ICC-ES Evaluation Report

ESR-1663

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Section: 09 22 16.23—Fasteners

REPORT HOLDER:

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EVALUATION SUBJECT:

HILTI LOW-VELOCITY POWER-DRIVEN FASTENERS

1.0 EVALUATION SCOPE

Compliance with the following codes:

- 2012, 2009 and 2006 *International Building Code*® (IBC)
- 2012, 2009 ~~and 2006~~ *International Residential Code*® (IRC)
- ~~2013 *Abu Dhabi International Building Code* (ADIBC)†~~

~~†The ADIBC is based on the 2009 IBC. 2009 IBC code sections referenced in this report are the same sections in the ADIBC.~~

Properties evaluated:

Structural

2.0 USES

Hilti power-driven fasteners are used to attach wood, cold-formed steel, and other building elements to normal-weight and sand-lightweight concrete, steel deck panels with sand-lightweight concrete fill, concrete masonry units (CMUs) and steel base materials. The fasteners are alternatives to the cast-in-place anchors described in 2012 IBC Section 1908 (2009 and 2006 IBC Section 1911) for placement in concrete; the embedded anchors described in Section 2.1.4 of TMS 402/ACI 530/ASCE 5 (which is referenced in IBC Section 2107); and the welds and bolts used to attach materials to steel, described in IBC Sections 2204.1 and 2204.2, respectively. The fasteners may also be used under the IRC where an engineered design is submitted in accordance with IRC Section R301.1.3.

3.0 DESCRIPTION

3.1 Fasteners:

The fasteners are manufactured as nails or threaded studs with various shank diameters, thread diameters, lengths, and smooth or knurled shanks. The carbon steel fasteners are manufactured from austempered steel conforming to SAE 1060 or 1070 (modified). The carbon steel fasteners are zinc-plated to ASTM B633, SC 1, Type III. The stainless steel X-CR fasteners are manufactured from a proprietary CrNiMo alloy complying with the requirements of SAE 316. The premounted washers for the X-CR fasteners are manufactured from stainless steel conforming to SAE 316. All fasteners have a Rockwell C hardness ranging from 49 to 61.

3.2 Normal-weight Concrete:

Normal-weight concrete must be normal-weight, stone-aggregate concrete complying with IBC Chapter 19 or IRC Section R402.2, as applicable. The minimum concrete compressive strength at the time of fastener installation is noted in Table 2.

3.3 Lightweight Concrete:

Lightweight concrete must be sand-lightweight complying with IBC Chapter 19, and must have a minimum 3,000 psi (19.17 MPa) compressive strength at the time of fastener installation.

3.4 Masonry:

Masonry must be comprised of normal-weight or lightweight concrete masonry units (CMUs) complying with ASTM C90 and mortar complying with ASTM C270 Type N in accordance with 2012 IBC Section 2103.9 (2009 and 2006 IBC Section 2103.8) or IRC Section R607, as applicable. Where specified in Table 5 of this report, concrete-masonry construction must be fully grouted and have a minimum prism strength, f'_m, of 1,500 psi (10.3 MPa) at the time of fastener installation. Grout must comply with Article 2.2 of TMS 602/ACI 530.1/ASCE 6, referenced in 2012 IBC Section 2103.13 (2009 and 2006 IBC Section 2103.12) or IRC Section R609.1.1, as applicable.

* Deleted by the City of Los Angeles

3.5 Steel Substrates:

3.5.1 Steel: Structural steel used in supports must comply with the minimum strength requirements of ASTM A36, ASTM A572 Grade 50 or ASTM A992, as applicable, and must have the thickness shown in Table 1.

3.5.2 Steel Deck Panels: Steel deck panels must conform to a code-referenced material standard, and have the minimum thickness and minimum yield strength noted in Tables 3 and 4. See Figures 1 through 3 for panel configuration requirements.

