LightweightSteelFraming

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Technical BULLETIN

Report on:

Member Selection and Structural Design

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Design Capacities for Sheet Metal Screws in Lightweight Steel Framing Applications

This Technical Bulletin provided the factored resistance of connections made with sheet metal screws calculated in accordance with CAN/CSA-S136-16 North American Specification for the Design of Cold Formed Steel Structural Members. This bulletin is intended as a guide to help simplify the design of these connections.[1]

Material Properties

Calculations were based on the mechanical properties of the lightweight steel framing components listed in Table 1, and the properties of the screws listed in Table 2.

Table 1: Design Thickness and Mechanical Properties of LSF Components

Gauge Number	Thickness Designation (mils)	Design Thickness (mm)	Strengths	
			Yield, F_y (MPa)	Ultimate, F_u (MPa)
20	33	0.879	230	310
18	43	1.146	230	310
16	54	1.438	345	450
14	68	1.811	345	450
12	97	2.583	345	450

Table 2: Nominal Diameter and Strength of Screws[2]

Number Designation for Screw	Nominal Diameter (mm)	Nominal Shear Strength, P_{nvs} (kN)	Nominal Tension Strength, P_{nts} (kN)
#6 - 20	3.56	3.34	5.72
#8 – 18	4.06	4.45	6.87
#10 – 16	4.83	6.23	8.61
#12 – 14	5.33	8.90	12.36
¼ - 14	6.35	11.57	18.06

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1 While the material is believed to be technically correct and in accordance with recognized practice at the time of publication, it does not obviate the need to determine its suitability for a given situation. Neither the Canadian Sheet Steel Building Institute nor its Members warrant or assume any liability for the suitability of the material for any general or particular purpose.

2 These values were taken from the ITW Buildex 2010/2011product catalogue for TEKS self-drilling self-tapping screws and may not be appropriate for other screw types or products from other screw manufacturers.

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Factored Resistance of Screwed Connections

The factored resistance of screwed connections is a function of the failure type, screw size and sheet properties. Listed in Table 3 are the factored resistance values for the various limits. The minimum value of the controlling limit state will govern.

Minimum Edge and End Distance (S136 Clause J4.2)

The distance from the center of a fastener to the edge or end of any part shall not be less than 1.5d.

Design Equations for Shear (S136 Clause J4.3)

Connection Shear Limited by Tilting and Bearing (S136 Clause J4.3.1):

For $t_2/t_1 \leq 1.0$, P_{nv} equals the smallest of;

$P_{nv} = 4.2(t_2^3 d)^{1/2} F_{u2}$

$P_{nv} = 2.7 t_1 d F_{u1}$

$P_{nv} = 2.7 t_2 d F_{u2}$

For $t_2/t_1 \geq 2.5$, P_{nv} equals the smallest of;

$P_{nv} = 2.7 t_1 d F_{u1}$

$P_{nv} = 2.7 t_2 d F_{u2}$

For t_2/t_1 values between 1.0 and 2.5, P_{nv} is determined through linear interpolation

Shear in Screws (S136 Clause J4.3.2):

The nominal shear resistance of the screw is taken as P_{nvs}.

Design Equations for Tension (S136 Clause J4.4)

Pull-out (S136 Clause J4.4.1):

$P_{not} = 0.85 t_c d F_{u2}$

Pull-over (S136 Clause J4.4.2):

$P_{nov} = 1.5 t_1 d'_w F_{u1}$

Tension in Screws (S136 Clause J4.4.3):

The nominal tensile resistance of the screw is taken as P_{nts}.

Combined Shear and Pull-Over (S136 Clause J4.5.1)

For connections subjected to a combination of both shear and tension forces, the following interaction equation applies.

$$\frac{\overline{V}}{P_{nv}} + 0.71 \quad \frac{\overline{T}}{P_{nov}} \leq 1.10\,\Phi$$

where, $\Phi = 0.55$

The shear/pull-over interaction equation is valid for connections that meet the following limits:

(1) $0.724 \text{ mm} \leq t_1 \leq 1.13 \text{ mm}$

(2) #12 and #14 self-drilling screws with or without washers

(3) $d_w \leq 19.1 \text{ mm}$

(4) $F_{u1} \leq 483 \text{ MPa}$

(5) $t_2/t_1 \geq 2.5$

(6) washer dimensions limitations of Section J4.4 apply

For eccentrically loaded connections that produce a non-uniform pull-over force on the fastener, the nominal pull-over resistance shall be taken as 50% of P_{nov}.

