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DIVISION: 03—CONCRETE
Section: 03151—Concrete Anchoring

REPORT HOLDER:

SIMPSON STRONG-TIE COMPANY, INC.
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EVALUATION SUBJECT:

TITEN HD® SCREW ANCHOR FOR CRACKED AND UNCRACKED 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)
- 1997 *Uniform Building Code™* (UBC)

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 structural 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 structural 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 Titen HD® is an alternative to cast-in-place anchors described in Sections 1911 and 1912 of the 2006 IBC, Sections 1912 and 1913 of the 2003 IBC, and Sections 1923.1 and 1923.2 of the UBC. The anchors may also be used where an engineering design is submitted in accordance with Section R301.1.3 of the 2006 and 2003 IRC.

3.0 DESCRIPTION

3.1 Titen HD®:

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 in accordance with ASTM B 633, SC1, Type III. Titen HD® screw anchors are available with nominally $^3/_8$-, $^1/_2$-, and $^3/_4$-inch (9.5, 12.7, and 19.1 mm) shank diameters, and various lengths in each diameter. Figure 1 illustrates a typical Titen HD® screw anchor.

3.2 Concrete:

Normal-weight and structural sand-lightweight concrete must comply with Sections 1903 and 1905 of the IBC or UBC, as applicable.

3.3 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 0.034 inch (0.864 mm). Steel must comply with ASTM A 653/A 653M SS Grade 40, and have a minimum yield strength of 40,000 ksi (276 MPa).

4.0 DESIGN AND INSTALLATION

4.1 Strength Design:

Anchor design strengths, φN_n and φV_n, must be determined in accordance with ACI 318-05 Appendix D using the design parameters provided in Tables 2, 3 and 4 and in Figures 2, 3, and 4 of this report. The anchor design must satisfy the requirements in ACI 318 D.4.1.1 and D.4.1.2. The value of f'_c used in the calculations must be limited to 8,000 psi (55.2 MPa), maximum, in accordance with ACI 318 D.3.5. Strength reduction factors, φ, described in ACI 318 Section D.4.4 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, Section 9.2 of ACI 318, or Section 1612.2.1 of the UBC. Strength reduction factors, φ, described in ACI 318 Section D.4.5, must be used for load combinations calculated in accordance with ACI 318 Appendix C or Section 1909.2 of the UBC.

4.1.1 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 described in Table 2.

4.1.2 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}, 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_c as described in Table 2 of this report. The modification factors in ACI 318 D.5.2.4, D.5.2.5, D.5.2.6, and D.5.2.7 must be applied to the concrete breakout strength as applicable.

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 structural sand-lightweight or normal-weight concrete fill as shown in Figure 3 or Figure 4, respectively.

4.1.3 Static Pullout Strength in Tension: The nominal pullout strength of a single screw anchor in tension satisfying ACI 318 D.5.3.1 and D.5.3.2 in cracked and uncracked concrete, $N_{pn,cr}$ and $N_{pn,uncr}$, respectively, is described in Table 2 of this report. $N_{pn,cr}$ and $N_{pn,uncr}$ must be used in lieu of N_{pn}. 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, $N_{pn,uncr}$, applies. Where values for $N_{pn,cr}$ or $N_{pn,uncr}$ 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 structural sand-lightweight or normal-weight concrete filled profile steel deck floor and roof assemblies, $N_{pn,deck,cr}$, as shown in Figures 3 and 4, is given in Table 4. $N_{pn,deck,cr}$ must be used in lieu of $N_{pn,cr}$. 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 $N_{pn,deck,uncr}$ applies in lieu of $N_{pn,uncr}$. The value of $\Psi_{c,p}$ is 1.0 for all cases.

4.1.4 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. 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, $V_{st,deck}$, of a single screw anchor installed in the lower flute or upper flute of the soffit of structural 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.

4.1.5 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} and 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_o as described 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 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 structural sand-lightweight or normal-weight concrete filled profile steel deck floor and roof assemblies, as shown in Figures 3 and 4.

4.1.6 Static Concrete Pryout Strength in Shear: The nominal concrete pryout strength for a single screw anchor or group of screw anchors, V_{cp} and V_{cpg}, respectively, must be calculated in accordance with ACI 318 D.6.3, modified by using the value of coefficient for pryout strength, k_{cp}, described 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 4.1.2 of this report.