4.0 DESIGN AND INSTALLATION

4.1 Design:

4.1.1 Allowable Loads: The most critical applied loads, excluding seismic load effects, resulting from the load combinations in IBC Section 1605.3.1 or 1605.3.2 must not exceed the allowable loads. For fasteners which are subjected to seismic loads, see Section 4.1.3 for additional information. The allowable tension and shear loads, along with fastener descriptions and shank diameters for power-driven fasteners installed in structural steel base materials, are shown in Table 1. The allowable tension and shear loads with minimum required embedment depths, along with fastener descriptions and shank diameters for fasteners installed in normal-weight and sand-lightweight concrete base materials, are shown in Tables 2, 3, and 4. The allowable tension and shear loads with minimum required embedment depths, along with fastener descriptions and shank diameters, for fasteners installed in concrete masonry units (CMUs), are shown in Table 5. The stress increases and load reductions described in IBC Section 1605.3 are not allowed. Allowable loads apply to the connection of the fastener to the base material only. Design of the connection of the fastener to the attached material must comply with the applicable requirements of the IBC.

Allowable loads for fasteners subjected to combined shear and tension forces are determined by the following formula:

$$(p/P_a) + (v/V_a) \leq 1$$

where:

p = Actual tension load, lbf (N).

P_a = Allowable tension load, lbf (N).

v = Actual shear load, lbf (N).

V_a = Allowable shear load, lbf (N).

4.1.2 Attachment of Wood to Steel, Concrete, or Masonry: Reference lateral design values for fasteners determined in accordance with Part 11 of ANSI/AF&PA NDS are applicable to Hilti fasteners of equal or greater diameters. The wood element must be considered to be the side member. The fastener bending yield strength must be the value noted in the NDS based on the fastener diameter.

Hilti X-CR stainless steel fasteners may be installed in contact with preservative-treated or fire-retardant-treated wood, as set forth in the applicable code. Hilti carbon steel fasteners may be used in contact with fire-retardant-treated wood in dry, interior locations only, in accordance with 2012 and 2009 IBC Section 2304.9.5.4 and Hilti's recommendations. Use of the Hilti carbon steel fasteners in contact with preservative-treated wood or in contact with fire-retardant-treated wood in exterior applications is outside the scope of this report.

4.1.3 Seismic Considerations: The Hilti fasteners are recognized for use when subjected to seismic loads as follows:

1. The Hilti fasteners may be used with nonstructural components, listed in Section 13.1.4 of ASCE 7, which are exempt from the requirements of ASCE 7.
2. Concrete base materials: The Hilti fasteners installed in concrete may be used to support acoustical tile or lay-in panel suspended ceiling systems, distributed systems and distribution systems where the service load on any individual fastener does not exceed the lesser of 90 lbf (400 N) or the published allowable load in Tables 2, 3 and 4, as applicable.
3. Steel base materials: When the Hilti fasteners are installed in steel and subjected to seismic loads, the most critical load applied to each individual fastener must be determined from the applicable equations in IBC Section 1605.3.1 or Section 1605.3.2, and must not exceed the allowable load shown in Table 1. Recognition of the Hilti fasteners installed in steel base material for use in the design of lateral force resisting systems, such as shear walls and diaphragms, is outside the scope of this report.
4. For interior, nonstructural walls that are not subject to sustained tension loads and are not a bracing application, the power-driven fasteners may be used to attach steel track to concrete or steel in all Seismic Design Categories. In Seismic Design Categories D, E, and F, the allowable shear load due to transverse pressure shall be no more than 90 pounds (400 N) when attaching to concrete; or the allowable load shown in Table 1 when attaching to steel. Substantiating calculations shall be submitted addressing the fastener-to-base-material capacity and the fastener-to-attached-material capacity. Interior nonstructural walls are limited to locations where bearing walls, shear walls or braced walls are not required by the approved plans. The design load on the fastener must not exceed the allowable load established in this report for the concrete or steel base material.

