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COLD-FORMED STEEL ENGINEERS INSTITUTE

# TECHNICAL NOTE

*On Cold-Formed Steel Construction*

Cold-Formed Steel Engineers Institute ● Washington, DC ● www.cfsei.org ● 1-800-79-STEEL

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

**This Technical Note updates and replaces LGSEA Technical Note 565D**

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



## INTRODUCTION

Cold-Formed Steel (CFS) framing is often used with wood products. Steel stud walls often support wood trusses, wood I-joists or glued-laminated (glulam) beams. Screws are often used to connect these members. In addition, wood structural panels are used as sheathing over CFS rafters, joists and wall studs.

The capacity of self-drilling tapping screws in CFS-to-CFS connections is referenced in the AISI S100 Specification and is relatively straightforward. The capacity of screws in wood is more complicated to determine due to the many factors that affect screw connection strength. Also, particular attention must be paid to selecting a fastener that will penetrate steel and wood layers and properly grip the members.

## SCREWS FOR CFS-TO-WOOD ATTACHMENTS

### Standard Wood Screws

Where steel connectors have pre-punched or pre-drilled 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 pull-over 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 design to penetrate wood only. These screws are not intended to penetrate steel of any thickness.

Chapter 11 of the NDS provides guidelines and design equations for the use of standard wood screws. In order to use the NDS installation requirements, fasteners must comply with ANSI/ASME Standard B18.6.1-1981. This standard dictates the head size, threads, diameter, and manufacturing tolerances for wood screws. Table 1 shows pre-drilling requirements for wood screws. Pre-drilling of the wood member is often required to prevent splitting of wood and to prevent 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 in order for design equations to be applicable. Pre-drilling may not be required for some proprietary screws.

