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TECHNICAL NOTE
On Cold-Formed Steel Construction

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SCREWS FOR COLD-FORMED STEEL-TO-WOOD AND WOOD-TO-COLD-FORMED STEEL ATTACHMENTS

This Technical Note updates and replaces CFSEI Tech Note F101-12

Summary: Screws are commonly used to fasten Cold-Formed Steel (CFS) framing to wood members or attach wood structural panel decking to CFS joists or rafters. The *AISI S100, North American Specification for the Design of Cold-Formed Steel Structural Members*, provides design equations for determining the capacity of screw connections in CFS members. For wood members, the *National Design Specification for Wood Construction (NDS)* offers design equations for determining the capacity of various fastener connections, including nails, wood screws, bolts, etc. The *APA - Engineered Wood Association* and building codes provide multiple resources for determining the capacity of screw connections when attaching wood sheathing. This Tech Note reviews these resources and discusses the design and detailing of these fastener connections.

INTRODUCTION

Cold-Formed Steel (CFS) framing is often used with wood products. Steel stud walls support wood trusses, I-joists, glued-laminated beams, and engineered wood like Structural Composite Lumber (SCL). Additionally, wood structural panels are applied as sheathing over CFS rafters, joists, and wall studs. To connect these elements, screws are commonly used.

The capacity of self-drilling tapping screws in CFS-to-CFS connections is referenced in the *AISI S100 Specification* and is relatively straightforward. Determining the capacity of screws in wood is more complex due to various factors that affect screw connection strength. Careful attention is needed when choosing a fastener that can penetrate through both steel and wood layers and securely hold the members.

SCREWS FOR CFS-TO-WOOD ATTACHMENTS

Standard Wood Screws

Where steel connectors have pre-punched or predrilled holes, standard wood screws (or nails) may be used as shown in Figure 1. Figure 2 illustrates the geometry of standard wood screws. Pan head screws are most often used. Loose washers are not usually used unless required to increase pullover resistance of the attached steel sheet. The shaft is covered with coarse threads along at least 2/3 of the screw length. Standard wood screws are not typically fully threaded; in certain situations, fully threaded screws may be used to maximize withdrawal capacity of the fasteners in wood. Standard wood screws have an unhardened gimlet point and are designed to penetrate wood only. These screws are not intended to penetrate steel of any thickness.

Chapter 12 of the NDS provides guidelines and design equations for the use of standard wood screws. To meet the NDS installation requirements, fasteners must comply with ANSI/ASME Standard B18.6.1. This standard dictates the head size, threads, diameter, and manufacturing tolerances for wood screws.

Table 1 shows lead hole or pre-drilling requirements for wood screws. Pre-drilling of the wood member is often required to prevent wood splitting and fastener failure during driving. This pre-drilling is specified by the NDS for screws loaded in withdrawal in wood species with a specific gravity (G) of 0.50 or greater, and for wood screws loaded laterally in all wood species. The NDS requires that lead holes not exceed these values for design equations to be applicable. Pre-drilling may not be required for some proprietary screws.

