

ICC-ES Evaluation Report

ESR-2787

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

DIVISION: 06 00 00—WOOD, PLASTICS AND COMPOSITES
Section: 06 05 23—Wood, Plastic and Composite Fastenings

REPORT HOLDER:

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EVALUATION SUBJECT:
USP CAST-IN-PLACE STRUCTURAL CONNECTORS
1.0 EVALUATION SCOPE
Compliance with the following codes:

- 2015 *International Building Code*® (IBC)
- 2015 *International Residential Code*® (IRC)
- 2012 and 2009 *International Building Code*®*
- 2012 and 2009 *International Residential Code*®*
- * ■ ~~2013 *Abu Dhabi International Building Code* (ADIBC)†~~

*Codes indicated with an asterisk are addressed in Section 8.0.

†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
- Use with treated lumber

2.0 USES
2.1 General:

The products described in this report are connectors used to transfer uplift and lateral loads from wood framing members to cast-in-place cold-formed sheet steel connectors embedded in concrete in accordance with IBC Section 1604.8 and are alternatives to the cast-in-place concrete anchors addressed in IBC Section 1901.3.

2.2 Foundation Anchors:

The FA3 and FA4 foundation anchors are used to attach wood sill plates to concrete in accordance with IBC Sections 2308.3 and 2308.6.7.3 and IRC Section R403.1.6 and R602.11.

2.3 Strap-Style Hold-downs:

USP PAHD42, HPAHD22 and STAD series strap-style hold-downs are used to attach vertical framing members to concrete and act as hold-downs, for which capacity requirements are addressed in IBC Sections 2308.6.5.1 and 2308.6.5.2, IRC Sections R602.10.6.1, R602.10.6.2 and R602.10.7, and engineered designs.

3.0 DESCRIPTION
3.1 General:

The connectors described below are formed from one piece of cold-formed steel without welding. The connectors are manufactured from galvanized steel complying with ASTM A653, SS designation, and have a minimum G90 zinc coating, unless otherwise noted. The portions of the connectors which are to be fastened to the wood members have pre-punched holes for the required size and number of nails. Refer to the applicable tables for steel gage and dimensions and type and number of required fasteners. See the table below for base metal thicknesses corresponding to the steel gage:

GAGE NO.	MINIMUM BASE-METAL THICKNESS (inch)
16	0.055
12	0.099
10	0.129

For SI: 1 inch = 25.4 mm

3.2 Foundation Anchors:

Foundation anchors consist of a single piece of cold-formed steel and provide anchorage of horizontal, nominally 2-by wood sill plates to concrete foundations. The foundation anchors have a minimum G90 coating in accordance with ASTM A653. Select anchors are also available with a G185 zinc coating, denoted by 'TZ' in the product designation. In accordance with 2015 IBC Section 2304.10.5.1 (2012 and 2009 IBC Section 2304.9.5.1), coating type and weight for anchors used with treated lumber must be in accordance with the lumber treater's recommendations and the recommendations from USP Structural Connectors, MiTek USA, Inc. In the absence of

such recommendations, the anchors with the G185 zinc coating must be used.

3.2.1 FA3 Foundation Mudsill Anchor: The anchor consists of a 5³/₄-inch-long (146 mm) embedded portion with a 1-inch long (25 mm) end hook bent at 75 degrees, and a protruding portion. The portion of the anchor extending out of the concrete consists of a strap split to provide two nailing flanges. This enables the product to have both flanges wrap over the mudsill, or one flange wrap over the mudsill and the other extend vertically along the narrow face of a stud. Embossment lines are provided on the flanges as a guide when the flanges are fastened to the edge of concrete form board. The anchors are manufactured from Grade 42 steel, with a minimum yield strength of 42,000 psi (289 MPa) and a minimum tensile strength of 56,000 psi (385 MPa). See Figure 1 and Table 1 for more information.

3.2.2 FA4 Foundation Anchors: The FA4 and FA4-TZ anchors consist of a 5³/₁₆-inch-long (132 mm) embedded portion with a tab bent at 90 degrees. The portion of the anchor extending out of the concrete consists of a strap split to provide two nailing flanges. This enables the product to have both flanges wrap over the mudsill, or one flange wrap over the mudsill and the other extend vertically along the edge of a stud. The anchors are manufactured from Grade 40 steel, with a minimum yield strength of 40,000 psi (276 MPa) and a minimum tensile strength of 55,000 psi (379 MPa). See Figure 1 and Table 1 for more information.

