Fasteners for Residential Steel Framing

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June 1993

INTRODUCTION

This publication was developed by the American Iron and Steel Institute with guidance from the AISI Residential Advisory Group. It is intended to provide designers and contractors with guidance on design, detailing and construction of buildings that utilize cold-formed steel framing members. AISI believes that the information contained in this publication substantially represents industry practice and related scientific and technical information, but the information is not intended to represent an official position of AISI or to restrict or exclude any other construction or design techniques.

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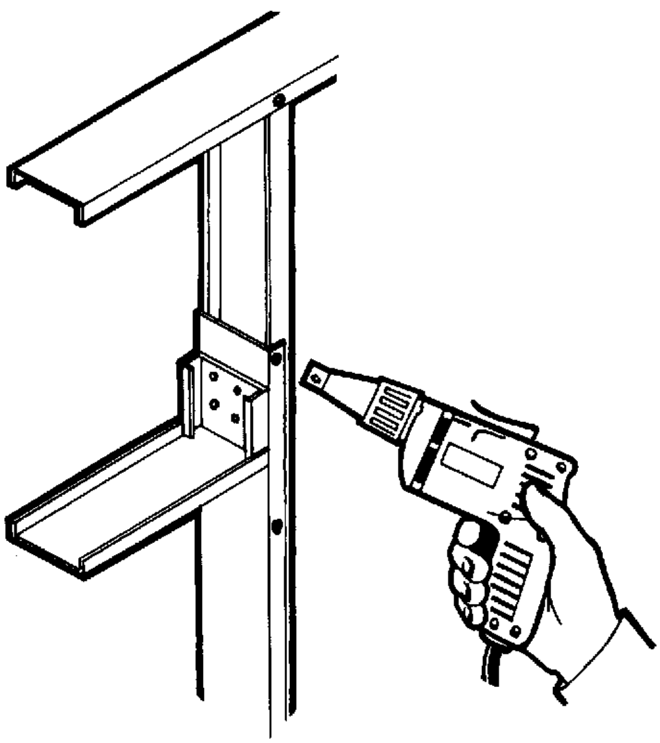
In a residential cold-formed steel framing system, framing components may include studs, joists, rafters or trusses. These vertical and horizontal framing members commonly serve as structural load carrying components and utilize durable and dependable connectors that develop positive connections, primarily through screws and welds. These systems make use of available fastening equipment and existing labor skills similar to woodframe cnstruction. Enabling fast, economical and versatile connections. The specific choice of a fastener depends on the loading conditions; thickness, strength and configuration of materials; the contractor's experience and the availability of fasteners. This coordination is the key to an economical and efficient framing system. The following discussion provides insight into the development of an efficient fastening system by providing guidance on the use and design of fasteners for cold-formed steel framing.

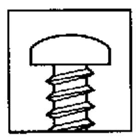


SCREWS

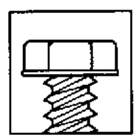
The most common fastener for steel framing is the self-drilling screw. In one operation it can drill the hole and securely fasten just about any material to steel framing. These screws come in a variety of styles to fit a vast range of requirements. For exterior applications screws are available finished with zinc, cadmium or co-polymer coatings.

Screw Head Styles

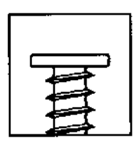
Self-drilling screws are manufactured in a variety of head configurations to meet specific installation needs. The most common driving recess for the screw head is the No. 2 Phillips design, but others are also available.



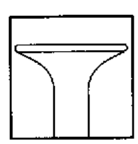
Pan Head: This common head configuration generally fastens studs to track, connects steel bridging, strapping or furring channels to studs or joists, and steel door frames to studs.



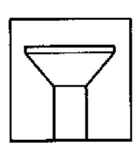
Hex Washer Head: This is also a common style for penetrating steel and is more commonly used on thicker steel materials. The washer face provides a bearing surface for the driver socket, assuring greater stability during driving. The $^{1}/_{4}$" size head is most common. A $^{5}/_{16}$" head is usually required for heavy applications. (Note: an alternate lower profile head should be considered when rigid finish materials are to be applied across the top of these screws).



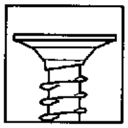
Low-Profile Head: Maintains a pleasing appearance at fastening points where the application does not require heads that are flush with the surface. This style should be used when rigid sheathing or finish material is to be installed over top of the screw head.