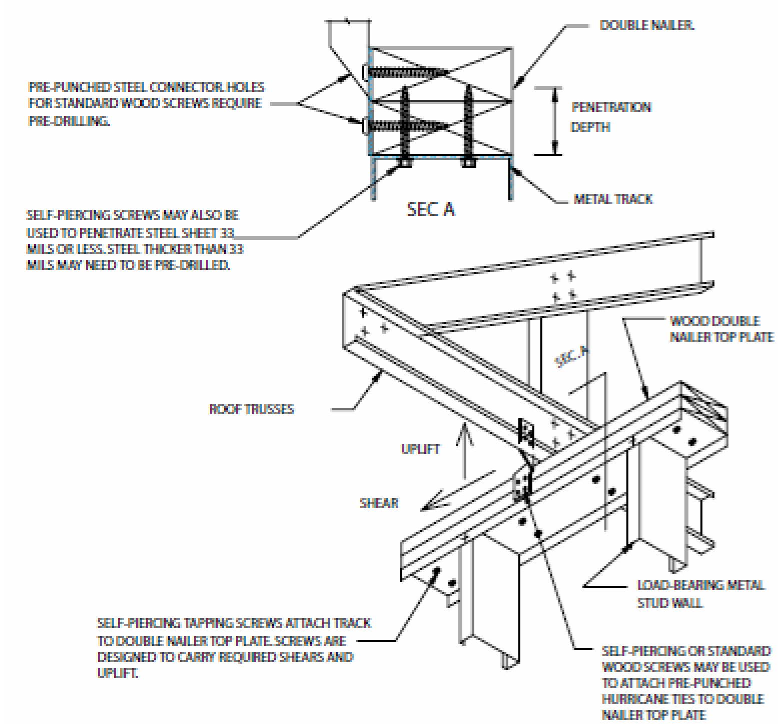

Figure 1: CFS-to-Wood Screw Applications

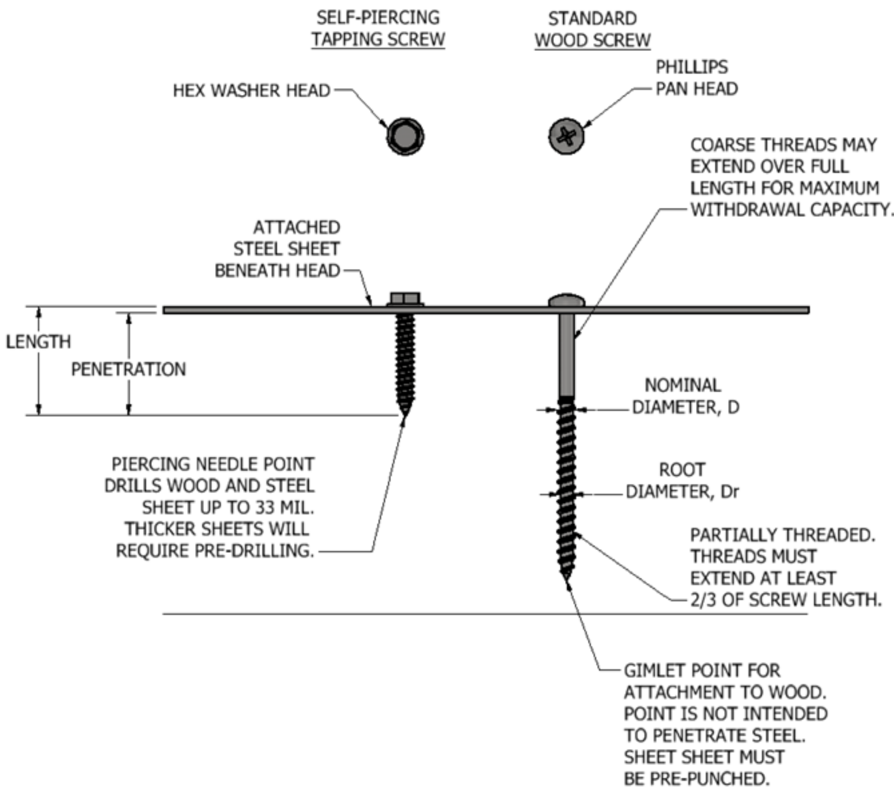

Figure 2: Screws for CFS-to-Wood Attachments

Table 1: Wood Screw Lead Hole Requirements (Based on 12.1.5 of NDS 2018)

Screw Number (#)	Nominal Diameter, D (in.)	Root Diameter, D_r (in.)	Lead hole diameter for withdrawal loading (in.)			Lead hole diameter for lateral loading (in.)			
						G ≤ 0.6		G > 0.6	
			G ≤ 0.5	0.5 < G ≤ 0.6	G > 0.6	Shank	Threads	Shank	Threads
6	0.138	0.113	None	1/16	1/8	1/8	1/8	1/8	1/8
7	0.151	0.122	None	1/16	1/8	1/8	1/8	1/8	1/8
8	0.164	0.131	None	1/16	1/8	1/8	1/8	3/16	1/8
9	0.177	0.142	None	1/8	1/8	1/8	1/8	3/16	1/8
10	0.190	0.152	None	1/8	1/8	3/16	1/8	3/16	1/8
12	0.216	0.171	None	1/8	1/8	3/16	1/8	3/16	3/16
14	0.242	0.196	None	1/8	1/8	3/16	3/16	1/4	3/16

Notes:
1. Wood screw shall be inserted into the lead hole using a screwdriver or other tool, not by driving with a hammer.
2. No reduction to design values is anticipated if soap or other lubricant is used on the screw or in the lead holes to facilitate insertion and to prevent damage to the wood screw.
3. G is the specific gravity of wood species group (See Table 12.3.3A of NDS).
4. Nominal diameter (D) and Root diameter (D_r) are taken from Table L3, Appendix L of NDS.