4.2 Installation:

4.2.1 General: The fasteners must be installed in accordance with this report and the Hilti, Inc., published installation instructions. A copy of the instructions must be available on the jobsite at all times during installation. Additional installation requirements are set forth in Tables 1 to 5 of this report.

Fastener placement requires a low-velocity powder-actuated tool used in accordance with Hilti, Inc. recommendations.

Installers must be certified by Hilti, Inc., and have a current, Hilti-issued, operator's license.

4.2.2 Fastening to Steel: When installation is in steel, minimum spacing between fasteners must be 1 inch (25.4 mm) on center, and minimum edge distance must be $^1/_2$ inch (12.7 mm).

4.2.3 Fastening to Concrete: Fasteners are to be driven into the concrete after the concrete attains the concrete strength specified in the tables of this report. Unless otherwise noted, minimum spacing between fasteners must be 4 inches (102 mm) on center and minimum edge distance must be 3 inches (76 mm). Unless otherwise noted, concrete thickness must be a minimum of three times the embedment depth of the fastener.

4.2.4 Fastening to Masonry: Fasteners are to be driven into the masonry after the mortar and grout materials have attained the specified strength. For CMUs, no more than one power-driven fastener may be installed per individual CMU cell.

4.2.5 Fastening to Sand-lightweight Concrete-filled Steel Deck Panels: Installation in sand-lightweight concrete-filled steel deck panels must comply with Tables 3 and 4 and Figures 1 through 3. Minimum distances from fastener centerline to rolled deck panel flute edges must be as depicted in Figures 1 through 3.

5.0 CONDITIONS OF USE

The Hilti Low-Velocity Power-Driven Fasteners 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 Fasteners must be manufactured and identified in accordance with this report.

5.2 Fasteners must be installed in accordance with this report and the Hilti, Inc., instructions. In the event of conflict between this report and Hilti, Inc., published instructions, this report governs.

5.3 Calculations demonstrating that the actual loads are less than the allowable loads described in Section 4.1 must be submitted to the code official for approval. The calculations must be prepared by a registered design professional where required by the statutes of the jurisdiction in which the project is constructed.

5.4 Refer to Section 4.1.3 for seismic considerations.

5.5 The use of the fasteners is limited to installations in uncracked concrete or masonry. Cracking occurs when $f_t > f_r$ due to service loads or deformations.

5.6 Hilti X-CR stainless steel fasteners may be used in exterior, damp environments. All other fasteners in this report must be limited to installation in dry, interior environments, which include exterior walls which are protected by an exterior wall envelope.

5.7 Installation must comply with Section 4.1.2 regarding fasteners in contact with preservative-treated and fire-retardant-treated wood.

5.8 Installers must be certified by Hilti, Inc., and have a current, Hilti-issued, operator's license.

6.0 EVIDENCE SUBMITTED

Data in accordance with the ICC-ES Acceptance Criteria for Fasteners Power-driven in Concrete, Steel, and Masonry Elements (AC70), dated June 2014, including seismic load test data in accordance with Annex A of AC70.

7.0 IDENTIFICATION

All fasteners are identified by an "H" imprinted on the fastener head. Where applicable, the word "Hilti" is stamped on the steel washers. All fasteners are packaged in containers noting the fastener type, size, manufacturer's name, and evaluation report number (ESR-1663).

TABLE 1—ALLOWABLE LOADS FOR LOW-VELOCITY FASTENERS DRIVEN INTO STEEL[1,2,4] (lbf)

FASTENER DESCRIPTION	FASTENER	SHANK DIAMETER (inch)	STEEL THICKNESS (inch)											
			1/8		3/16		1/4		3/8		1/2		3/4	
			Tension	Shear	Tension	Shear	Tension	Shear	Tension	Shear	Tension	Shear	Tension	Shear
Heavy Duty Knurled Shank	EDS	0.177	–	–	305	615	625	870	715	870	890	960	–	–
Heavy Duty Smooth Shank	DS	0.177	–	–	365	725	580	725	695	725	735	860	–	–
Stainless Steel Smooth Shank	X-CR	0.145	–	–	460	460	615	500	–	–	–	–	–	–
Stainless Steel Smooth Shank	X-CR[3]	0.145	300	190	615	495	760	500	220	325	225	335	–	–

For **SI:** 1 inch = 25.4 mm, 1 lbf = 4.4 N, 1 ksi = 6.89 MPa.