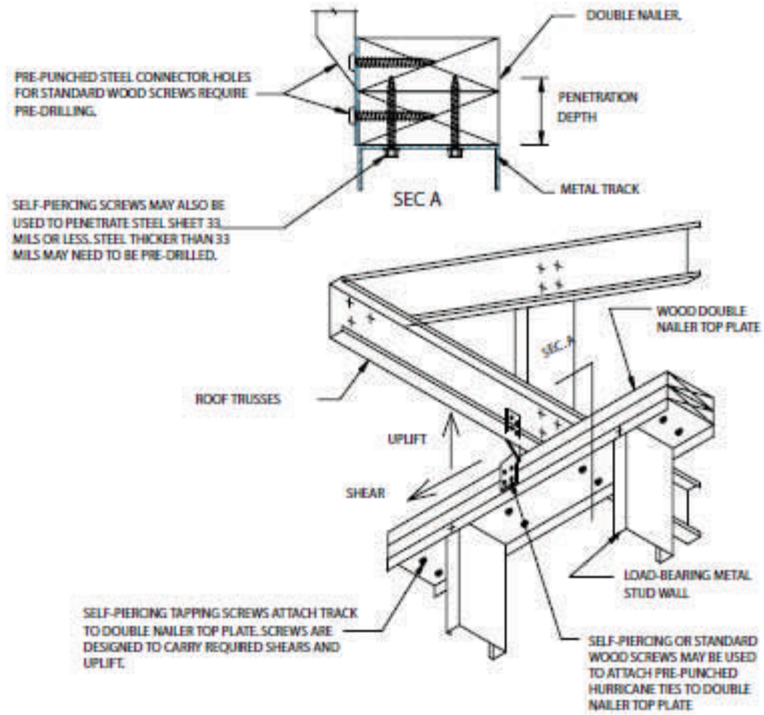


Figure 1: CFS-to-Wood Screw Applications

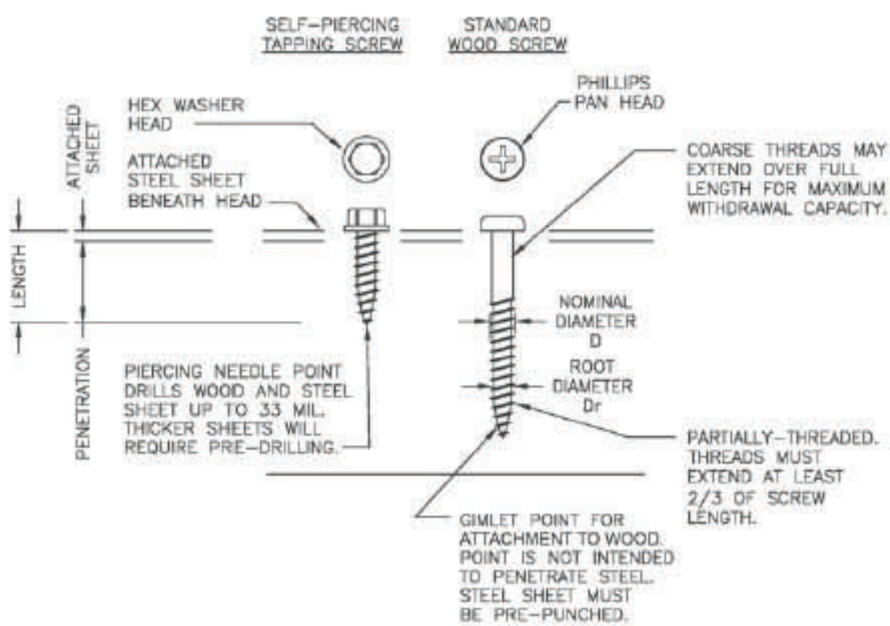


Figure 2: Screws for CFS-to-Wood Attachments

**Table 1: Wood Screw Lead Hole Requirements** (based on 11.1.5 of NDS 2012)

| 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 ≤ 0.5 | 0.5 < G ≤ 0.6 | G > 0.6 | 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 |
| 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 | 3/16 | 3/16 | 3/16 | 1/4 | 3/16 |

Notes:

Wood screw shall be inserted into the lead hole using a screw driver or other tool, not by driving with a hammer.

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.

G is the specific gravity of wood species group (See Table 11.3.3A of NDS).

Nominal diameter (D) and root diameter ($D_r$) are taken from Table L3, Appendix L of NDS.

Table 2 shows 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 given for three species groups commonly use in North America. Withdrawal is a function of wood strength, screw diameter and threaded penetration depth.

Table 3 shoes allowable shear loads for screws in wood. These values also depend on specific gravity of the wood, which determines the dowel bearing strength of the wood. In addition, these values also depend upon the dowel strength of the attached steel sheet and the bending strength of the screw.

The values listed in Tables 2 and 3 apply to wood and/or dowel bending-yielding failure only. Adjustment factors listed in Table 4 must be applied to determine the final allowable load for a connection. Screw connection failure in the steel sheet must also be checked. This should include checks for bearing, pullover, edge distance and other factors as required. Wood adjust factors should not be applied to the strength of the screws and the attached steel sheet when the capacity is determined per AISI S100.

Proprietary connectors, such as the "hurricane ties" shown in Figure 1 often have published tested capacities for specific size screws or nails. If the use of other fasteners is desired, the designer should determine what impact the change may have 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 un-punched cold-formed steel members 33 mils or less must be attached to wood members or for thicker steel member where pre-punched steel connectors are used .

Figure 2 illustrates the geometry of a self-piercing tapping screw. These screws have a self-piercing point as defined in ASTM C-1513 (2010) are casehardened and capable of piercing steel sheet up to 33 mils thick. Based on a manufacturer's recommendation, some self-piercing screws can penetrate thicker steels. Hex washer heads are used because this head style has the best torque capacity in order to enable both penetration of the un-punched steel sheet and penetration of the wood member without the benefit of a pilot hole. Commonly used sizes of self-piercing tapping screws are #8 and #10 diameter screws up to 3 in. long. These screws have coarse threads designed to better grip the wood members. Self-piercing tapping screws are typically fully threaded for lengths 1-1/2 in. and less. Longer screws are typically threaded over 2/3 of their length. Loose washers are not usually used unless required to increase pull-over resistance of the attached sheet. Steel backed, bonded neoprene washers are often used where watertight connections are desired.