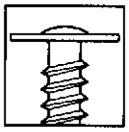
Bugle Head: Designed to countersink slightly in gypsum wallboard or sheathing, plywood or finish material without crushing the material or tearing the surface. Leaves a flat, smooth surface for easy finishing.



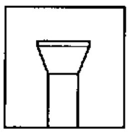
Flat Head: Designed to countersink and sit flush without causing splintering or splitting of wood flooring and finishes.



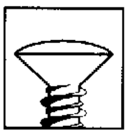
Wafer Head: Larger than the flat or bugle head, the wafer head is used for connecting soft materials to steel studs. The large head provides an ample bearing surface yet sits flush to achieve a clean, finished appearance.



Lath Head: An extremely low profile head commonly used for attaching metal lath to steel framing (also referred to as wafer head).



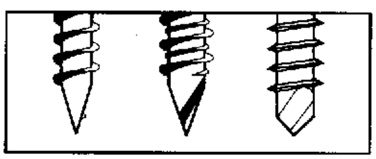
Trim Head: Used for fastening wood trim or other thick dense finish materials to steel studs. The small head sinks into the trim material, allowing easy finishing with minimal disturbance of the material surface.



Oval Head: Used when an accessory that will be attached to the framing has oversized holes or requires a low profile appearance. This type is used for attaching cabinets and brackets to framing.

Screw Point Type and Thread Configurations

There are two common screw point designations used in cold-formed steel framing: Type S and Type S-12, which generally refers to ASTM C-1002 and ASTM C-954 type screws, respectively. The American Society for Testing and Materials (ASTM) Designations refer to specifications for steel screws for the application of gypsum board or metal plaster bases to steel studs. Type S is for steels up to 0.035" thick and may have a sharp needle or piercing point similar to that used on wood screws, or it may be fluted to aid in the drilling process. Type S-12 is designed for steel up to 0.112" thick and has a shorter, fluted tip. For thicker materials, contact the manufacturer for the proper point type.



Type S needle point, fluted needle point, and Type S-12 fluted point.

Depending on the thickness of materials the thread along the shank should be held back from the point of the screw to prevent the threads from engaging the steel until the drilling process is complete. This is recommended to prevent over-drilling the first ply or stripping the threads after partial penetration, and also to allow the plies to be pulled tightly together.

At the other end of the screw, the threads should not continue to the screw head, when connecting wood or other rigid material to steel, but should allow the screw to draw the plies together with minimal lift-up of the wood or rigid material.

The choice of screw point type and thread configurations depends on how the fastener is required to perform during installation. Various configurations should be tested to find the type that performs most efficiently for different materials.

Screw Diameter Size

Screws are available in the following sizes: #6, #7, #8, #9, #10, #11, #12, #13, $^{1}/_{4}$, #14, where #6 is the smallest in diameter. Sizes should be specified based on the required capacity of the connection, the length of the screw and the thickness of the steel. The most common size range is from #6 to #10. Table 1 provides some guidance on the diameter sizes typically required for various thicknesses of steel. Contact screw manufacturers for assistance on the diameter sizes that are available in various lengths.

Table 1: Screw Diameter Size Guidelines Based on Total Thickness of Steel

Common Size	Nominal Diameter	Total Thickness (in.)	
#6	0.138	UP TO	0.110
#7, #8	0.151, 0.164		0.140
#10	0.190		0.175
#12	0.216		0.210*
$^{1}/_{4}$	0.250		0.210*

* Greater thicknesses are possible, consult a screw manufacturer.

Screw Length

Screws should be approximately $^{3}/_{8}$" to $^{1}/_{2}$" longer than the total material thickness. A minimum of 3 exposed threads should extend through the steel to assure an adequate connection. Table 2 summarizes the various lengths of screws used for different material thicknesses. The sizes shown in the Screw Length Table are those commonly used in cold-formed steel framing, but by no means cover all available sizes. Manufacturers can provide a more complete list of available products.

Table 2: Common Screw Lengths		
Common Sizes (#)	Length	Materials and Thickness of Materials that can be Connected
6,7	3/8" – 7/16"	Steel to steel
6, 8, 10, 12	1/2"	Steel to steel
8, 10	5/8" – 1"	Steel to steel; metal lath to steel
10, 12, 14	3/4" – 1 1/2"	Steel to steel
6, 8	1"	1/2" or 5/8" panels to steel
8, 10, 12	1 1/4"	Self-furring metal lath or masonry ties to steel
10	1 1/2"	Temp., panel-panel lamination
6, 7	1 1/2" – 2"	Multiple layers to steel
6, 7	2 1/4"	Wood trim and 3-layers of panels to steel
8	2" – 3 1/2"	Multiple layers to steel
10	3 1/2" – 6"	Multiple layers to steel
Consult manufacturers for other sizes and lengths.		

