{2}$		$^{3}/_{8}$ Rod Hanger	$^{1}/_{2}$ Rod Hanger	$^{3}/_{8}$	$^{1}/_{2}$
Minimum Hole Depth	h_{hole}	in.	$2^{1}/_{8}$	$2^{3}/_{4}$	$2^{1}/_{2}$	4	$2^{3}/_{4}$	3	$2^{1}/_{8}$	$2^{1}/_{2}$
Nominal Embedment Depth	h_{nom}	in.	$1^{7}/_{8}$	$2^{1}/_{2}$	2	$3^{1}/_{2}$	$2^{1}/_{2}$	$2^{1}/_{2}$	$1^{7}/_{8}$	2
Effective Embedment Depth	h_{ef}	in.	1.23	1.77	1.29	2.56	1.77	1.77	1.23	1.29
Pullout Resistance, Cracked Concrete[2,7]	$N_{p,deck,cr}$	lbf	375	870	905	2040	870	870	500	1700
Pullout Resistance, Uncracked Concrete[3,7]	$N_{p,deck,uncr}$	lbf	825	1905	1295	2910	1430	1430	1095	2430
Steel Strength in Shear[4]	$V_{sa,deck}$	lbf	2240	2395	2435	4430	N/A	N/A	4180	7145
Steel Strength in Shear, Seismic[4]	$V_{sa,deck,eq}$	lbf	1434	1533	1565	2846	N/A	N/A	2676	4591

For **SI:** 1 inch = 25.4mm, 1 lbf = 4.45N.

[1]Installation must comply with Sections 3.4, 4.1.10 and 4.3 and Figures 3 and 4 of this report.
[2]The values listed must be used in accordance with Section 4.1.4 and 4.1.8.2 of this report.
[3]The values listed must be used in accordance with Section 4.1.4 of this report.
[4]The values listed must be used in accordance with Section 4.1.5 and 4.1.8.3 of this report.
[5]The values for ϕ_p (reduction factor for pullout strength) can be found in Table 2 and the value for ϕ_{sa} (reduction factor for steel strength in shear) can be found in Table 3.
[6]The minimum anchor spacing along the flute must be the greater of $3h_{ef}$ or 1.5 times the flute width in accordance with Section 4.1.10 of this report.
[7]The characteristic pull-out resistance for greater concrete compressive strengths shall be increased by multiplying the tabular value by $(f'_c / 3,000\text{ psi})^{0.5}$.

TABLE 5—EXAMPLE TITEN HD® SCREW ANCHOR AND ROD HANGER ALLOWABLE STRESS DESIGN TENSION VALUES FOR ILLUSTRATIVE PURPOSES[1,2,3,4,5,6,7,8,9,10]

Nominal Anchor Diameter, d_o (inches)	Nominal Embedment Depth, h_{nom} (inches)	Effective Embedment Depth, h_{ef} (inches)	Allowable Tension Load, $\phi N_n/\alpha$ (lbs)
$^{3}/_{8}$	$2^{1}/_{2}$	1.77	1,185**
	$3^{1}/_{4}$	2.40	1,960
$^{1}/_{2}$	$3^{1}/_{4}$	2.35	1,900
	4	2.99	2,725
$^{5}/_{8}$	4	2.97	2,695
	$5^{1}/_{2}$	4.24	4,580
$^{3}/_{4}$	$5^{1}/_{2}$	4.22	4,570
	$6^{1}/_{4}$	4.86	5,645

Design Assumptions:
1. Single Anchor.
2. Tension load only.
3. Concrete determined to remain uncracked for the life of the anchorage.
4. Load combinations from ACI 318 Section 9.2 (no seismic loading).
5. 30% Dead Load (D) and 70% Live Load (L); Controlling load combination is 1.2 D + 1.6L
6. Calculation of α based on weighted average: α = 1.2D + 1.6L = 1.2(0.3) + 1.6(0.7) = 1.48
7. Normal weight concrete: f'_c = 2500 psi
8. $c_{a1} = c_{a2} \geq c_{ac}$
9. $h \geq h_{min}$
10. Values are for Condition B (Supplementary reinforcement in accordance with ACI 318-11 D.4.3 is not provided).