3.3 Strap-Style Hold-downs:

Strap-style hold-downs consist of a single piece of cold-formed steel. One end of the hold-down is embedded in concrete, and the remaining portion of the hold-down is fastened to a vertical wood member. The hold-downs are manufactured from Grade 42 steel, with a minimum yield strength of 42,000 psi (289 MPa) and a minimum tensile strength of 56,000 psi (385 MPa).

3.3.1 PAHD42 and HPAHD22 Strap-Style Hold-downs:

The end embedded in the concrete has an embossed, right-angle return 2 inches (51 mm) long. See Figure 2 and Table 2 for more information.

3.3.2 STAD Series Strap-style Hold-downs: The end embedded in the concrete has a right angle return, 2 inches (51 mm) long. See Figure 3 and Table 2 for more information.

3.4 Assembly Materials:

3.4.1 Wood: Wood members must be sawn lumber or structural glued laminated timber with a minimum specific gravity of 0.50 or, when approved by the code official, structural engineered lumber such as structural composite lumber or alternative stand lumber with a minimum equivalent specific gravity of 0.50. Wood members must have a moisture content not exceeding 19 percent for sawn lumber (16 percent for structural composite lumber), except as noted in Section 4.1.1. The thickness of each wood member must be of sufficient thickness that the specified fasteners do not protrude through the opposite side of the member. Wood members that are structural engineered lumber must be recognized in, and used in accordance with, a current ICC-ES evaluation report. Refer to Section 3.4.2 in this report for issues related to treated wood.

3.4.2 Fasteners: Fastener types noted in the tables in this report for use with the USP structural connectors must comply with the following requirements:

- Nails must comply with the material, physical property,

tolerance, workmanship, protective coating and finishes, packaging and package marking requirements specified in ASTM F1667, including the bending yield strength requirements specified in Section S1 of ASTM F1667; and must have the dimensions shown in the following table:

FASTENER TYPE	FASTENER LENGTH (inches)	SHANK DIAMETER (inch)	MINIMUM HEAD DIAMETER (inch)
10dx1 ¹ / ₂	1.5	0.148	0.281
10d common	3	0.148	0.281
16d sinker	3.25	0.148	0.310
16d common	3.5	0.162	0.310

For **SI**: 1 in. = 25.4 mm.

- Fasteners used in contact with preservative-treated or fire-retardant-treated lumber must comply with IBC Section 2304.10.5 or IRC Section R317.3, as applicable.

In addition, the lumber treater's recommendations or recommendations of USP Structural Connectors, MiTek USA, Inc., on minimum corrosion resistance and connection capacities of fasteners used with the specific proprietary preservative-treated or fire-treated lumber, must be followed.

3.4.3 Concrete: Concrete must be normal-weight concrete complying with the provisions of IBC Chapter 19 or IRC Section R402.2, as applicable. The allowable loads in the tables in this report are based on a minimum specified concrete compressive strength, f'_c , of 2,500 psi (17.24 MPa). The concrete must comply with the minimum dimensional requirements noted in the tables and figures.

3.4.4 Steel Reinforcement Bars (Rebar): Steel reinforcement bars must be minimum No. 4 deformed reinforcing bars complying with ACI 318.

4.0 DESIGN AND INSTALLATION

4.1 Design:

4.1.1 General: Allowable loads for the anchor assemblies for use in Allowable Stress Design (ASD) are shown in the tables in this report, based on anchorage to concrete strength and wood connection strength. The lesser of these applicable allowable loads must be used for design. The allowable loads for wood connection strength include the load duration factor applicable to wind and earthquake loading ($C_D = 1.6$) in accordance with the ANSI/AWC National Design Specification[®] (NDS) for Wood Construction, and no increase of these values is allowed. Allowable loads for anchorage to concrete are provided for both wind design and seismic design. The allowable seismic loads address installation into either cracked or uncracked concrete and different seismic design categories (SDCs). For simultaneous loads applied in more than one direction, the connector must be evaluated using a straight line interaction equation.

The tabulated allowable loads are for connectors connected to wood used under continuously dry interior conditions, and where sustained temperatures are 100°F (37.8°C) or less. When fastened to wood that will experience sustained exposure to temperatures exceeding 100°F (37.8°C), the allowable loads based on wood connection strength must be adjusted by the temperature factor, C_t , specified in the NDS. When connectors are fastened to wood having a moisture content greater than 19 percent (16 percent for engineered lumber), or where wet service is expected, the allowable loads based on

wood connection strength must be adjusted by the wet service factor, C_M , as specified in the NDS for lateral loads on dowel-type fasteners.