[1]Fasteners must be driven to where the point of the fastener penetrates through the steel base material, unless otherwise noted.
[2]Unless otherwise noted, allowable load capacities are based on base steel with minimum yield strength (F_y) of 36 ksi and minimum tensile strength (F_u) of 58 ksi.
[3]Allowable load capacity based on base steel with minimum yield strength (F_y) of 50 ksi and minimum tensile strength (F_u) of 65 ksi.
[4]Allowable loads are applicable to static and seismic loads in accordance with Section 4.1.

TABLE 2—ALLOWABLE LOADS FOR LOW-VELOCITY FASTENERS DRIVEN INTO NORMAL-WEIGHT CONCRETE[1]

FASTENER DESCRIPTION	FASTENER	SHANK DIAMETER (inch)	EMBEDMENT (inches)	CONCRETE COMPRESSIVE STRENGTH					
				2,000 psi		4,000 psi		6,000 psi	
				Tension (lbf)	Shear (lbf)	Tension (lbf)	Shear (lbf)	Tension (lbf)	Shear (lbf)
Standard Nail	X-C (Black Collated Strip or Guidance Washer)	0.138	3/4	45	75	65	105	95	195
			1	85	150	160	200	105	270
			1 1/4	130	210	270	290	165	325
			1 1/2	175	260	270	360	—	—
Standard Nail	X-C (White Collated Strip or Guidance Washer)	0.138	3/4	45	75	60	105	—	—
			1	85	150	90	200	—	—
			1 1/4	130	210	130	290	—	—
			1 1/2	175	260	245	360	—	—
Drywall Track Nail	X-C22 P8 TH (Black Collated Strip or Guidance Washer)	0.138	3/4	55	130	90	170	100	200
Drywall Track Nail	X-C22 P8 TH (White Collated Strip or Guidance Washer)	0.138	3/4	55	130	90	170	—	—
Heavy Duty Nail	DS	0.177	3/4	50	120	125	135	—	—
			1	130	195	155	240	—	—
			1 1/4	220	385	270	425	—	—
			1 1/2	300	405	355	450	—	—
1/4-20 Threaded Stud	X-W6	0.145	3/4	40	55	40	55	—	—
			1	85	195	110	225	—	—
3/8-16 Threaded Stud	W10	0.205	1	85	95	100	105	—	—
			1 1/4	175	345	200	380	—	—
			1 5/8	285	380	385	395	—	—
Stainless Steel Nail	X-CR	0.145	3/4	30	40	65	40	—	—
			1	55	185	120	190	100	170
			1 1/4	110	290	125	300	120	440
			1 1/2	265	405	350	450	—	—

For **SI:** 1 inch = 25.4 mm, 1 psi = 6895 Pa, 1 lbf = 4.4 N.

[1]Fasteners must not be driven until the concrete has reached the designated minimum compressive strength.

TABLE 3—ALLOWABLE LOADS FOR LOW-VELOCITY FASTENERS DRIVEN INTO MINIMUM f'_c=3,000 psi SAND-LIGHTWEIGHT CONCRETE[1]