Table 2 shows the allowable withdrawal loads for screws in wood. A key factor in wood screw strength is the specific gravity of the wood member (G), which determines the withdrawal capacity. Design values are provided for three species groups commonly used in North America. Withdrawal strength is a function of wood strength, screw diameter and threaded penetration depth.

Table 3 shows allowable shear loads for screws in wood. These values depend on the specific gravity of the wood, determining the dowel bearing strength of the wood. Additionally, they rely on the dowel strength of the attached steel sheet and the bending strength of the screw.

The values listed in Tables 2 and 3 apply specifically to wood and/or dowel bending-yielding failure. To determine the final allowable load for a connection, adjustment factors from Table 4 must be applied. Additionally, it is essential to check for screw connection failure in the steel sheet, which involves considerations such as bearing, pullover, edge distance, and other relevant factors. It is important to note that wood adjustment factors should not be applied to the strength of the screws and the attached steel sheet when determining capacity per AISI S100.

Proprietary connectors, such as the "hurricane ties" shown in Figure 1, often have published tested capacities for specific sizes of screws or nails. If alternative fasteners are preferred, the designer should evaluate the potential impact of this change on the allowable load of the connection.

Self-Piercing Tapping Screws

Self-piercing tapping screws used for wood connections may be used as shown in Figure 1, where unpunched cold-formed steel members 33 mils or less must be attached to wood members or for thicker steel members where pre-punched steel connectors are used. Figure 2 illustrates the geometry of a self-piercing tapping screw. These screws feature a self-piercing point, as defined in ASTM C1513 (2018), are case-hardened, and are capable of piercing steel sheets up to 33 mils thick. According to manufacturer recommendations, some self-piercing screws can penetrate thicker steels.

Hex washer heads are chosen because this head style provides the best torque capacity, enabling penetration of unpunched steel sheets and wood members without the need for a pilot hole. Commonly used sizes for self-piercing tapping screws include #8 and #10 diameter screws up to 3 inches long. These screws have coarse threads designed to enhance the grip on wood members.

Self-piercing tapping screws are typically fully threaded for lengths of 1-1/2 inches and less, while longer screws are usually threaded over 2/3 of their length. Loose washers are not typically used unless required to increase pull-over resistance of the attached sheet. Steel-backed, bonded neoprene washers are often employed in situations where watertight connections are desired.

Table 2: Wood Screw Withdrawal Capacity (based on 12.2.2 of NDS 2018)

Specific Gravity (Wood Species Combination)	Wood Screw Number (#)	Nominal Screw Diameter, D (in.)	Reference Withdrawal Design Value, W (lb/in.)	Adjusted Withdrawal Design Value, W' (lb) For Various Screw Lengths (in.)				
				1	**1.25**	**1.5**	**2**	**2.25**
G = 0.55 (Southern Pine)	6	0.138	119	79	99	119	159	178
	7	0.151	130	87	108	130	174	195
	8	0.164	141	94	118	141	189	212
	9	0.177	153	102	127	153	203	229
	10	0.19	164	109	137	164	218	246
	12	0.216	186	124	155	186	248	279
	14	0.242	209	139	174	209	278	313
G = 0.50 (Douglas Fir-Larch)	6	0.138	98	66	82	98	131	147
	7	0.151	108	72	90	108	143	161
	8	0.164	117	78	97	117	156	175
	9	0.177	126	84	105	126	168	189
	10	0.19	135	90	113	135	181	203
	12	0.216	154	103	128	154	205	231
	14	0.242	172	115	144	172	230	259
G = 0.42 (Spruce-Pine-Fir)	6	0.138	69	46	58	69	93	104
	7	0.151	76	51	63	76	101	114
	8	0.164	82	55	69	82	110	124
	9	0.177	89	59	74	89	119	133
	10	0.19	96	64	80	96	127	143
	12	0.216	109	72	90	109	145	163
	14	0.242	122	81	101	122	162	182