Screw Load Capacity and Spacing Requirements

Load carrying capacities of screws should be based on the criteria outlined in the Center for Cold-Formed Steel Structures (CCFSS) Technical Bulletin, Vol. 2, No. 1, dated February 1993, or based on manufacturer's data with an appropriate safety factor. The information included in the Technical Bulletin will be included in future editions of the AISI Specification for Cold-Formed Steel Structural Members (AISI Specification). Table 3 contains some screw capacities based on the CCFSS Technical Bulletin.

A minimum dimension of 3 times nominal screw diameter (d) should be maintained to the edge of the steel and to the center of other fasteners for steel to steel connections. The edge distance may be reduced to 1.5d in the direction perpendicular to the load. Connectors for gypsum wallboard and plywood should not be spaced less than 3/8" from the edges or ends of the board. Additional fastener spacing criteria for gypsum board and plywood can be found in the Gypsum Association Specification (GA-216) and the American Plywood Association's Design and Construction Guide/Residential and Commercial (E-30), respectively. Contact the manufacturer for fastener spacing requirements for other materials.

Driving Techniques for Self-Drilling Screws

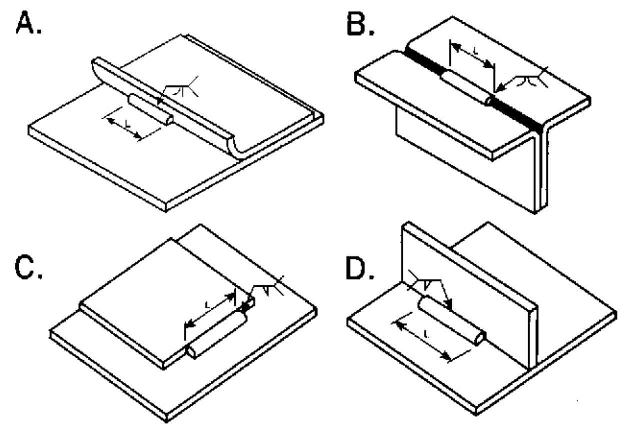
Screws are typically installed with hand-held power screw guns that operate on pneumatic or electrical power.

Table 3: Suggested Capacity for Screws Connecting Steel to Steel (lbs.)

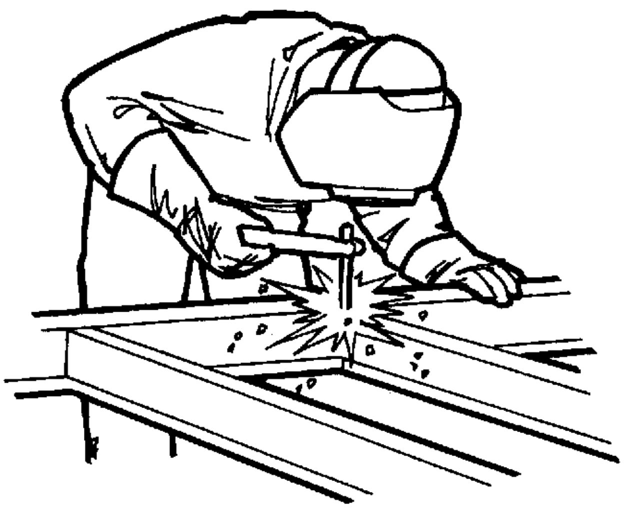
Steel Thickness - Thinnest Component	1/4 -14 Screw		#12-14 Screw		#10-16 Screw *		#8-18 Screw *		#6 Screw *	
	Shear	Pullout	Shear	Pullout	Shear	Pullout	Shear	Pullout	Shear	Pullout
0.1017"	1000	320	890	280	780	245	675	210	560	175
0.0713"	600	225	555	195	520	170	470	145	395	125
0.0566"	420	180	390	155	370	135	340	115	310	95
0.0451"	300	140	280	120	260	105	240	90	220	75
0.0347"	200	110	185	95	175	80	165	70	150	60

Notes:
1. Design values are based on CCFSS Technical Bulletin Vol. 2, No. 1 which outlines the proposed AISI Specification provisions for screw connections. For shear connections the cold-formed steel section should be evaluated for tension.
2. Based on Fy = 33ksi, Fu = 45ksi minimum. Adjust values for other steel strengths.
3. * = Refer to Table 1 for limits on recommended total steel thickness of connected parts.