For anchors installed in the lower flute or upper flute of the soffit of structural 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.

4.1.7 Requirements for Seismic Design:

4.1.7.1 General: When the screw anchor design includes seismic loads, the additional requirements of ACI 318 D.3.3 must apply, as modified by Section 1908.1.16 of the 2006 IBC, or the following for legacy codes:

CODE	ACI 318 D.3.3 SEISMIC REGION	CODE EQUIVALENT DESIGNATION
2003 IBC & IRC	Moderate or high seismic risk	Seismic Design Categories C, D, E and F
UBC	Moderate or high seismic risk	Seismic Zones 2B, 3 and 4

Except for use in Seismic Design Category A or B of the IBC or Seismic Zone 0, 1 or 2A of the UBC, design strengths must be determined presuming the concrete is cracked.

As the screw anchors include brittle steel elements, the screw anchors and attachments must be designed in accordance with ACI 318 D.3.3.5 as modified by Section 1908.1.16 of the 2006 IBC for locations in Seismic Design Category C, D, E or F (IBC) or Seismic Zone 2B, 3 or 4 (UBC).

4.1.7.2 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 4.1.1 and 4.1.2 of this report. In accordance with ACI 318 D.5.3.2, the appropriate value for nominal pullout strength in tension for seismic loads, $N_{pn,eq}$ or $N_{pn,deck,cr}$, described in Tables 2 and 4 of this report, must be used in lieu of N_{pn}.

4.1.7.3 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 4.1.5 and 4.1.6 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 $V_{s\ t,deck}$, described in Tables 3 and 4 of this report, must be used in lieu of V_{sa}.

4.1.8 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.

4.1.9 Requirements for Minimum Member Thickness, Minimum Anchor Spacing and Minimum Edge Distance: In lieu of ACI 318 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. In lieu of ACI 318 D.8.6, values of c_{ac} provided in Table 1 must be used. For anchors installed in the lower flute or upper flute of the soffit of structural 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 3.0 h_{ef} or 1.5 times the flute width.

4.1.10 Structural Sand-lightweight Concrete: Where structural sand-lightweight concrete is used, in lieu of ACI 318 D.3.4, the values determined in Sections 4.1.2, 4.1.3, 4.1.5, 4.1.6 and 4.1.7 of this report must be multiplied by 0.60 and utilized. For anchors installed in the lower flute or upper flute of the soffit of structural 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 and Section 1612.3 of the UBC, must be established using the following relationships:

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

and

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

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 2006 IBC Section 1908.1.16, as applicable (lbf orN).

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 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, $V_{allowable,ASD}$, must be permitted.

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

For all other cases: $T_{applied} / T_{allowable,ASD} + V_{applied} / V_{allowable,ASD} \leq 1.2$.

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® 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 diameter as the nominal diameter of the anchor. The hole is drilled to the specified nominal embedment depth plus ½ inch (12.7 mm). Dust and debris in the hole must be removed by using oil-free compressed air. The Titen HD® screw anchors 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 are detailed in Table 1.

For anchors installed in the lower flute or upper flute of the soffit of structural 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 ⅛ inch (3.2 mm).

4.4 Special Inspection:

Installations must be made under special inspection in accordance with Section 1704.13 of the IBC and Section 1701.5.2 of the UBC. The special inspector must be on the jobsite continuously during anchor installation to verify anchor type, anchor dimensions, hole cleanliness, embedment depth, concrete type, concrete compressive strength, drill bit diameter, hole depth, edge distance(s), anchor spacing(s), concrete thickness, installation torque, and maximum impact wrench torque rating.

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

5.0 CONDITIONS OF USE

The Simpson Strong-Tie Titen HD® Screw Anchors 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 5.1 of this report in cracked and uncracked normal-weight and structural 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 structural 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 and edge distance, as well as minimum member thickness, must comply with Tables 1 and 4, and Figures 3 and 4, of this report.

5.8 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.

5.9 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.

5.10 Anchors may be installed in regions of concrete where cracking has occurred or where analysis indicates cracking may occur, subject to the conditions of this report.

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

5.12 Anchors are not permitted to support fire-resistance-rated construction. Where not otherwise prohibited by the code, Titen HD® anchors 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 for 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.