Allowable loads for installation into uncracked concrete are applicable for connectors installed in a region of a concrete member where analysis indicates no cracking at service level loads. When analysis indicates cracking at service level loads, the allowable loads for installation into cracked concrete must be used.

The allowable loads were derived assuming the entire load applied to the anchor was either from wind or seismic forces. Refer to the footnotes to the tables to determine the design strengths for use in load and resistance factor design (LRFD).

4.1.2 Foundation Anchors: The capacities shown in Table 1 are for assemblies using an FA3 or FA4 foundation anchor. Each assembly consists of a foundation anchor; a wood member having minimum specified dimensions and properties; fasteners of the tabulated type and quantity, used to attach the anchor to the wood member; and a concrete member (supplemental reinforcement not required).

When one strap leg is fastened to a stud, it is assumed that the uplift, F1, F2 and F3 loads on the anchor are transmitted through the sill plate into the anchor. Fastening requirements for transferring load from the stud to the sill plate must be determined in accordance with the applicable code.

4.1.3 Strap-style Hold-downs: The capacities shown in Table 2 are for assemblies using strap-style hold-downs. Each assembly consists of a hold-down device; a wood member having minimum specified dimensions and properties; fasteners of the tabulated type and quantity used to attach the hold-down device to the wood member; and a concrete member with supplemental reinforcement described in the footnotes to Table 2.

Wood members to which the hold-downs are attached must be analyzed in accordance with the NDS for combined axial tension stress and flexural stress due to hold-down eccentricities relative to the centroid of the connected wood member.

The deflection of a shear wall restrained from overturning by hold-downs installed in accordance with this report must be calculated using Equation 23-2 shown in IBC Section 2305.3 for stapled shear walls, or Equation 4.3-1 shown in Section 4.3.2 of ANSI/AWC Special Design Provisions for Wind and Seismic (SDPWS) for nailed shear walls, or a proprietary deflection equation recognized in an ICC-ES evaluation report, as applicable. The total deflection values at ASD level shown in Table 3 include all sources of hold-down assembly elongation (e.g., fastener slip and hold-down device extension).

4.2 Installation:

4.2.1 General: Installation of the connectors must be in accordance with this evaluation report and the manufacturer's published installation instructions. In the event of a conflict between this report and the manufacturer's published installation instructions, this report governs.

Refer to Figures 1 through 3 and the footnotes to Tables 1 and 2 for typical installation details. The connectors must be placed prior to casting the concrete or while the concrete is still wet, in accordance with the manufacturer's instructions. The anchors must be placed in such a way as to ensure they will have the required embedment depth,

spacing and edge distance. The connectors must not be bent and/or fastened to the wood until the concrete has sufficiently cured so that the anchor placement does not shift and the concrete is not damaged. The connectors must be fastened to the wood members using the fastener type and minimum quantity noted in the applicable table.

4.2.2 Foundation Anchors: Foundation anchors must be spaced a minimum of 8 inches (203 mm) and a minimum of 4 inches (102 mm) from the end of the concrete foundation wall. Anchors must be placed no more than 12 inches (305 mm) from the end of the sill plate, in accordance with the manufacturer's instructions. When one strap leg is fastened to a stud, the minimum distance from the center of the fasteners to the edge of the stud must be $\frac{3}{8}$ inch (10 mm). In addition to being fastened with the anchor, the wood stud must be fastened to the wood sill plate in accordance with the minimum fastening requirements in the code.

4.3 Special Inspection:

4.3.1 IBC: For the purpose of determining special inspection requirements, connectors are considered special cases (they are alternates to anchor bolts and must be installed following the manufacturer's installation instructions) and may be used as elements of a main wind or seismic force-resisting system.