For best results, the screw gun should be kept perpendicular to the work surface. Adequate pressure must be exerted to engage the clutch and prevent "walking." A one-piece socket makes driving easier and more efficient than separate socket and extension pieces because it provides more rigid and firmer control. Depth finders are useful to ensure proper penetration. A clamp (usually a "C-clamp") should be used to hold the steel members in place. Clamping during fastening will help assure that the members are in full contact and will prevent over-drilling of the hole as the plies pull together. When connecting steel materials of different thicknesses, the connection should be made from the thinner material to the thicker, so the screw head will bring the thinner more flexible material in tight contact with the heavier material.



***A.** Flare-bevel groove weld;* ***B.** Flare V-groove weld;* ***C.** Lap joint fillet weld;* ***D.** T-joint fillet weld*



WELDING

Welding can be used to prefabricate steel framing components into panel assemblies and trusses, whether done at a contractor's shop or at the job site. Welding is also commonly used in the attachment of site-fabricated or erected panels and for connecting shelf angles to steel framing.

To help assure quality installation, all work should be completed by welders qualified in the welding of sheet steel, in accordance with American Welding Society (AWS) D1.3 standards. Where the studs, joists and framing accessories have been fabricated from galvanized or painted steel, the coating will normally be burned away by the welding processes. Welding of coated materials should be completed in a well-ventilated area according to the AWS standards. Where required, weld areas should be re-touched with the appropriate paint or cold galvanizing to retain corrosion resistance.

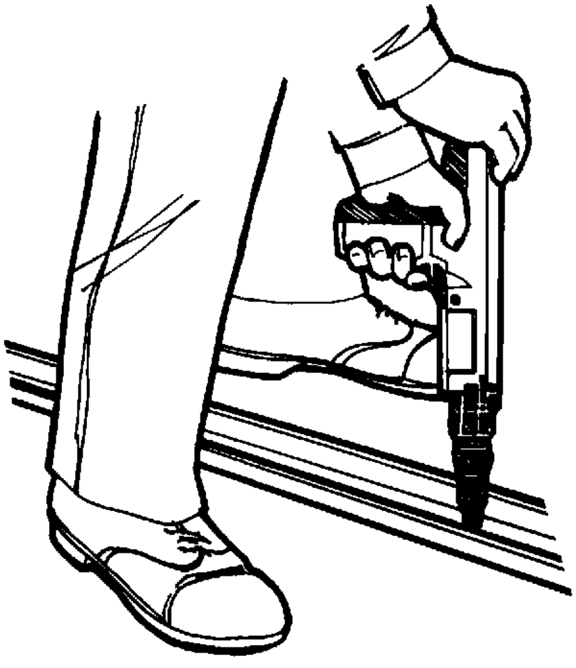
Weld Design Capacities

Welds should be designed in accordance with Section E of the latest edition of the AISI Specification. Table 4 provides some allowable shear loads for common arc welds. Values in the table can be used for fillet, flare bevel-groove, or flare V-groove welds and for longitudinal or transverse load conditions. When joining members of different thicknesses, use the allowable load for the thinner member.

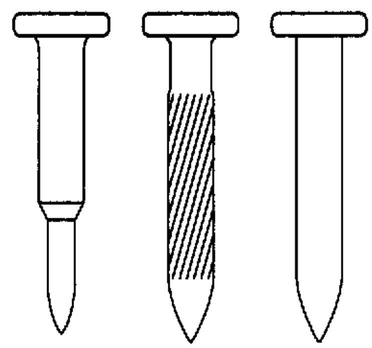
Table 4: Allowable Load per Inch of Arc Weld

Steel Design Thickness	Weld Size	Allowable Load (lbs./inch)
0.1017"	5/32"	1370
0.0713"	1/8"	960
0.0566"	1/8"	760
0.0451"	1/8"	605
0.0341"	1/8"	440

Note: Design values are based on the 1986 AISI Specification for the Design of Cold-Formed Steel Structural Members (with 1989 addendum), assuming Fy = 33ksi and Fu = 45ksi for the steel. Adjust if the specified tensile strength varies.



These fasteners are available with mechanical or electro-zinc plating, or co-polymer coatings, depending on corrosion resistance requirements. Head diameters range from 1/4" to 3/8", shank diameters vary from .100" to .236", and lengths from 1/2" to 8". The shanks may be smooth, knurled, or step-down. Step-down shanks are generally used on thicker materials for greater load carrying capacities. Pins are typically supplied in bulk, in collated strips, or in coils, depending on tool requirements. Tables 5 and 6 contain suggested capacities for fasteners in concrete and steel. Contact the pin manufacturer for information on load carrying capabilities of specific fasteners.