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

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

5.15 The anchors are manufactured by Simpson Strong-Tie Company, Inc., in Brampton, Ontario, Canada, 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 May 2008, including optional suitability test for seismic tension and shear; profile steel deck soffit tests; mechanical properties tests; calculations; and a quality control manual.

7.0 IDENTIFICATION

The Titen HD® Screw Anchor packaging is marked with the Simpson Strong-Tie Company name; product name (Titen HD®); anchor diameter and length; 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 the each screw anchor.

Table 1 – Titen HD® Installation Information and Anchor Data[1]

Characteristic	Symbol	Units	Nominal Anchor Diameter					
			⅜ inch		½ inch		¾ inch	
Installation Information								
Nominal Diameter	d_o	in.	⅜		½		¾	
Drill Bit Diameter	d	in.	⅜		½		¾	
Minimum Baseplate Clearance Hole Diameter[2]	d_c	in.	½		⅝		⅞	
Maximum Installation Torque	$T_{inst,max}$	ft-lbf	50		65		150	
Maximum Impact Wrench Torque Rating	$T_{impact,max}$	ft-lbf	150		385		385	
Minimum Hole Depth	h_{hole}	In.	3	3¾	3¾	4½	6	6¾
Embedment Depth	h_{nom}	in.	2½	3¼	3¼	4	5½	6¼
Effective Embedment Depth	h_{ef}	in.	1.77	2.40	2.35	2.99	4.22	4.86
Critical Edge Distance	c_{ca}	in.	$2\frac{11}{16}$	3⅝	$3\frac{9}{16}$	4½	6⅜	$7\frac{5}{16}$
Minimum Edge Distance	c_{min}	in.	$1\frac{3}{4}$					
Minimum Spacing	s_{min}	in.	3					
Minimum Concrete Thickness	h_{min}	in.	3¾	5	5	6¼	8¾	10
Anchor Data								
Yield Strength	f_{ya}	psi	97,000					
Tensile Strength	f_{uta}	psi	110,000					
Minimum Tensile & Shear Stress Area	A_{se}	in^2	0.099		0.183		0.414	
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 Pa, 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.

Table 2 – Titen HD® Tension Strength Design Data[1]

Characteristic	Symbol	Units	Nominal Anchor Diameter					
			⅜ inch		½ inch		¾ inch	
Anchor Category	1, 2 or 3		1					
Embedment Depth	h_{nom}	in.	2½	3¼	3¼	4	5½	6¼
Steel Strength in Tension (ACI 318 D.5.1)								
Tension Resistance of Steel	N_{sa}	lb.	10,890		20,130		45,540	
Strength Reduction Factor - Steel Failure[2]	φ_{sa}	-	0.65					
Concrete Breakout Strength in Tension (ACI 318 D.5.2)								
Effective Embedment Depth	h_{ef}	in.	1.77	2.40	2.35	2.99	4.22	4.86
Critical Edge Distance	c_{ca}	in.	2 11/16	3⅝	3 9/16	4½	6⅜	7 5/16
Effectiveness Factor - Uncracked Concrete	k_{uncr}	-	24					
Effectiveness Factor - Cracked Concrete	k_{cr}	-	17					
Ratio of k_{uncr}/k_{cr}	$\Psi_{c,N}$	-	1.4					
Strength Reduction Factor - Concrete Breakout Failure[3]	φ_{cb}	-	0.65					
Pullout Strength in Tension (ACI 318 D.5.3)								
Pullout Resistance Uncracked Concrete (f'_c=2,500 psi)	$N_{pn,uncr}$	lbf.	2,700[6]	N/A[4]	N/A[4]	N/A[4]	N/A[4]	N/A[4]
Pullout Resistance Cracked Concrete (f'_c=2,500 psi)	$N_{pn,cr}$	lbf.	1,235[6]	2,700[6]	N/A[4]	N/A[4]	6,070[6]	7,195[6]
Strength Reduction Factor - Pullout Failure[5]	φ_p	-	0.65					
Tension Strength for Seismic Applications (ACI 318 D.3.3.3)								
Nominal Pullout Strength for Seismic Loads (f'_c=2,500 psi)	$N_{pn,eq}$	lbf.	1,235[6]	2,700[6]	N/A[4]	N/A[4]	6,070[6]	7,195[6]
Strength Reduction Factor - Breakout or Pullout Failure[5]	φ_{eq}	-	0.65					