**Table 2: Wood Screw Withdrawal Capacity** (based on 11.2.2 of NDS 2012)

| Wood Species Combination | Screw Number (#) | Nominal Diameter, D (in.) | Withdrawal Capacity, W (lb/in.) | Screw Length (in.) | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | 1 | 1.25 | 1.50 | 2 | 2.25 |
| **G = 0.55** (Southern Pine) | 6 | 0.138 | 119 | 79 | 99 | 119 | 159 | 179 |
| | 8 | 0.164 | 141 | 94 | 118 | 141 | 188 | 212 |
| | 9 | 0.177 | 152 | 101 | 127 | 152 | 203 | 228 |
| | 10 | 0.190 | 163 | 109 | 136 | 163 | 217 | 245 |
| | 12 | 0.216 | 186 | 124 | 155 | 186 | 248 | 279 |
| | 14 | 0.242 | 208 | 139 | 173 | 208 | 277 | 312 |
| **G = 0.50** (Douglas Fir-Larch) | 6 | 0.138 | 98 | 65 | 82 | 98 | 131 | 147 |
| | 8 | 0.164 | 117 | 78 | 98 | 117 | 156 | 176 |
| | 9 | 0.177 | 126 | 84 | 105 | 126 | 168 | 189 |
| | 10 | 0.190 | 135 | 90 | 113 | 135 | 180 | 203 |
| | 12 | 0.216 | 154 | 103 | 128 | 154 | 205 | 231 |
| | 14 | 0.242 | 172 | 115 | 143 | 172 | 229 | 258 |
| **G = 0.42** (Spruce-Pine-Fir) | 6 | 0.138 | 69 | 46 | 58 | 69 | 92 | 104 |
| | 8 | 0.164 | 82 | 55 | 68 | 82 | 109 | 123 |
| | 9 | 0.177 | 89 | 59 | 74 | 89 | 119 | 134 |
| | 10 | 0.190 | 95 | 63 | 79 | 95 | 127 | 143 |
| | 12 | 0.216 | 108 | 72 | 90 | 108 | 144 | 162 |
| | 14 | 0.242 | 121 | 81 | 101 | 121 | 161 | 182 |

Notes:

Withdrawal design value, $W = 2850\, G^2 D$ (Equation 11.2-2 of NDS).

To determine the adjusted design value W′, multiply W by all applicable adjustment factors $C_D$, $C_M$ and $C_t$ (See Table 4(a)).

Values are for screws inserted in side grain, with screw axis perpendicular to wood fibers. Values are not appropriate for end-grain loading.

Screws must comply with ANSI/ASME Standard B18.6.1-1981.

Assumes threaded length is 2/3 of total wood screw length.

Steel sheet must also be checked for pull-over resistance based on AISI S100 screw provisions.

Tabulated values are for failure in the wood member.

G is the specific gravity of wood species group (See Table 11.3.3A of NDS).

**Table 3: Wood Screw Lateral Capacity** (based on 11.3 of NDS 2012)
**Shear design Values, Z (pounds) Allowable Loads**

| 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) $F_{em}$ = 5526 psi $F_{es}$ = 61875 psi (ASTM A1003, Grade 33 steel) | 0.138 | 100,000 | 0.828 | 76 | 77 | 78 | 81 | 88 |
| | 0.164 | 90,000 | 0.984 | 96 | 97 | 99 | 102 | 110 |
| | 0.177 | 90,000 | 1.062 | 113 | 114 | 115 | 118 | 127 |
| | 0.190 | 80,000 | 1.140 | 122 | 123 | 124 | 127 | 136 |
| | 0.216 | 80,000 | 1.296 | 154 | 154 | 156 | 158 | 167 |
| | 0.242 | 70,000 | 1.452 | 170 | 170 | 171 | 174 | 182 |
| **G = 0.50** (Douglas Fir-Larch, Structural I Plywood, OSB-All Grades) $F_{em}$ = 4637 psi $F_{es}$ = 61875 psi (ASTM A1003, Grade 33 steel) | 0.138 | 100,000 | 0.828 | 67 | 68 | 69 | 70 | 76 |
| | 0.164 | 90,000 | 0.984 | 89 | 90 | 91 | 94 | 100 |
| | 0.177 | 90,000 | 1.062 | 104 | 105 | 107 | 109 | 116 |
| | 0.190 | 80,000 | 1.140 | 113 | 114 | 115 | 118 | 127 |
| | 0.216 | 80,000 | 1.296 | 142 | 143 | 144 | 147 | 155 |
| | 0.242 | 70,000 | 1.452 | 157 | 157 | 158 | 161 | 169 |
| **G = 0.42** (Spruce-Pine-Fir, Other Plywood Grades) $F_{em}$ = 3364 psi $F_{es}$ = 61875 psi (ASTM A1003, Grade 33 steel) | 0.138 | 100,000 | 0.828 | 49 | 50 | 51 | 53 | 59 |
| | 0.164 | 90,000 | 0.984 | 67 | 68 | 69 | 71 | 77 |
| | 0.177 | 90,000 | 1.062 | 79 | 79 | 80 | 82 | 88 |
| | 0.190 | 80,000 | 1.140 | 90 | 91 | 92 | 94 | 100 |
| | 0.216 | 80,000 | 1.296 | 115 | 115 | 116 | 118 | 123 |
| | 0.242 | 70,000 | 1.452 | 132 | 133 | 134 | 135 | 140 |