FASTENER DESCRIPTION	FASTENER	SHANK DIAMETER (inch)	MINIMUM EMBEDMENT (inches)	FASTENER LOCATION				
				Installed into Concrete		Installed Through Steel Deck Panel into Concrete[2,3]		
				Tension (lbf)	Shear (lbf)	Tension (lbf)		Shear (lbf)
						Upper Flute	Lower Flute	
Standard Nail	X-C (Black Collated Strip or Guidance Washer)	0.138	3/4	120	175	120	95	265
			1	180	260	215	155	485
			1 1/4	225	400	250	200	500
			1 1/2	285	400	285	210	555
Standard Nail	X-C (White Collated Strip or Guidance Washer)	0.138	3/4	110	175	120	-	265
			1	135	180	215	145	485
			1 1/4	220	260	250	200	500
			1 1/2	285	315	285	210	555
Drywall Track Nail	X-C20 THP	0.138	5/8	55	110	-	45	285
	X-C22 P8TH (Black Collated Strip or Guidance Washer)	0.138	3/4	120	220	120	95	260
	X-C22 P8TH (White Collated Strip or Guidance Washer)	0.138	3/4	110	220	120	60	260
Heavy Duty Nail	DS[4]	0.177	3/4	100	200	-	-	200
			1	180	360	-	180	405
			1 1/4	300	520	-	-	515
			1 1/2	450	680	-	325	625
Stainless Steel Nail	X-CR	0.145	1	230	240	-	-	240
			1 1/4	320	400	-	-	400
			1 1/2	405	500	-	-	500
1/4-20 Threaded Stud	X-W6	0.145	3/4	125	185	125	115	185
			1	175	185	160	180	185
3/8-16 Threaded Stud	W10	0.205	1	265	185	-	-	185
			1 1/4	280	380	160	210	685
			1 5/8	445	540	435	325	945

For **SI:** 1 inch = 25.4 mm, 1 psi = 6895 Pa, 1 lbf = 4.4 N.

[1]Fasteners must not be driven until the concrete has reached the designated minimum compressive strength.
[2]The steel deck panel profile must be 3-inch-deep composite floor deck panel, with a minimum 0.0329-inch base-metal thickness, and a minimum yield strength of 33 ksi. Lower and upper flute widths must be a minimum of 3 7/8 inches. Figure 1 shows the nominal flute dimensions, fastener locations and load orientations for the deck panel profile.
[3]Sand-lightweight concrete fill depth above top of steel deck panel must be a minimum of 3 1/4 inches.
[4]DS fasteners installed at 1 1/2-inch embedment through steel deck panel into the lower flute must be installed at a minimum distance of 6 inches from the edge of the floor deck panel.

TABLE 4—ALLOWABLE LOADS FOR LOW-VELOCITY FASTENERS DRIVEN INTO MINIMUM f'_c = 3,000 psi SAND-LIGHTWEIGHT CONCRETE-FILLED $1^1/_2$-INCH-DEEP, B-DECK STEEL PANEL[1]

FASTENER DESCRIPTION	FASTENER	SHANK DIAMETER (inch)	EMBEDMENT (inch)	FASTENER LOCATION		
				Installed Through Steel Deck Panel Into Concrete[2,3]		
				Tension (lbf)		Shear (lbf)
				Upper Flute	Lower Flute	
Drywall track nail	X-C22 P8 TH[4]	0.138	$^3/_4$	90	110	295
Standard nail	X-C[4]	0.138	$^3/_4$	80	80	315
			1	205	205	445

For **SI:** 1 inch = 25.4 mm, 1 psi = 6895 Pa, 1 lbf = 4.4 N.

[1]Fasteners must not be driven until the concrete has reached the designated minimum compressive strength.
[2]Steel deck panel profiles are $1^1/_2$-inch-deep, B-type deck panel with a minimum base-metal thickness of 0.0329 inch, and a minimum yield strength of 38 ksi. Fasteners may be installed through steel deck panels having either normal or inverted orientations with minimum lower flute widths of $1^3/_4$ and $3^1/_2$ inches, respectively. Fasteners must be placed at centerline of deck panel flutes. Figures 2 and 3 describe additional flute dimensions, fastener locations, and load orientations for both deck panel profiles.
[3]Sand-lightweight concrete fill above top of steel deck panel must be a minimum of $2^1/_2$ inches.
[4]Allowable load values apply to fasteners with black or white collated strip or guidance washer.