4.3.2 IRC: For installations complying with the IRC, special inspection is not required.

5.0 CONDITIONS OF USE

The USP Structural Connectors 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 connectors must be manufactured, identified and installed in accordance with this report and the manufacturer's published installation instructions. In the event of a conflict between this report and the manufacturer's published installation instructions, the more restrictive governs.
- 5.2** Calculations showing compliance with this report must be submitted to the code official. The calculations must be prepared by a registered design professional where required by the statutes of the jurisdiction in which the project is to be constructed.
- 5.3** Connected wood members, fasteners, concrete and reinforcement must comply with Sections 3.4.1, 3.4.2, 3.4.3 and 3.4.4, respectively.
- 5.4** Adjustment factors noted in Section 4.1.1 and the applicable codes must be considered, where applicable.
- 5.5** Use of fasteners with preservative- or fire-retardant-treated lumber shall be in accordance with Section 3.4.2 of this report. Foundation anchors with a G185 coating may be used with preservative- or fire-retardant-treated lumber in accordance with IBC Section 2304.10.5.1. Other connectors addressed in this report may be used in accordance with the manufacturer's recommendations only.
- 5.6** Use of the connectors is limited to dry, interior locations, which include exterior walls which are protected by an exterior wall envelope, except as noted in Section 3.2.
- 5.7** The USP connectors are manufactured under a quality control program with inspections by ICC-ES.

6.0 EVIDENCE SUBMITTED

Data in accordance with the ICC-ES Acceptance Criteria for Cast-in-place Cold-formed Steel Connectors in Concrete for Light-frame Construction (AC398), dated October 2008 (editorially revised July 2015).

7.0 IDENTIFICATION

Each connector described in this report is identified by the product model (stock) number, the coating designation (if greater than G90), the evaluation report (ESR-2787), and one or more of the following designations: USP Structural Connectors, *MiTeK*[®] USA, Inc., or USP or United Steel Products Company.

8.0 OTHER CODES

8.1 Evaluation Scope:

In addition to the 2015 IBC and 2015 IRC addressed in Sections 2.0 through 7.0, the products in this report were evaluated for compliance with the requirements of the following codes:

- 2012 and 2009 *International Building Code*[®] (2012 and 2009 IBC)
- 2012 and 2009 *International Residential Code*[®] (2012 and 2009 IRC)

8.2 Uses:

8.2.1 General:

The products described in this report are connectors used for to transfer uplift and lateral loads from wood framing members to cast-in-place cold-formed sheet steel connectors in concrete in accordance with 2012 and 2009 IBC Section 1604.8 and are alternatives to the cast-in-place anchors addressed in 2012 IBC Sections 1908 and 1909 and 2009 IBC Sections 1911 and 1912.

8.2.2 Foundation Anchors:

Foundation anchors are used to attach wood sill plates to concrete in accordance with 2012 and 2009 IBC Sections 2308.3.3, 2308.6, 2308.12.8 and 2308.12.9, and IRC Section R403.1.6 and R602.11.

8.2.3 Strap-Style Hold-downs:

Strap-style hold-downs are used to attach vertical framing members to concrete and act as hold-downs, for which capacity requirements are addressed in 2012 IRC Sections R602.10.6.1, R602.10.6.2 and R602.10.7; 2009 IRC Sections R602.10.3.2, R602.10.3.3 and R602.10.4.4; and engineered designs.

8.3 Description:

See Section 3.0, except use of fasteners with treated lumber must comply with 2012 and 2009 IBC Section 2304.9.5.

8.4 Design and Installation:

8.4.1 Design: See Section 4.1.

8.4.2 Installation: See Section 4.2.

8.4.3 Special Inspection: See Section 4.3.

8.5 Conditions of Use:

See Section 5.0, except use of fasteners with treated lumber is addressed in 2012 and 2009 IBC Section 2304.9.5.

8.6 Evidence Submitted:

See Section 6.0.

8.7 Identification:

See Section 7.0.