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} applies when the load combinations of Section 1605.2.1 of the IBC, Section 1612.2.1 of the UBC, or ACI 318 9.2 are used. If the load combinations of Section 1909.2 of the UBC or 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, Section 1612.2.1 of the UBC, 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 Section 1909.2 of the UBC or 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 tabulated values of φ_p or φ_{eq} applies when both the load combination of ACI 318 Section 9.2, IBC Section 1605.2.1 or UBC Section 1612.2.1are 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 or UBC Section 1909.2 are used, the appropriate value of φ must be determined in accordance with ACI 318 D.4.5(c) for Condition B.
[6]The characteristic pullout resistance for greater compressive strengths maybe increased by multiplying the tabular value by $(f'_c/2,500)^{1/2}$ for psi or (f'_c/17.2)1/2 for MPa.

Table 3 - Titen HD® Shear Strength Design Data[1]

Characteristic	Symbol	Units	Nominal Anchor Diameter					
			3/8 inch		1/2 inch		3/4 inch	
Anchor Category	1, 2 or 3		1					
Embedment Depth	h_{nom}	in.	2 1/2	3 1/4	3 1/4	4	5 1/2	6 1/4
Steel Strength in Shear (ACI Section D.6.1)								
Shear Resistance of Steel	V_{sa}	lbf.	4,460		7,455		16,840	
Strength Reduction Factor - Steel Failure[2]	φ_{sa}	-	0.60					
Concrete Breakout Strength in Shear (ACI 318 D.6.2)								
Nominal Diameter	d_o	in.	0.375		0.500		0.750	
Load Bearing Length of Anchor in Shear	l_e	in.	1.77	2.40	2.35	2.99	4.22	4.86
Strength Reduction Factor - Concrete Breakout Failure[3]	φ_{cb}	-	0.70					
Concrete Pryout Strength in Shear (ACI 318 D.6.3)								
Coefficient for Pryout Strength	k_{cp}	-	1.0			2.0		
Strength Reduction Factor - Concrete Pryout Failure[4]	φ_{cp}	-	0.70					
Shear Strength for Seismic Applications (ACI 318 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		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, Section 1612.2.1 of the UBC, or ACI 318 9.2 are used. If the load combinations of Section 1909.2 of the UBC or 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 value φ_{cb} of applies when both the load combinations of Section 1605.2.1 of the IBC, Section 1612.2.1 of the UBC, 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 Section 1909.2 of the UBC or 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 tabulated values of φ_{cp} applies when both the load combinations of ACI 318 Section 9.2, IBC Section 1605.2.1, or UBC Section 1612.2.1 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 or UBC Section 1907.2 are used, the appropriate value of φ must be determined in accordance with ACI 318 D.4.5(c) for Condition B.

Table 4 – Titen HD® Tension and Shear Design Data For The Soffit of Concrete-Filled Profile Steel Deck Assemblies[1]

Characteristic	Symbol	Units	Lower Flute				Upper Flute	
			Anchor Diameter				Anchor Diameter	
			⅜ inch		½ inch		⅜ inch	½ inch
Minimum Hole Depth	h_{hole}	in.	2	3	2½	4	2	2½
Embedment Depth	h_{nom}	in.	1½	2½	2	3½	1½	2
Effective Embedment Depth	h_{ef}	in.	0.92	1.77	1.29	2.56	0.92	1.29
Pullout Resistance, concrete on metal deck (cracked)[2]	$N_{pn,deck,cr}$	lbf.	580	1.335	905	2,040	765	1,700
Pullout Resistance, concrete on metal deck (uncracked)[3]	$N_{pn,deck,uncr}$	lbf.	825	1,905	1,295	2,910	1,095	2,430
Steel Strength in Shear, concrete on metal deck[4]	$V_{st,deck}$	lbf.	2,240	2,395	2,435	4,430	4,180	7,145

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

[1]Installation must comply with Section 3.3, 4.1.9 and 4.3 and Figures 3 and 4 of this report.
[2]The tabulated values must be used in accordance with Section 4.1.3 and 4.1.7.2 of this report.
[3]The tabulated values must be used in accordance with Section 4.1.3 of this report.
[4]The tabulated values must be used in accordance with Section 4.1.3 and 4.1.7.3 of this report.