Step-down, knurled and smooth pins

DRIVE PINS OR NAILS

Pneumatically Driven Fasteners

These fasteners are fairly new to the cold-formed steel framing industry. They use techniques similar to nail guns for wood, and are commonly used for nailing plywood to steel. They are also available for fastening to thicker cold-formed steel, concrete or solid concrete block. Pneumatically driven fasteners are now being developed for steel products less than 0.056" thick.

Table 5: Suggested Capacity for Power Driven Fasteners Connecting Cold-Formed Steel to Structural Steel (lbs.)

Sheet Steel Thickness	Shank Diameter: 0.145" Structural Steel Thickness		Shank Diameter: 0.177" Structural Steel Thickness		Shank Diameter: 0.205" Structural Steel Thickness	
	1/4"	3/8"	1/4"	3/8"	1/4"	3/8"
0.1046"	210	210	335	395	485	525
0.0740"	210	210	335	395	485	525
0.0592"	210	210	335	395	465	465
0.0478"	210	210	321	321	372	372
0.0359"	197	197	241	241	279	279

Notes:
1. Values are from the Metal Lath/Steel Framing Association Lightweight Steel Framing Systems Manual (NAAMM-ML/SFA 540-87).
2. Fastener should project completely through the structural steel component.
3. Fasteners should not be located less than 1/2" from the edge of the steel. Minimum spacing of fasteners should be 1 1/2".
4. Capacity values are for shear or pullout for cold-formed steel with Fy = 33ksi. 1/3 increase for wind should not be included.

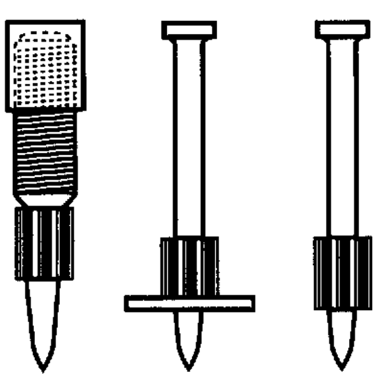
Table 6: Suggested Capacity for Power Driven Fasteners in Concrete (lbs.)				
Shank Diameter	Penetration: 0.145" minimum	Type of Loading	Concrete Compressive Strength (psi)	
			2000	3000
0.145"	1 1/8"	Pullout Shear	90 160	115 225
0.177"	1 7/16"	Pullout Shear	150 250	205 285
0.205"	1 1/4"	Pullout Shear	220 390	280 445

Notes:
1. Values are from the Metal Lath/Steel Framing Association Lightweight Steel Framing Systems Manual (NAAMM-ML/SFA 540-87).
2. Values based on low velocity shot and stone aggregate.
3. Fasteners should not be located less than 1/2" from the edge of the concrete. Minimum spacing of fasteners should be 4".
4. 1/3 increase for wind should not be included. These values do not take into account the capacity of the connected steel member, which may control. Capacity in shear should not exceed the following steel bearing capacities against the fastener shank:

Steel Thickness	Shank Diameter 0.145"	0.177"	0.205"
0.0478"	210	321	372
0.0359"	197	241	279

Powder-Actuated Fasteners

Cold-formed steel framing members may be fastened to concrete or to structural steel with headed drive pins or threaded studs driven by powder-actuated tools. Powder-actuated fastening systems are widely used to attach steel track to concrete slabs and foundations. The holding strength of the fastener in concrete depends on the compressive strength of the concrete, shank diameter, depth of penetration, and spacing and edge conditions. Tables 5 and 6 contain suggested capacities for fasteners in concrete and steel. Contact the manufacturer for more information on capacity and spacing requirements. Headed or threaded drive pins are available with knurled shanks to increase holding power in structural steel. Fasteners loaded in tension may require washers to prevent the fastener from prematurely pulling through the sheet steel.



Threaded, headed with a washer and standard headed pins

Powder-actuated fastening tools use .22 to .27 caliber cartridges to provide the powder load. Correct fastener penetration is obtained by matching the required energy level to the job requirements. The available energy levels are listed in manufacturers' catalogs for low velocity models. In low-velocity models, the force of the powder load acts on a central piston which drives the fastener. The velocity of the fastener can be changed to suit material densities by load selection and/or placing the fasteners at different depths in the barrel bore.