Notes:

Lateral design value, Z, is based on the minimum computed yield mode value using equations in Tables 11.3.1A and 11.3.1B of NDS.

Minimum penetration of wood screw ($P_{min}$) into the main member shall be 6D per Section 11.1.5.6 of NDS.

Steel sheet must also be checked for shear resistance, using screw root diameter and AISI S100 Section E4. Values above are for failure in the wood member and dowel bending yield only.

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)).

Screw bending yield strengths were taken from NDS Appendix I, Table 1. Presumed screw yield strength is based on commonly available screws. Confirm with selected screw supplier.

Screws must comply with ANSI/ASME Standard B18.6.1-1981.

Assumes threaded length is 2/3 of total wood screw length.

G is specific gravity of wood species group (See Tables 11.3.3A and 11.3.3B of NDS).

**Table 4: Wood Screw Adjustment Factors** (based on Table 10.3.1 of NDS 2012)

**4(a) Applicability of Adjustment Factors for Wood Screws** (Table 10.3.1 of NDS)*

| Loads | | Load Duration Factor | Wet Service Factor | Temperature Factor | End Grain Factor |
|---|---|---|---|---|---|
| **Withdrawal,** | W' = W x | $C_D$ | $C_M$ | $C_t$ | N/A |
| **Lateral,** | Z' = Z x | $C_D$ | $C_M$ | $C_t$ | $C_{eg}$ |

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

**4(b) Load Duration Factors** (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 10.3.3 of NDS)**

| Loads | Moisture Content | | |
|---|---|---|---|
| | At Time of Fabrication | In-Service | $C_M$ |
| **Withdrawal (W)** | Any | ≤ 19% | 1.0 |
| | Any | > 19% | 0.7 |
| **Lateral (Z)** | ≤ 19% | ≤ 19% | 1.0 |
| | > 19% | ≤ 19% | 0.4* |
| | 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 10.3.1 of NDS)*

| In-Service Moisture Conditions* | $C_t$ | | |
|---|---|---|---|
| | T ≤ 100°F | 100°F < T ≤ 125°F | 125°F < T ≤ 150°F |
| **Dry** | 1.0 | 0.8 | 0.7 |
| **Wet** | 1.0 | 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, $C_{eq}$** (Section 11.5.2 of NDS)

$C_{eq}$ = 0.67, when the screws are inserted in the end grain of the main member, with the screw axis parallel to the wood fibers.

There are no design provisions that specifically address the strength of self-piercing tapping screws. Many manufacturers supply tested design values for these fasteners; however this data is limited and does not address the numerous factors that the NDS accounts for in its wood screw provisions. The NDS requires that wood screws comply with ANSI/ASME Standard B18.6.1-1981 in order for its design provisions to apply. It should be noted that most self-piercing tapping wood screws comply with ANSI/ASME Standard B18.6.1-1981 in all ways except for head style. This is because hex washer heads are no considered in the standard. If a particular self-piercing tapping wood screws complies with all other portions of ANSI/ASME Standard B18.6.1-1981 it would be reasonable for the design values in the NDS and tables 2, 3 and 4 to be used, 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 by Figures 3 and 4. Heads have a countersunk design, to mount flush with the wood surface and are usually Phillips-drive type. Other available head types are 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, which helps prevent wood splitting. All wood-to-CFS screw fasteners should comply with ASTM C1513 (2010), which governs the performance requirements of steel tapping screws.