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Combined Shear and Pull-Out (S136 Clause J4.5.2)

For connections subjected to a combination of both shear and pull-out forces, the following interaction equation applies.

$$\frac{\overline{V}}{P_{nv}} + \frac{\overline{T}}{P_{not}} <= 1.15\,\Phi$$

where, $\Phi = 0.50$

The shear/pull-out interaction equation is valid for connections that meet the following limits:

(1) $0.754\text{ mm} \le t_1 \le 1.84\text{ mm}$
(2) #8, #10, #12 or #14 self-drilling screws with or without washers
(3) $F_{u2} \le 834\text{ MPa}$
(4) $1.0 \le F_u/F_y \le 1.62$

Combined Shear and Tension (S136 Clause J4.5.3)

For connections subjected to a combination of both shear and tension forces, the following interaction equation applies.

$$\frac{\overline{V}}{P_{nvs}} + \frac{\overline{T}}{P_{nts}} <= 1.3\,\Phi$$

where, $\Phi = 0.40$

Rupture (S136 Clause J6)

The other failure mode that must be considered is the block tear-out of a group of fasteners.

Symbols

d	=	Nominal screw diameter
d'_w	=	Effective pull-over resistance diameter
F_{u1}	=	Tensile strength of member in contact with screw head
F_{u2}	=	Tensile strength of member not in contact with screw head
P_{nov}	=	Nominal pull-over resistance per screw
P_{nvs}	=	Nominal shear resistance of screw as reported by manufacturer or determined by independent laboratory testing
P_{nts}	=	Nominal tension resistance of screw as reported by manufacturer or determined by independent laboratory testing
$\overline{V}$	=	V_f = Factored shear force in connection
t_1	=	Thickness of member in contact with screw head
t_2	=	Thickness of member not in contact with screw head
t_c	=	Lesser of depth of penetration and thickness t_2
$\overline{T}$	=	T_f = Factored tensile force in connection

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Table 3: Factored Resistances of Screwed Connections (kN)

Using the Tables:

For shear loading, the lesser of ΦP_{nvs} or ΦP_{nv} governs.
For tension loading the lesser of ΦP_{nts}, ΦP_{not} or ΦP_{nov} governs.
Check P_{nvs} and P_{nts} for different screw types or manufacturer.
Interaction equations also need to be checked where there are combined forces.

#6 Screw	ΦP_{nvs} = 1.34 kN					ΦP_{nts} = 2.29 kN					Φ = 0.40				
	Shear (ΦP_{nv})					Tension									
						Pull-Out (ΦP_{not})					Pull-Over (ΦP_{nov})*				
t_1 \ t_2	20	18	16	14	12	20	18	16	14	12	20	18	16	14	12
20	0.810	1.05	1.05	1.05	1.05	0.330	0.430	0.783	0.986	1.41	1.30	1.30	1.30	1.30	1.30
18	0.810	1.21	1.37	1.37	1.37	0.330	0.430	0.783	0.986	1.41	1.69	1.69	1.69	1.69	1.69
16	0.810	1.21	2.46	2.49	2.49	0.330	0.430	0.783	0.986	1.41	3.08	3.08	3.08	3.08	3.08
14	0.810	1.21	2.46	3.13	3.13	0.330	0.430	0.783	0.986	1.41	3.88	3.88	3.88	3.88	3.88
12	0.810	1.21	2.46	3.13	4.47	0.330	0.430	0.783	0.986	1.41	5.54	5.54	5.54	5.54	5.54