TABLE 1—ALLOWABLE LOADS FOR FA3 AND FA4 FOUNDATION ANCHOR ASSEMBLIES^{1,2}

ANCHOR		INSTALLATION					ALLOWABLE LOADS (lbf)					DEFLECTION AT ALLOWABLE LOAD BASED ON WOOD CONNECTION STRENGTH (inch)				
Stock Number	Steel Gage	Application	Wood Sill Plate Nominal Size	Quantity of 10dx1 1/2 Nails Into:			Concrete Stemwall Minimum Thickness (inches)	LOAD DIRECTION ¹	Based On Anchorage To Concrete Strength ^{2,3}				Based On Wood Connection Strength C _D = 1.6 ^{4,5}			
				SILL PLATE		Stud			Concrete Condition	Type of Load						
				Side	Top					Wind	Seismic for Seismic Design Categories:					
								A, B	C, D, E, F							
FA3	16	Both legs bent over sill plate and attached with 10dx1 1/2 nails	2x4 or 2x6	2	4	—	6	F1	Uncracked	780	780	625	625	0.090		
									Cracked	545	545	470				
								F2	Uncracked	1,080	1,080	925	735			
									Cracked	755	755	645				
		Uplift	Uncracked	1,410	1,410	1,205	1,010									
			Cracked	985	985	845										
		One leg bent over sill plate and one leg vertical against stud and attached with 10dx1 1/2 nails	2x4 or 2x6	2	2	2	2	6	F1	Uncracked	780	780	625		615	0.023
										Cracked	545	545	470			
F2	Uncracked								1,080	1,080	925	465				
	Cracked								755	755	645					
Uplift	Uncracked								1,410	1,410	1,205	755				
	Cracked								985	985	845					
FA4, FA4-TZ	16	Both legs bent over sill plate and attached with 10dx1 1/2 nails	2x4 or 2x6	3	6	—	6	F1	Uncracked	1460	1460	1460	1460	0.020		
									Cracked	1280	1280	1095				
								F2	Uncracked	1115	1115	875	1,210			
									Cracked	780	780	670				
								F3	Uncracked	655	655	655	655			
									Cracked	610	610	520				
								Uplift	Uncracked	905	905	875	905			
									Cracked	780	780	670				
		One leg bent over sill plate and one leg vertical against stud and attached with 10dx1 1/2 nails	2x4 or 2x6	3	3	3	3	6	F1	Uncracked	955	955	955	955	0.008	
										Cracked	955	955	955			
									F2	Uncracked	1115	1115	875	1,430		
										Cracked	780	780	670			
									F3	Uncracked	515	515	515	515		
										Cracked	515	515	515			
									Uplift	Uncracked	780	780	780	780		
										Cracked	780	780	670			

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

¹Refer to Figure 1 for illustrations of foundation anchors and typical installation; additional installation requirements and depiction of Load Directions.

²Allowable loads based on anchorage to concrete strength require a minimum anchor spacing of 8 inches, and a minimum distance from the end of the concrete wall of 4 inches.

³To obtain design strengths for use in LRFD, the tabulated allowable (ASD) loads based on anchorage to concrete strength for wind and SDC A and B must be multiplied by 1.6, and the tabulated allowable (ASD) loads for SDC C, D, E, and F must be multiplied by 1.4.

⁴Wood members must comply with Section 3.4.1 and must have a minimum specific gravity of 0.50.

⁵Allowable loads for anchors fastened to wood members are based on allowable stress design (ASD) and include the load duration factor (C_D) corresponding to wind and earthquake loading in accordance with the NDS. No further increase is allowed and the ASD value must also be used for LRFD.

TABLE 2—ALLOWABLE UPLIFT LOADS FOR STAD, HPAHD, PAHD STRAP-STYLE HOLD-DOWN ASSEMBLIES^{1,3}

ANCHOR		INSTALLATION				ALLOWABLE LOADS ^{5,7} (lbf)				DEFLECTION AT ALLOWABLE LOAD BASED ON WOOD CONNECTION STRENGTH (inch)		
Stock Number	Steel Gage	Fastener Schedule		Concrete Stemwall Minimum Thickness (inches)	EMBEDMENT DEPTH (inches)	STRAP LOCATION ²	Based On Anchorage To Concrete Strength ⁴				Based On Wood Connection Strength $C_D = 1.6^5$	
		Quantity	Nail Type				Concrete Condition	Type of Load				
								Wind	Seismic for Seismic Design Categories:			
		A, B	C, D, E, F									
STAD8	12	24	16d Sinker or 10d common	6	8	Corner	Uncracked	2405	2405	2060	4700	0.115
							Cracked	1685	1685	1445		
STAD10	12	28	16d Sinker or 10d common	6	10	Middle	Uncracked	3930	3930	3060	4700	0.115
							Cracked	2805	2805	2405		
STAD14	12	38	16d Sinker or 10d common	6	14	Corner	Uncracked	5035	5035	4030	4685	0.104
							Cracked	3525	3525	3020		
HPAHD22	10	23	16d Common	6	9 ¹ / ₂	Middle	Uncracked	5580	5580	4345	4685	0.104
							Cracked	4270	4270	3660		
PAHD42	12	15	16d Common	6	8	Corner	Uncracked	3300	3300	2635	3830	0.118
							Cracked	2310	2310	1980		
PAHD42	12	15	16d Common	6	8	Middle	Uncracked	3460	3460	2965	3830	0.118
							Cracked	2425	2425	2075		
PAHD42	12	15	16d Common	6	8	Corner	Uncracked	1225	1225	1050	2065	0.095
							Cracked	855	855	735		
PAHD42	12	15	16d Common	6	8	Middle	Uncracked	2610	2610	2140	2065	0.095
							Cracked	1830	1830	1565		

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

¹Refer to Figures 2 and 3 for illustrations of the hold-downs and typical installation, and for additional installation requirements. At least 1- #4 rebar must be installed in the shear cone as shown in the figures.