Table 5 - Example Titen HD® Allowable Stress Design Tension Values for Illustrative Purposes

Nominal Anchor Diameter, d_o (inches)	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
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 percent dead load (*D*)and 70 percent live load (*L*); Controlling load combination is 1.2*D* + 1.6*L*
6. Calculation of α based on weighted average: $\alpha = 1.2D + 1.6L = 1.2 (0.3) + 1.6 (0.7) = 1.48$
7. Normal weight concrete: f'_c = 2,500 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 D.4.4 is not provided).

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

Titen HD®, 3/8 inch diameter, with an effective embedment, h_{ef} = 1.77"
Step 1: Calculate static steel strength in tension ACI 318 D.5.1 = $\Phi_{sa}N_{sa}$ = 0.65 x 10,890 = 7,078 lbs.
Step 2: Calculate static concrete breakout strength in tension in accordance with ACI 318 D.5.2 = $\Phi_{cb}N_{cb}$ = 0.65 x 2,826 = 1,837 lbs.
Step 3: Calculate static pullout strength in tension in accordance with ACI 318 D.5.3 = $\Phi_p N_{pn,uncr}$ = 0.65 x 2,700 = 1,755 lbs.
Step 4: The controlling value (from Steps 1, 2 and 3 above) in accordance with ACI 318 D.4.1.2 = ΦN_n = 1,755 lbs.
Step 5: Divide the controlling value by the conversion factor in accordance with Section 4.2.1 of this report:

$T_{allowable,ASD} = \Phi N_n/\alpha$ = 1,755 / 1.48 = 1,185 lbs.

Figure 1 - Titen HD® Screw Anchor

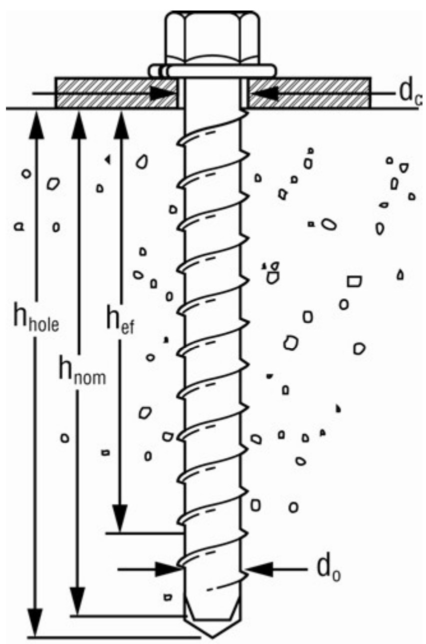

Figure 2 - Titen HD® Screw Anchor Installation

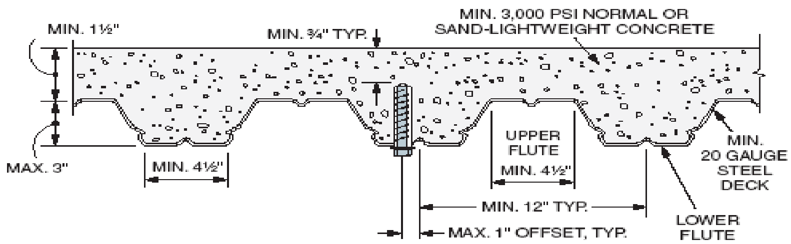

FIGURE 3 - INSTALLATION IN THE SOFFIT OF CONCRETE OVER PROFILE STEEL DECK FLOOR AND ROOF ASSEMBLIES (LOWER FLUTE)

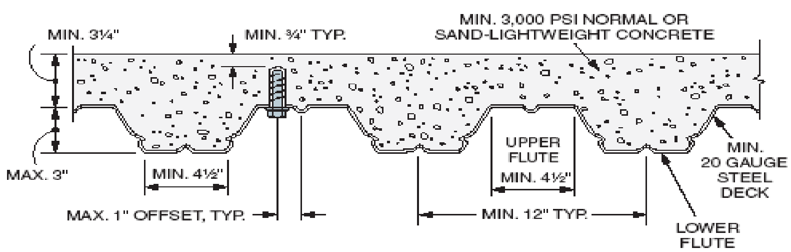

FIGURE 4 - INSTALLATION IN THE SOFFIT OF CONCRETE OVER PROFILE STEEL DECK FLOOR AND ROOF ASSEMBLIES (UPPER FLUTE)