Notes:

1. Withdrawal Design Value, $W = 2850\, G^2 D$ (Equation 12.2-2 of NDS).
2. G is the specific gravity of wood species group (See Table 12.3.3A of NDS).
3. To determine the Adjusted Withdrawal Design Value W', multiply W by all applicable adjustment factors C_D, C_M and C_t (See Table 4(a)). Assumed $C_D = C_M = C_t = 1.0$.
4. Values are for screws inserted in the side grain, with the screw axis perpendicular to thewood fibers. Values are not applicable for end-grain loading.
5. Screws must comply with ANSI/ASME Standard B18.6.1. Assumed thread length is 2/3 oftotal wood screw length.
6. Tabulated values are for failure in the wood member.
7. Steel sheet must also be checked for pull-over and/or pull-out resistance per AISI S100 provisions.

Table 3: Wood Screw Lateral Capacity (based on 12.3 of NDS 2018)

Single shear reference design values, Z (lb)								
Wood Species Combination	**Nominal Diameter, D (in.)**	**Screw Bending Yield Strength, F_{yb} (psi)**	**Min. screw penetration, P_{min} (in.)**	**Sheet Steel Thickness (mils)**				
				33	**43**	**54**	**68**	**97**
G = 0.55 (Southern Pine) Fem = 5526 psi Fes = 61875 psi (ASTM A1003, Grade 33 steel)	0.138	100,000	0.83	76	77	78	81	88
	0.164	90,000	0.98	96	97	99	102	110
	0.177	90,000	1.06	113	114	115	118	127
	0.190	80,000	1.14	122	123	124	127	136
	0.216	80,000	1.30	154	154	156	158	167
	0.242	70,000	1.45	170	170	171	174	182
G = 0.50 (Douglas Fir-Larch, Structural I Plywood, OSB-All Grades) Fem = 4637 psi Fes = 61875 psi (ASTM A1003, Grade 33 steel)	0.138	100,000	0.83	67	68	69	70	76
	0.164	90,000	0.98	89	90	91	94	100
	0.177	90,000	1.06	104	105	107	109	116
	0.190	80,000	1.14	113	114	115	118	127
	0.216	80,000	1.30	142	143	144	147	155
	0.242	70,000	1.45	157	157	158	161	169
G = 0.42 (Spruce-Pine-Fir, Other Plywood Grades) Fem = 3364 psi Fes = 61875 psi (ASTM A1003, Grade 33 steel)	0.138	100,000	0.83	49	50	51	53	59
	0.164	90,000	0.98	67	68	69	71	77
	0.177	90,000	1.06	79	79	80	82	88
	0.190	80,000	1.14	90	91	92	94	100
	0.216	80,000	1.30	115	115	116	118	123
	0.242	70,000	1.45	132	133	134	135	140

Notes:

1. Lateral design value, Z, is based on the minimum computed yield mode value using equations in Tables 12.3.1A and 12.3.1B of NDS.
2. Minimum penetration of wood screw (P_{min}) into the main member shall be 6D per Section 12.1.5.6 of NDS.
3. Steel sheet must also be checked for shear resistance, using screw root diameter and AISI S100. The values above are for failure in the wood member and dowel bending yield only.
4. To determine the adjusted design value Z′, multiply Z by all applicable adjustment factors – C_D, C_M, C_t and C_{eq} [See Table 4(a)].
5. Screw bending yield strengths were taken from NDS Appendix I, Table I1. Presumed screw yield strength is based on commonly available screws. Confirm with selected screw supplier.
6. Screws must comply with ANSI/ASME Standard B18.6.1.
7. Assumes threaded length is 2/3 of total wood screw length.
8. G is specific gravity of wood species group (See Tables 12.3.3A and 12.3.3B of NDS).

Table 4: Wood Screw Adjustment Factors (based on Table 11.3.1 of NDS 2018)

4(a) Applicability of Adjustment Factors for Wood Screws (Table 11.3.1 of NDS)

Adjusted Reference Design Values	Load Duration Factor	Wet Service Factor	Temperature Factor	End Grain Factor
Withdrawal, W′ = W *	C_D	C_M	C_t	n/a
Lateral, Z′ = Z *	C_D	C_M	C_t	C_{eg}
Pull-Through, W_H	C_D	C_M	C_t	n/a

Notes:

1. Other factors may apply; refer to NDS for Group Action Factor (C_g), Geometry Factor (C_Δ) and Diaphragm Factor (C_{di}).