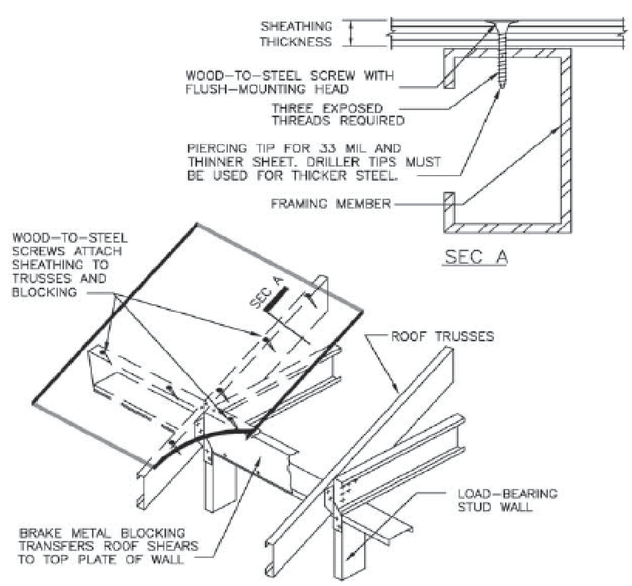


**Figure 3: Wood-to-CFS Screw Applications**

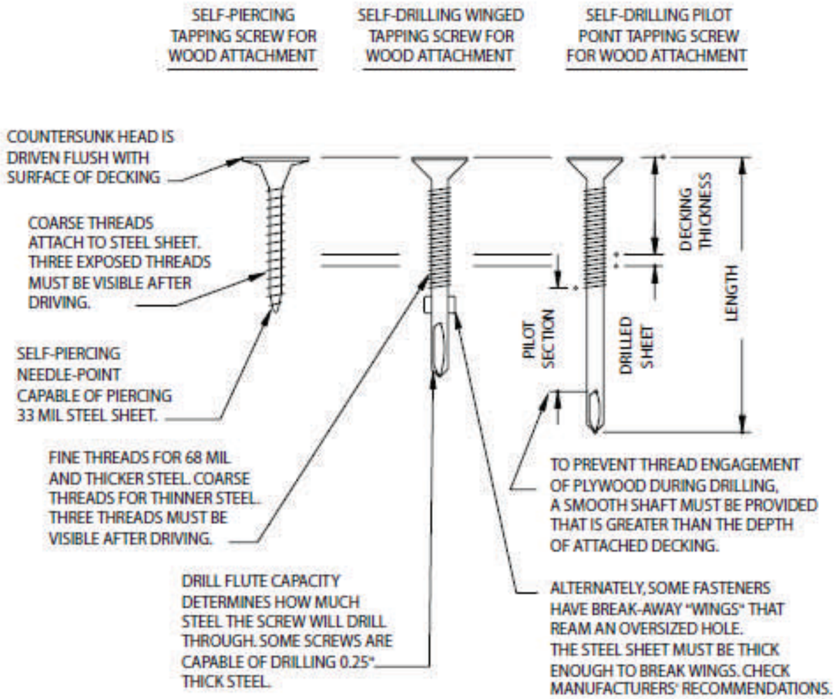


**Figure 4: Screws for Wood-to-CFS Attachment**

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 (1998), 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. Drill capacity for screws is tabulated in both the SAE J78 standard, and in CFSEI Tech Note F102 (2011), Table 1. Most self-drilling tapping screws for wood attachment use number 2, 3 or 4 point style. (The larger the number, the larger the 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 feature small “wings” 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 strike 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 sheet 68 mils and thicker, while coarse threads should be used for thinner sheets. Based on AISI S200, proper installation requires a minimum of three threads must be 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 C-1513 (2010) and comply with ASI/ASME B18.6.3 (2010), which governs the manufacture of thread-forming tapping screws. Self-piercing tapping screws for wood attachment are casehardened and have a piercing tip which enables them to penetrate the steel sheet. Self-piercing tapping screws for wood attachment have 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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