Spiral Shank Nails

Spiral shank nails are case hardened and phosphate treated to etch their surface for increased holding power. They can be used to fasten plywood subfloors and underlayment to steel. Contact the manufacturer for information on the load carrying capacity of spiral shank nails.

BOLTS, ANCHOR BOLTS AND EXPANSION ANCHORS

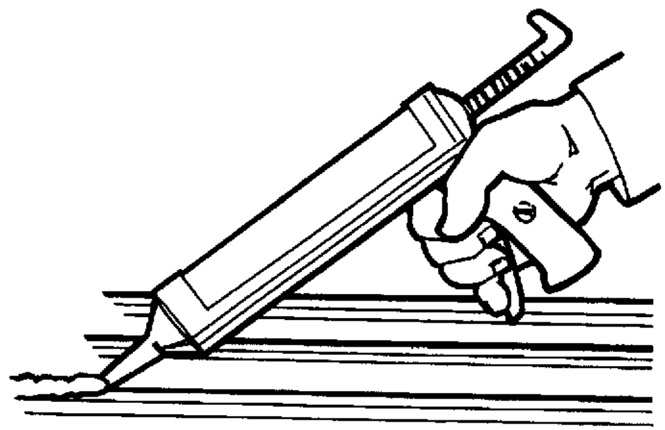
Bolts and anchors are also commonly used to fasten steel framing to masonry, concrete, and other steel components. Except for some proprietary anchors, pre-drilling of holes is necessary. Table 7 lists the maximum standard hole sizes for bolts in steel. Washers should be provided for oversized or slotted holes. Oversized or slotted holes in the direction of the anticipated load are generally not permitted unless evaluated by the designer. When the bolt or anchor is loaded in tension, washers may be required to prevent premature pull-through of the anchor.

Spacing requirements, minimum edge distances and design requirements for bolted connections can be found in Section E of the latest edition of the AISI Specification. In no case should the spacing or edge dimension be less than 3 times the nominal diameter (d). Edge distances may be reduced to 1.5d in the direction perpendicular to the load.

Expansion anchors are commonly used for connections to concrete or masonry and require information from the manufacturer to determine the capacity and spacing requirements.

Table 7: Maximum Size of Bolt Holes (inches)

Nominal Bolt Diameter, d	Standard Hole Size (in.)
Less than $\frac{1}{2}$"	$d + \frac{1}{32}$
Greater than $\frac{1}{2}$"	$d + \frac{1}{16}$



ADHESIVES

Adhesives are generally optional when self-drilling screws are used in attaching subfloors or underlayment to steel joists, and are necessary when spiral shank nails are employed. The use of adhesives can provide for long-term bonding capability that contributes to a stable assembly. Adhesives are also utilized in attaching drywall materials and paneling to steel studs or when laminating panels together, serving to eliminate some, but not all, of the mechanical fasteners.

Only approved types of adhesives should be employed as specified by the adhesive manufacturer. Consideration for temperature and moisture conditions should be included to assure that adhesive strength is maintained.

Note:

It is important in the construction of cold-formed steel framing systems that manufacturers' recommendations, on framing and fastening systems, be observed in all construction phases.

METRIC CONVERSION TABLE

Quantity	From Inch-Pound Units	To Metric Units	Multiply by
Length	foot inch	m mm mm	0.304 8 304.8 25.4
Area	square foot square inches	m^2 mm^2	0.092 903 04 645.16
Force	lb kip	N kN	4.448 22 4.448 22
Force/unit length	plf klf	N/m kN/m	14.593 9 14.593 9
Pressure, stress, modulus of elasticity	psf ksf	Pa kN/m	47.880 3 47.880 3
Bending moment, torque moment of force	ft-lb kt-kip	N-m kN-m	1.355 82 1.355 82
Second moment of area	in^4	mm^4	416 231
Section modulus	in^3	mm^3	16 387.064

CCFSS Technical Bulletin

Vol. 2, No. 1 February 1993

AISI Specification Provisions for Screw Connections

The following design provisions for screw connections were prepared by Subcommittee 3 on Connections of the AISI Committee on Specifications. It was approved by the AISI Committee on Specifications at its Feb. 6, 1993, meeting held in Nashville, Tenn. and will be included in future editions of the AISI Specifications.