#8 Screw	ΦP_{nvs} = 1.78 kN					ΦP_{nts} = 2.75 kN					Φ = 0.40				
	Shear (ΦP_{nv})					Tension									
						Pull-Out (P_{not})					Pull-Over (P_{nov})*				
t_1 \ t_2	20	18	16	14	12	20	18	16	14	12	20	18	16	14	12
20	0.865	1.19	1.19	1.19	1.19	0.376	0.490	0.893	1.12	1.60	1.30	1.30	1.30	1.30	1.30
18	0.865	1.29	1.56	1.56	1.56	0.376	0.490	0.893	1.12	1.60	1.69	1.69	1.69	1.69	1.69
16	0.865	1.29	2.63	2.84	2.84	0.376	0.490	0.893	1.12	1.60	3.08	3.08	3.08	3.08	3.08
14	0.865	1.29	2.63	3.57	3.57	0.376	0.490	0.893	1.12	1.60	3.88	3.88	3.88	3.88	3.88
12	0.865	1.29	2.63	3.57	5.10	0.376	0.490	0.893	1.12	1.60	5.54	5.54	5.54	5.54	5.54

#10 Screw	ΦP_{nvs} = 2.49 kN					ΦP_{nts} = 3.44 kN					Φ = 0.40				
	Shear (ΦP_{nv})					Tension									
						Pull-Out (P_{not})					Pull-Over (P_{nov})*				
t_1 \ t_2	20	18	16	14	12	20	18	16	14	12	20	18	16	14	12
20	0.943	1.41	1.42	1.42	1.42	0.447	0.583	1.06	1.34	1.91	1.30	1.30	1.30	1.30	1.30
18	0.943	1.40	1.85	1.85	1.85	0.447	0.583	1.06	1.34	1.91	1.69	1.69	1.69	1.69	1.69
16	0.943	1.40	2.87	3.38	3.38	0.447	0.583	1.06	1.34	1.91	3.08	3.08	3.08	3.08	3.08
14	0.943	1.40	2.87	4.05	4.25	0.447	0.583	1.06	1.34	1.91	3.88	3.88	3.88	3.88	3.88
12	0.943	1.40	2.87	4.05	6.06	0.447	0.583	1.06	1.34	1.91	5.54	5.54	5.54	5.54	5.54

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#12 Screw	ΦP_{nvs} = 3.56 kN					ΦP_{nts} = 4.94 kN					Φ = 0.40				
	Shear (ΦP_{nv})					Tension									
						Pull-Out (P_{not})					Pull-Over (P_{nov})*				
t_1 \ t_2	20	18	16	14	12	20	18	16	14	12	20	18	16	14	12
20	0.991	1.49	1.57	1.57	1.57	0.494	0.644	1.17	1.48	2.11	1.30	1.30	1.30	1.30	1.30
18	0.991	1.48	2.05	2.05	2.05	0.494	0.644	1.17	1.48	2.11	1.69	1.69	1.69	1.69	1.69
16	0.991	1.48	3.01	3.72	3.72	0.494	0.644	1.17	1.48	2.11	3.08	3.08	3.08	3.08	3.08
14	0.991	1.48	3.01	4.25	4.69	0.494	0.644	1.17	1.48	2.11	3.88	3.88	3.88	3.88	3.88
12	0.991	1.48	3.01	4.25	6.69	0.494	0.644	1.17	1.48	2.11	5.54	5.54	5.54	5.54	5.54

1/4 Screw	ΦP_{nvs} = 4.63 kN					ΦP_{nts} = 7.22 kN					Φ = 0.40				
	Shear (ΦP_{nv})					Tension									
						Pull-Out (P_{not})					Pull-Over (P_{nov})*				
t_1 \ t_2	20	18	16	14	12	20	18	16	14	12	20	18	16	14	12
20	1.08	1.66	1.87	1.87	1.87	0.588	0.767	1.40	1.76	2.51	1.30	1.30	1.30	1.30	1.30
18	1.08	1.61	2.44	2.44	2.44	0.588	0.767	1.40	1.76	2.51	1.69	1.69	1.69	1.69	1.69
16	1.08	1.61	3.29	4.44	4.44	0.588	0.767	1.40	1.76	2.51	3.08	3.08	3.08	3.08	3.08
14	1.08	1.61	3.29	4.64	5.59	0.588	0.767	1.40	1.76	2.51	3.88	3.88	3.88	3.88	3.88
12	1.08	1.61	3.29	4.64	7.91	0.588	0.767	1.40	1.76	2.51	5.54	5.54	5.54	5.54	5.54

* Tabulated values assume d'_w=7.94 mm. For d'_w larger than 7.94 mm, multiply tabulated P_{nov} values by (actual d'_w)/7.94. The limit of $d'_w \leq$ 19.1 mm also applies.

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