TABLE 5—ALLOWABLE LOADS FOR LOW-VELOCITY FASTENERS DRIVEN INTO CONCRETE MASONRY UNITS[1,2,3]

FASTENER DESCRIPTION	FASTENER	SHANK DIAMETER (inch)	EMBED-MENT (inch)	HOLLOW CMU				GROUT-FILLED CMU					
				Face Shell		Mortar Joint		Face Shell		Mortar Joint		Top of Grouted Cell[5]	
				Tension (lbf)	Shear[6] (lbf)	Tension (lbf)	Shear[6] (lbf)	Tension (lbf)	Shear[6] (lbf)	Tension (lbf)	Shear[4] (lbf)	Tension (lbf)	Shear[6] (lbf)
Standard Nail	X-C[7]	0.138	1	40	85	15	50	85	85	45	85	115	175
$^1/_4$-20 Threaded Stud	X-W6	0.145	1	105	175	80	110	125	175	135	150	—	—

For **SI:** 1 inch = 25.4 mm, 1 lbf = 4.4 N.

[1]Fasteners must be installed a minimum of 8 inches from the end of the wall. Multiple fasteners in a bed joint must be spaced a minimum of 8 inches.
[2]See Section 3.4 for CMU, mortar and grout requirements.
[3]No more than one low-velocity fastener may be installed in an individual CMU cell.
[4]Shear direction must be horizontal (bed joint or t-joint) along the CMU wall plane.
[5]Fastener located in center of grouted cell must be installed vertically.
[6]Shear load can be in any direction.
[7]Allowable load values apply to fasteners with black or white collated strip or guidance washer.