²Corner Location implies that the distance from the corner of the wall to the edge of the strap is no less than 1/2 inch. Middle Location implies that the minimum distance from the corner of the wall to the centerline of the strap is no less than 1.5 times the embedment depth. For edge distances between 1/2 inch and 1.5 times the embedment depth, use straight line interpolation to determine the allowable load.

³Minimum anchor spacing for full capacity is 2 times the Embedment Depth. For spacing less than this, reduce the tabulated capacity proportionally.

⁴To obtain design strengths for use in LRFD, the tabulated allowable (ASD) loads based on anchorage to concrete strength for wind and SDC A and B must be multiplied by 1.6, and the tabulated allowable (ASD) loads for SDC C, D, E, and F must be multiplied by 1.4.

⁵Allowable loads for anchors fastened to wood members are based on allowable stress design (ASD) and include the load duration factor (C_D) corresponding to wind and earthquake loading in accordance with the NDS. No further increase is allowed and the ASD value must also be used for LRFD.

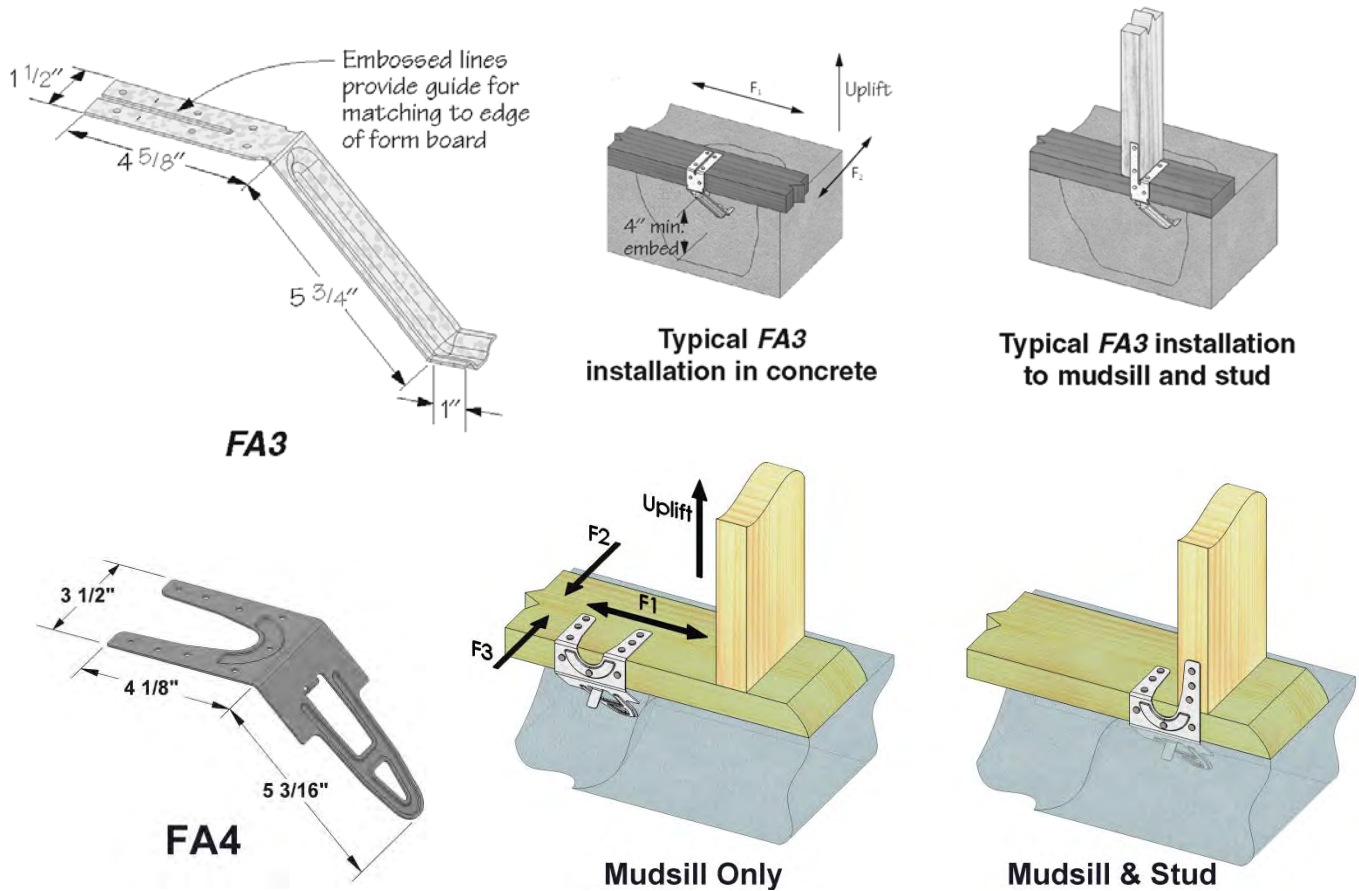


FIGURE 1—FA3 AND FA4 FOUNDATION ANCHORS

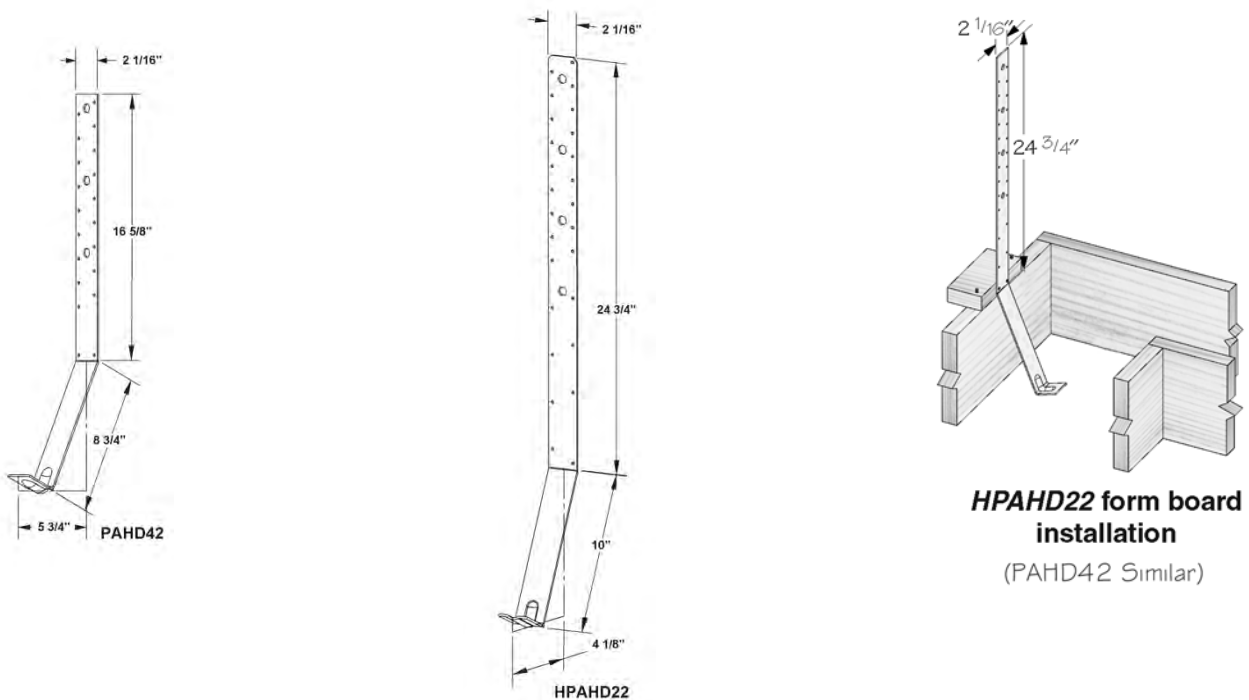


FIGURE 2—PAHD AND HPAHD STRAP STYLE HOLD-DOWN CONNECTORS (continued on next page)