A. *Provisions for Screw Connections—AISI Specification for the Design of Cold-Formed Steel Structural Members*

E4 Screw Connections

The following notation applies to this section:

d = nominal screw diameter
Ω = factor of safety = 3.0
P_{as} = allowable shear force per screw
P_{ns} = nominal shear strength per screw
P_{at} = allowable tension force per screw
P_{nt} = nominal tension strength per screw
P_{not} = pull-out force per screw
P_{nov} = pull-over force per screw
t_1 = thickness of member in contact with the screw head
t_2 = thickness of member not in contact with the screw head
F_{u1} = tensile strength of member in contact with the screw head
F_{u2} = tensile strength of member not in contact with the screw head

All E4 requirements shall apply to self-tapping screws with $0.08 \text{ in.} \leq d \leq 0.25 \text{ in.}$ The screws shall be thread-forming or thread-cutting, with or without a self-drilling point. Alternatively, design values for a particular application shall be permitted to be based on tests according to Section F.* For diaphragm applications, Section D5* shall be used.

Screws shall be installed and tightened in accordance with the manufacturer's recommendations.

The tension force on the net section of each member joined by a screw connection shall not exceed T_a from Section C2* or P_a from Section E3.2.*

***See AISI Specification, 1986 ed. with 1989 Addendum**

E4.1 Minimum Spacing

The distance between the centers of fasteners shall not be less than 3d.

E4.2 Minimum Edge and End Distance

The distance from the center of a fastener to the edge of any part shall not be less than 3d. If the connection is subjected to shear force in one direction only, the minimum edge distance shall be reduced to 1.5d in the direction perpendicular to the force.

E4.3 Shear

E4.3.1 Connection Shear

The shear force per screw shall not exceed P_{as} calculated as follows:

$$P_{as} = P_{ns} / \Omega$$

For $t_2/t_1 \leq 1.0$, P_{ns} shall be taken as the smallest of

$$P_{ns} = 4.2\,(t_2^3 d)^{1/2} F_{u2} \qquad \text{(Eq. E4.3.1)}$$

$$P_{ns} = 2.7\, t_1\, d\, F_{u1} \qquad \text{(Eq. E4.3.2)}$$

$$P_{ns} = 2.7\, t_2\, d\, F_{u2} \qquad \text{(Eq. E4.3.3)}$$

For $t_2/t_1 \geq 2.5$, P_{ns} shall be taken as the smaller of

$$P_{ns} = 2.7\, t_1\, d\, F_{u1} \qquad \text{(Eq. E4.3.4)}$$

$$P_{ns} = 2.7\, t_2\, d\, F_{u2} \qquad \text{(Eq. E4.3.5)}$$

For $1.0 < t_2/t_1 < 2.5$, P_{ns} shall be determined by linear interpolation between the above two cases.

E4.3.2 Shear in Screws

The shear capacity of the screw shall be determined by test according to Section F1(a).* The shear capacity of the screw shall not be less than 1.25 P_{ns}.

E4.4 Tension

For screws which carry tensile loads, the head of the screw or washer, if a washer is provided, shall have a diameter d_w not less than 5/16 in. Washers shall be at least 0.050 in. thick.

The tension force per screw shall not exceed P_{at}, calculated as follows:

$$P_{at} = P_{nt} / \Omega \qquad \text{(Eq. E4.4.1)}$$

P_{nt} shall be taken as the lesser of P_{not} and P_{nov} as determined in Sections E4.4.1 and E4.4.2.

E4.4.1 Pull-Out

The pull-out force, P_{not}, shall be calculated as follows:

$$P_{not} = 0.85\, t_c\, d\, F_{u2} \qquad \text{(Eq. E4.4.1.1)}$$

where t_c is the lesser of the depth of the penetration and the thickness, t_2.

E4.4.2 Pull-Over

The pull-over force, P_{nov}, shall be calculated as follows:

$$P_{nov} = 1.5\, t_1\, d_w\, F_{u1} \qquad \text{(Eq. E4.4.2.1)}$$

where d_w is the larger of the screw head diameter or the washer diameter, and shall be taken not larger than 1/2 in.

E4.4.3 Tension in Screws

The tensile capacity of the screw shall be determined by test according to Section F1(a)*. The tensile capacity of the screw shall not be less than 1.25 P_{nt}.

***See AISI Specification, 1986 ed. with 1989 Addendum**

B. Commentary on Section E4

E4. Screw Connections

Results of over 3500 tests worldwide were analyzed to formulate screw connection provisions (Reference R1). European Recommendations (Reference R2) and British Standards (Reference R3) were considered and modified as appropriate. Since the provisions apply to many different screw connections and fastener details, a greater degree of conservatism is implied than is otherwise typical within this Specification. These provisions are intended for use when a sufficient number of test results is not available for the particular application. A higher degree of accuracy can be obtained by testing any particular application (Reference R4).