4(b) Load Duration Factors, C_D (Table 2.3.2 of NDS)

Load Duration	C_D	Typical Design Loads
Permanent	0.9	Dead Load
Ten Years	1.0	Occupancy Live Load
Two Months	1.15	Snow Load
Seven Days	1.25	Construction Load
Ten Minutes	1.6	Wind/Earthquake Load

4(c) Wet Service Factors for Wood Screws, C_M (Table 11.3.3 of NDS)

Loads	Moisture Content		C_M
	At Time of Fabrication	In-Service	
Withdrawal, W	Any	≤ 19%	1
	Any	> 19%	0.7
Lateral, Z	≤ 19%	≤ 19%	1
	> 19%	≤ 19%	0.4*
	Any	> 19%	0.7
Pull-Through, W_H	Any	≤ 19%	1
	Any	> 19%	0.7

* C_M = 0.7 for screws with diameter, D, less than 1/4 in. C_M = 1.0 for screw connections with: (1) one fastener only, or (2) two or more fasteners placed in a single row parallel to grain, or (3) fasteners placed in two or more rows parallel to grain with separate splice plates for each row. Note: Steel framing will require special corrosion protection for conditions that would warrant the use of wet service factors in wood design.

4(d) Temperature Factors for Wood Screws, C_t (Table 11.3.4 of NDS)

In-Service Moisture Conditions*	C_t		
	T ≤ 100°F	100°F < T ≤ 125°F	125°F < T ≤ 150°F
Dry	1	0.8	0.7
Wet	1	0.7	0.5

*Wet and Dry service conditions for screws are specified above in Table 4(c).

4(e) End Grain Factor for Wood Screw, C_{eg} (Section 12.5.2 of NDS)

For end-grain screw applications, use C_{eg} = 0.67 to determine the lateral design value, Z, when the screw axis aligns parallel to the wood fibers in the main member. Wood screws are not permitted to be loaded in withdrawal from the end-grain of wood (C_{eg} = 0).

There are no design provisions that specifically address the strength of self-piercing tapping screws. While many manufacturers supply tested design values for these fasteners, the data is limited and does not account for the numerous factors addressed by the NDS in its wood screw provisions. The NDS requires wood screws to comply with ANSI/ASME Standard B18.6.1-1981 for its design provisions to apply. It is important to note that most self-piercing tapping wood screws comply with ANSI/ASME Standard B18.6.1-1981 in all aspects except for head style. This exception is due to hex washer heads not being considered in the standard. If a particular self-piercing tapping wood screw complies with all other portions of ANSI/ASME Standard B18.6.1-1981, it would be reasonable to use the design values in the NDS and tables 2, 3, and 4, provided that the screw does not split the wood (or a pre-drilled hole must be provided per NDS to prevent splitting).

SCREWS FOR WOOD-TO-CFS ATTACHMENTS

Wood-to-CFS screw connections are used to attach wood panels or members to steel framing members, as shown in Figures 3 and 4. The heads have a countersunk design to mount flush with the wood surface and are typically Phillips-drive type. Other available head types include trim-head, bugle-head, wafer-head, and flat-head. Specialty countersunk head styles may include the flat or wafer style with cutting nibs under the head to create a counter-bore in the wood, to help prevent wood splitting. All wood-to-CFS screw fasteners should comply with ASTM C1513 (2018), which governs the performance requirements of steel tapping screws.