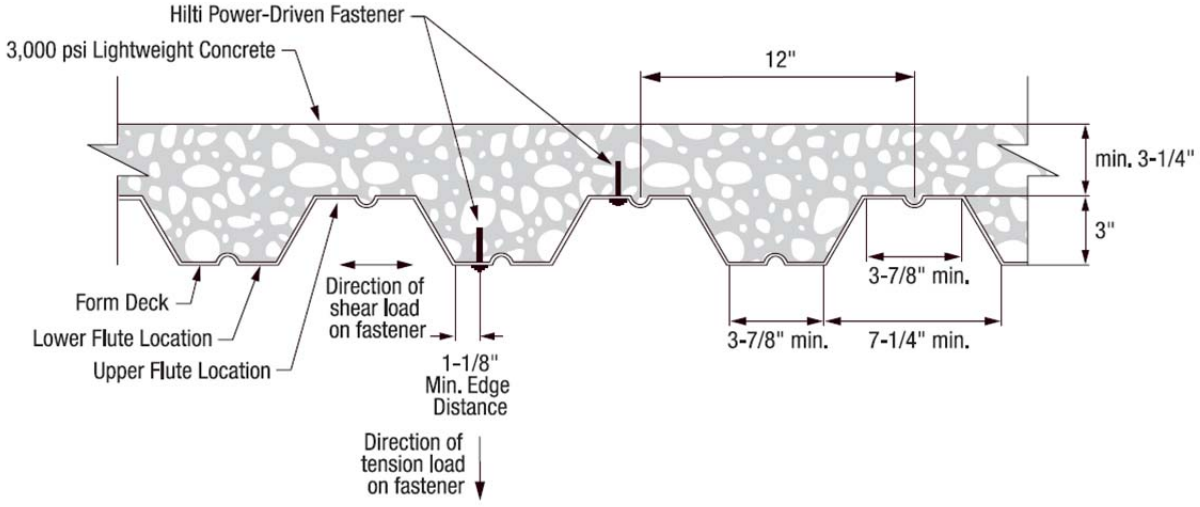


FIGURE 1—HILTI FASTENER LOCATIONS IN 3-INCH-DEEP COMPOSITE FLOOR DECK PANEL

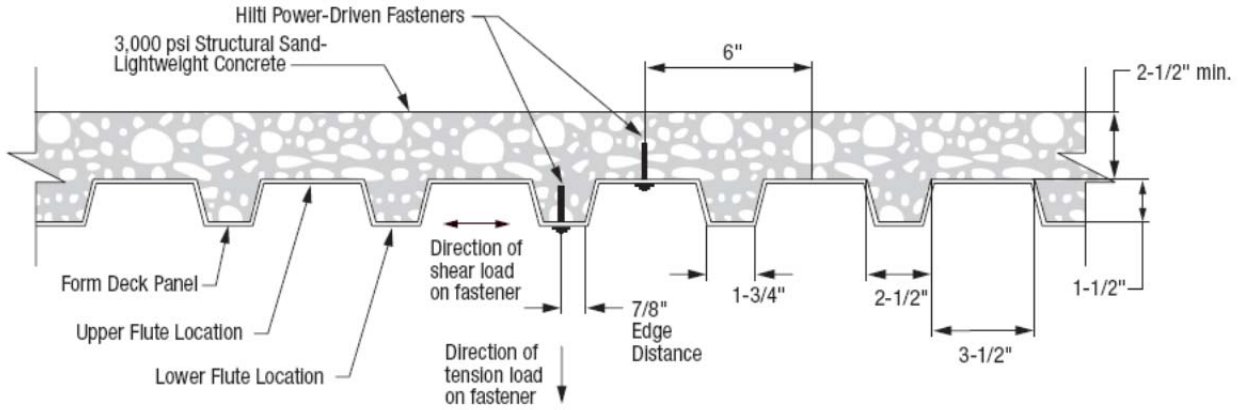
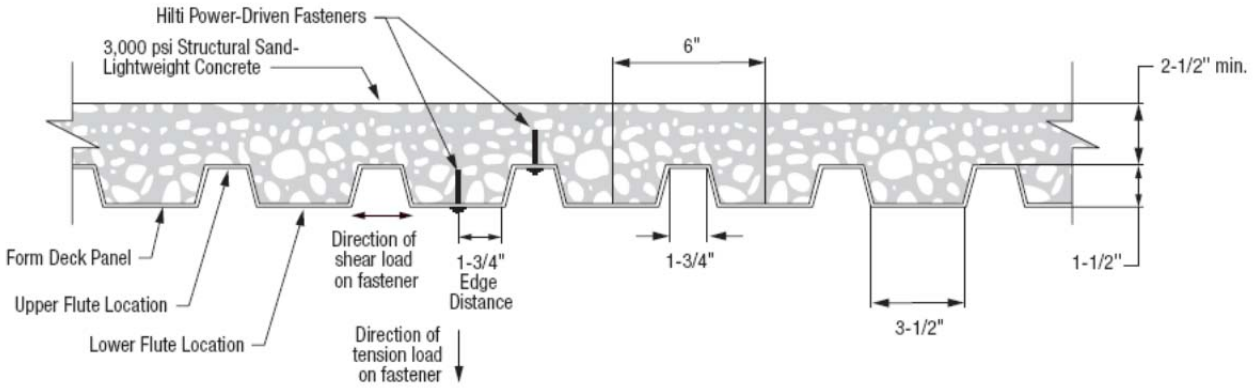


FIGURE 2—HILTI FASTENER LOCATIONS IN $1^1/_2$-INCH-DEEP COMPOSITE FLOOR DECK PANEL, NORMAL DECK PANEL PROFILE ORIENTATION



For **SI:** 1 inch = 25.4 mm, 1 psi = 6895 Pa.

FIGURE 3—HILTI FASTENER LOCATIONS IN $1^1/_2$-INCH-DEEP COMPOSITE FLOOR DECK PANEL, INVERTED DECK PANEL PROFILE ORIENTATION