Proper installation of screws is important to achieve satisfactory performance. Power tools with adjustable torque controls and driving depth limitations are usually used.

Screw connection tests used to formulate the provisions included single fastener specimens as well as multiple fastener specimens. However, it is recommended that at least two screws should be used to connect individual elements. This provides redundancy against under-torquing, over- torquing, etc., and limits lap shear connection distortion of flat unformed members such as straps.

For the convenience of designers, Table 1 gives the correlation between the common number designation and the nominal diameter for screws.

Table 1

Number Designation	Nominal Diameter, d, in.*
0	0.0600
1	0.0730
2	0.0860
3	0.0990
4	0.1120
5	0.1250
6	0.1380
7	0.1510
8	0.1640
10	0.1900
12	0.2160
1/4	0.2500

***See Figure 1.**

Fig. 1

E4.1 Minimum Spacing

Minimum Spacing is the same as specified for bolts.

E4.2 Minimum Edge and End Distance

Tests have shown that screw connections loaded in shear will almost always exhibit edge failure when the distance from the center of the screw to the free edge is less than three times the diameter of the screw.

E4.3 Shear

Screw connections loaded in shear can fail in one mode or in combination of several modes. These modes are screw shear, edge tearing, tilting and subsequent pull-out of the screw and bearing of the joined materials.

Tilting of the screw followed by threads tearing out of the lower sheet reduces the connection shear capacity from that of the typical connection bearing strength.

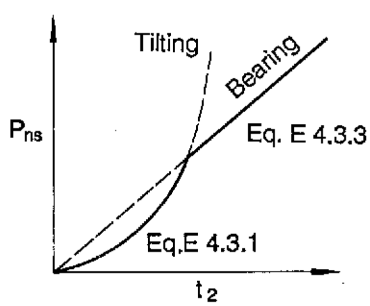


Fig. 2

These provisions are focused on the tilting and bearing failure modes. Two cases are given depending on the ratio of thicknesses of the connected members. Normally, the head of the screw will be in contact with the thinner material as shown in Figure 3. However, when both members are the same thickness, or when the thicker member is in contact with the screw head, Equations E4.3.1, E4.3.2 and E4.3.3 apply as shown in Figure 4.

a) $t_2/t_1 \geq 2.5$

tilting N/A
bearing $P_{ns} = 2.7\, t_1 d F_{u1}$ or
bearing $P_{ns} = 2.7\, t_2 d F_{u2}$

Fig. 3

b) $t_2/t_1 \leq 1.0$

tilting $P_{ns} = 4.2\, (t_2^3 d)^{1/2} F_{u2}$ or
bearing $P_{ns} = 2.7\, t_1 d F_{u1}$ or
bearing $P_{ns} = 2.7\, t_2 d F_{u2}$

Fig. 4

It is necessary to determine the lower bearing capacity of the two members based on the product of their respective thicknesses and tensile strengths.

Shear capacity of the screw fastener itself should be known and documented from testing. Screw strength should be well established and published by the manufacturer.

E4.4 Tension

Screw connections loaded in tension can fail either by pulling out of the screw from the plate (pull-out) or pulling of material over the screw head and the washer, if a washer is present, (pull-over) or by tensile fracture of the screw. The serviceability concerns of gross distortion are not covered by the formulas given in E4.4.

Diameter and rigidity of the fastener head assembly as well as sheet thickness and tensile strength have a significant effect on the pull-over failure load of a connection.

There are a variety of washers and head styles in use. Washers must be at least .050 in. thick to withstand bending forces with little or no deformation.

References

R1. Pekoz, T., "Design of Cold-Formed Steel Screw Connections," Proceedings of the Tenth International Specialty Conference on Cold-Formed Steel Structures, Oct. 23-24, 1990, University of Missouri-Rolla, Mo.

R2. European Convention for Constructional Steelwork, "European Recommendations for the Design of Light Gage Steel Members," First Edition, 1987, Brussels, Belgium.

R3. British Standards Institution, "British Standard-Structural Use of Steelwork in Building—Part 5. Code of Practice for Design of Cold-Formed Sections," BS 5950: Part 5:1987.

R4. American Iron and Steel Institute, "Test Methods for Mechanically Fastened Cold-Formed Steel Connections", Research Report CF92-2, February 1992.

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