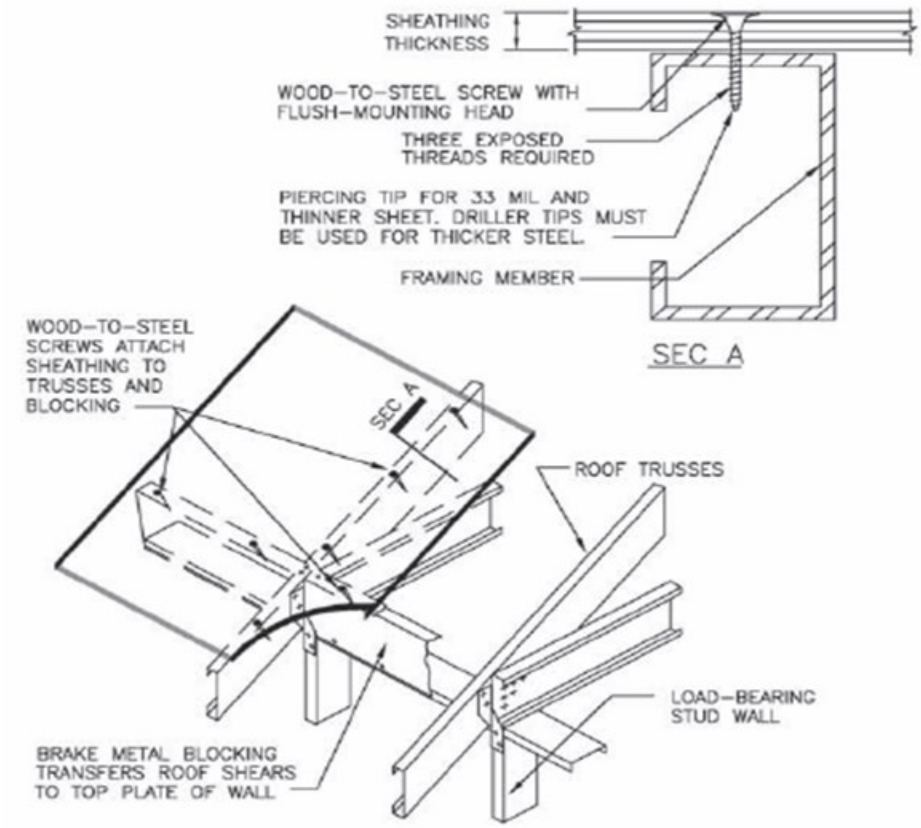

Figure 3: Wood-to-CFS Screw Applications

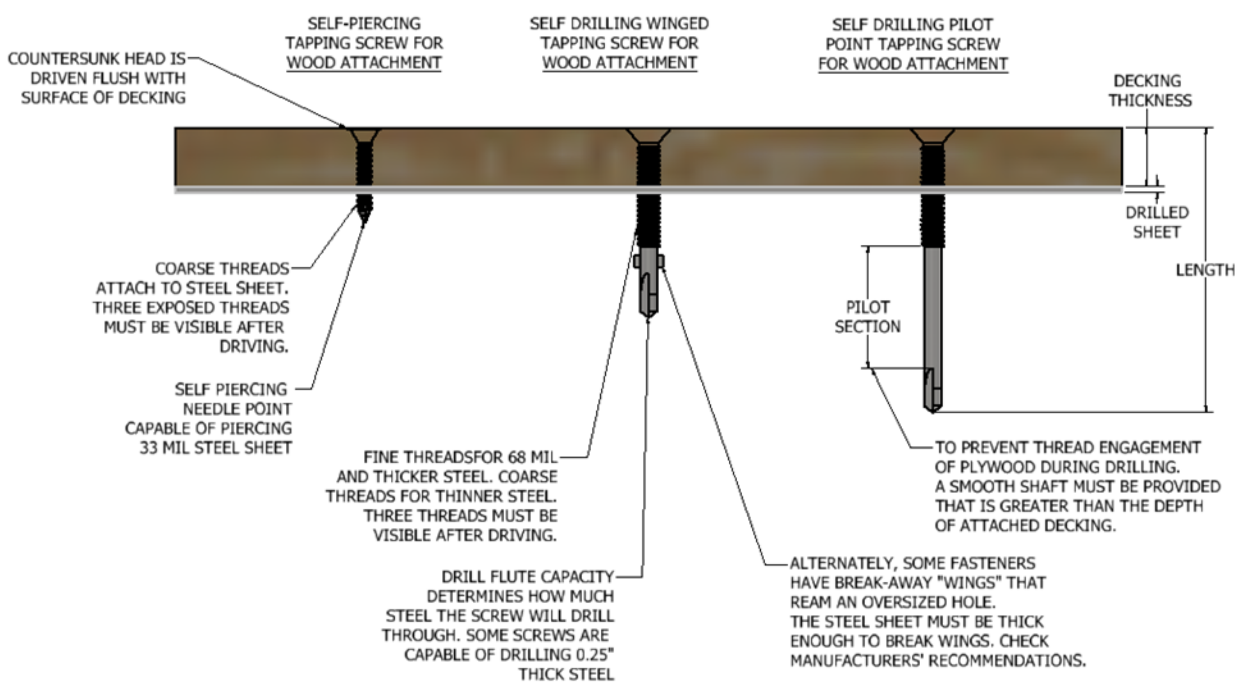

Figure 4: Screws for Wood-to-CFS Attachments

Common structural uses of wood-to-CFS screws are roof and floor diaphragms and shear walls. In these applications, the strength of the entire assembly must be determined by tests, and allowable loads are published in the model building codes. The APA publishes diaphragm values for roof and floor assemblies in a publication titled "Wood Structural Panels over Metal Framing" (Form No. T625C, 2009). When the strength of an individual fastener is required, the APA also publishes "Fastener Loads for Plywood-Screws" (Form No. E830E, 2011), which provides tested allowable shear and uplift values for plywood-to-steel connections.

Self-Drilling Tapping Screws

When attaching wood to 43 mils or thicker steel, self-drilling tapping screws may be required. These screws must comply with SAE J78 (2021), which specifies the dimensions and performance of self-drilling screws. Self-drilling screws have a specific "drill capacity", which is the total thickness of steel they are capable of drilling through. The drill capacity is a function of both screw size and point style.

The drill capacity for these screws is documented in both the SAE J78 standard and CFSEI Tech Note F102-21, titled *"Screw Fastener Selection for Cold-Formed Steel Frame Construction*, specifically in Table 1. Most self-drilling tapping screws for wood attachment utilize number 2, 3 or 4-point style, with the larger number indicating a greater drill capacity of the screw.

During driving, the screw quickly drills through the decking but remains on the surface of the CFS framing member, while the driller tip penetrates the steel sheet. To prevent the decking from riding up the screw shaft, the tip of the screw and the pilot section must be longer than the depth of the decking, as shown in Figure 4.