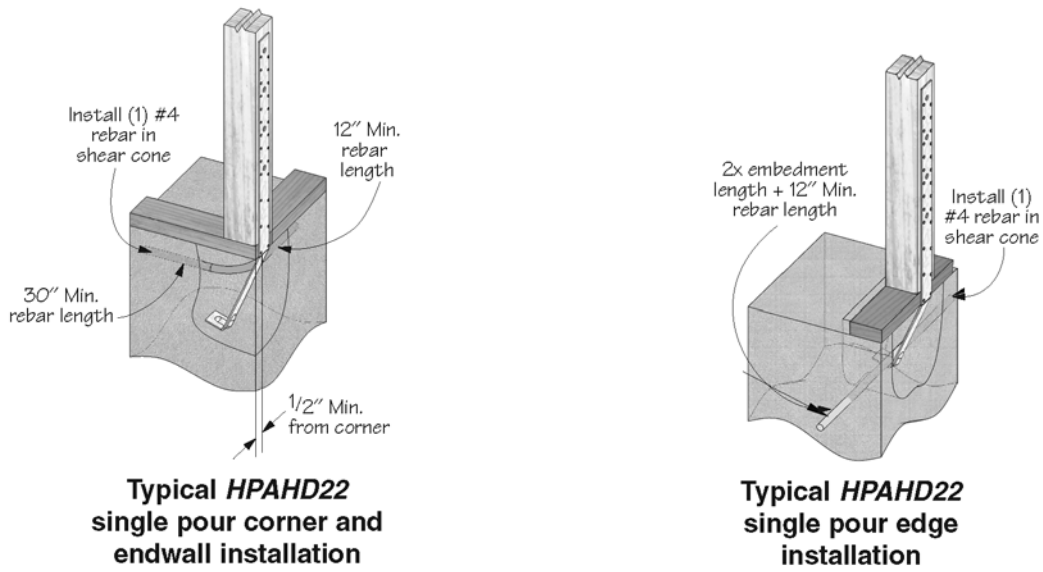


FIGURE 2—PAHD AND HPAHD STRAP STYLE HOLD-DOWN CONNECTORS (Continued)

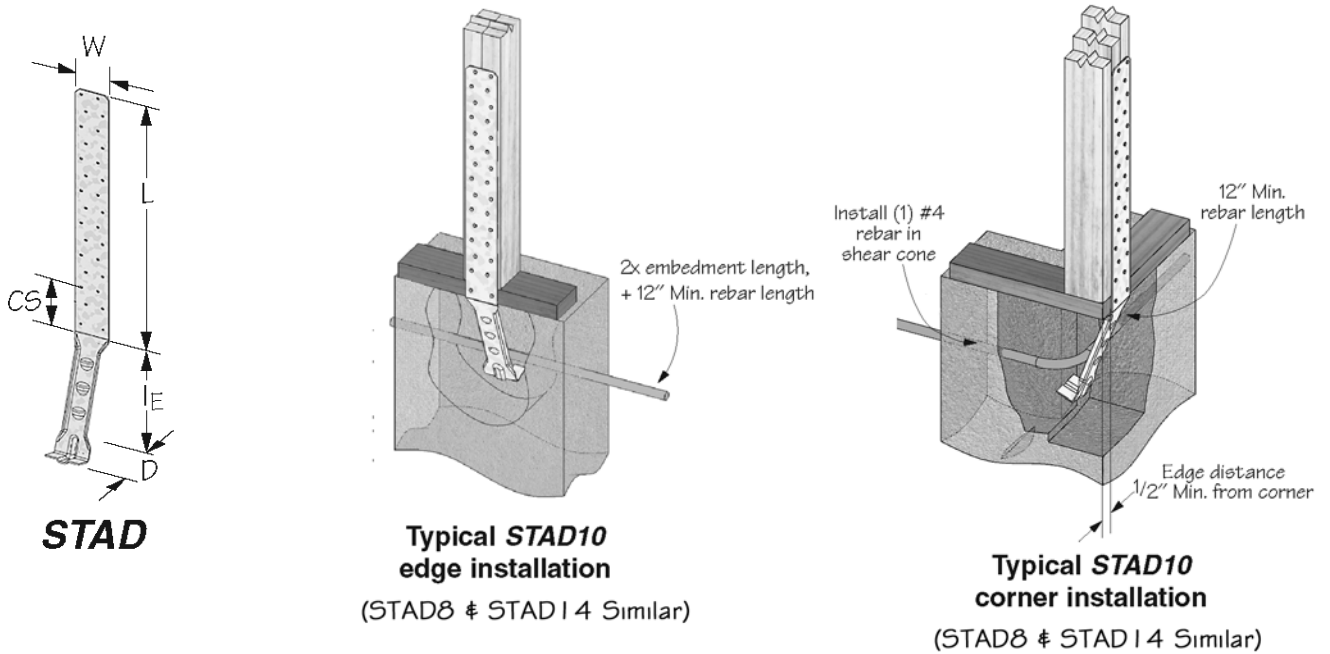


FIGURE 3—STAD STRAP STYLE HOLD-DOWN CONNECTORS