**** Illustrative Procedure (reference Table 2 of this report):**

$^{3}/_{8}$" Titen HD with an Effective Embedment, h_{ef} = 1.77"

Step 1: Calculate Static Steel Strength in Tension per ACI 318 Section D.5.1; $\phi_{sa}N_{sa}$ = 0.65 x 10,890 = 7,078 lbs.
Step 2: Calculate Static Concrete Breakout Strength in Tension per ACI 318 Section D.5.2; $\phi_{cb}N_{cb}$ = 0.65 x 2,826 = 1,837 lbs.
Step 3: Calculate Static Pullout Strength in Tension per ACI 318 Section D.5.3; $\phi_p N_{p,uncr}$ = 0.65 x 2,700 = 1,755 lbs.
Step 4: The controlling value (from Steps 1, 2 and 3 above) per ACI 318 Section D.4.1`; ϕN_n = 1,755 lbs.
Step 5: Divide the controlling value by the conversion factor α per section 4.2.1 of this report:
$T_{allowable,ASD} = \phi N_n/\alpha$ = 1,755 / 1.48 = 1,185 lbs.

TABLE 6—TITEN HD® SCREW ANCHOR AND ROD HANGER IDENTIFICATION INFORMATION

Anchor Size	Catalog Number
$^3/_8$"	THD37xxxxH
$^1/_2$"	THD50xxxxH
$^5/_8$"	THDB62xxxxH
$^3/_4$"	THD75xxxxH
$^3/_8$" Rod Hanger	THD37212RH
$^1/_2$" Rod Hanger	THD50234RH

FIGURE 1A—TITEN HD® SCREW ANCHOR

FIGURE 1B—TITEN HD® ROD HANGER

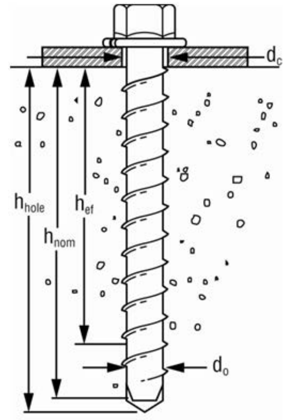

FIGURE 2—TITEN HD® SCREW ANCHOR INSTALLATION

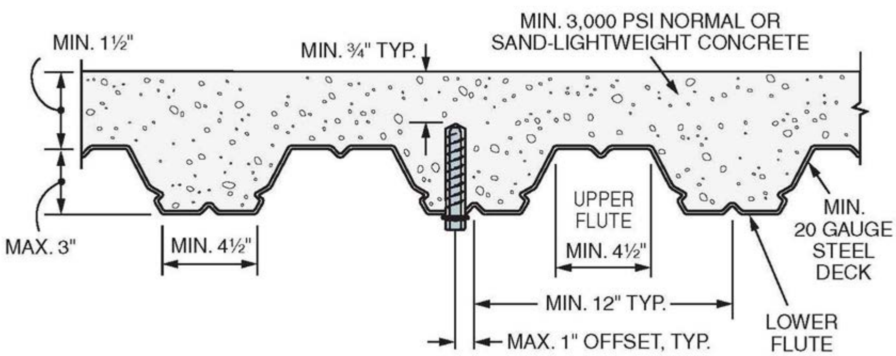

FIGURE 3 - INSTALLATION IN THE SOFFIT OF CONCRETE OVER PROFILE STEEL DECK FLOOR AND ROOF ASSEMBLIES (LOWER FLUTE)

(1 in = 25.4 mm)

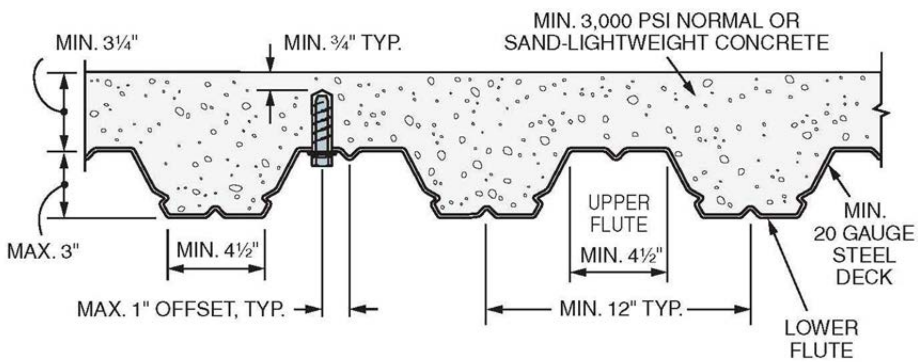

FIGURE 4 - INSTALLATION IN THE SOFFIT OF CONCRETE OVER PROFILE STEEL DECK FLOOR AND ROOF ASSEMBLIES (UPPER FLUTE)

(1 in = 25.4 mm)