Alternatively, some decking screws are featured with small "wings" located above the drill point on the pilot section of the screw These wings prevent the deck from riding up the shaft by reaming out a hole that is slightly larger than the threaded diameter of the screw. The wings are intended to break off once they contact the steel sheet.

The shaft of the self-drilling tapping screw for wood attachment has threads suitable for tapping and gripping the steel member. Fine threads are typically used for steel sheets 68 mils and thicker, while coarse threads should be used for thinner sheets. According to AISI S200, proper installation requires a minimum of three threads being exposed beyond the thickness of the member.

Self-Piercing Tapping Screws

When attaching wood decking to 33 mils or thinner steel, self-piercing tapping screws may be used. This type of fastener pierces the wood and steel in one continuous motion. These screws are defined in ASTM C1513 (2018) and comply with ANSI/ASME B18.6.3 (2010), which governs the manufacture of thread forming tapping screws.

Self-piercing tapping screws for wood attachment are case-hardened and have a piercing tip which enables them to penetrate the steel sheet. These screws feature coarse threads, suitable for tapping and gripping the steel sheet and should be long enough so that a minimum of three threads are exposed after installation.

REFERENCES

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3. ANSI/ASME B18.6.3 (2010), *Machine Screws, Tapping Screws, and Metallic Drive Screws (Inch Series),* American Society of Mechanical Engineers, New York, NY.

4. ANSI/AWC NDS (2018), *National Design Specification for Wood Construction – With 2018 NDS Supplement,* American Wood Council, Leesburg, VA.

5. ASTM C1513 (2018), *Standard Specification for Steel Tapping Screws for Cold-Formed Steel Framing Connections,* ASTM International, West Conshohocken, PA.

6. Tech Note F102-21, *Screw Fastener Selection for Cold-Formed Steel Frame Construction,* Cold-Formed Steel Engineers Institute, Falls Church, VA.

7. Form No. E830E. (2011). *Fastener Loads for Plywood – Screws,* APA - The Engineered Wood Association, Tacoma, WA.

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