BAILEY SHEET METAL SCREWS

Design Capacities for Sheet Metal Screws in Lightweight Steel Framing Applications

This Technical Product Data Sheet provides the factored resistance of connections made with sheet metal screws calculated in accordance with CAN/CSA-S136-12 *North American Specification for the Design of Cold Formed Steel Structural Members*. This data is intended as a guide to help simplify the design of these connections.[1]

Material Properties

Calculations are 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.

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.

TABLE 1: Design Thickness and Mechanical Properties of LSF Components

Thickness Designation (mils)	Design Thickness, t (mm)	Strength	
		Yield, F_y (MPa)	Ultimate, F_u (Mpa)
33	0.879	230	310
43	1.146	230	310
54	1.438	345	450
58	1.811	345	450
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_{ss} (kN)	Nominal Tension Strength, P_{ts} (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
1/4 - 14	6.35	11.57	18.06

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 2010/2011 product 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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Minimum Edge and End Distance (S136 Clause E4.2):

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

Design Equations for Shear (S136 Clause E4.3)

Connection Shear Limited by Tilting and Bearing (S136 Clause E4.3.1):

For $t_2 / t_1 \leq 1.0$,

P_{ns} equals the smallest of;

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

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

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

For $t_2 / t_1 \geq 2.5$,

P_{ns} equals the smallest of;

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

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

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

Shear in Screws (S136 Clause E4.3.2): The nominal shear resistance of the screw is taken as P_{ss}.

Design Equations for Tension (S136 Clause E4.4)

Pull-Out (S136 Clause E4.4.1):

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

Pull-Over (S136 Clause E4.4.2):

$P_{nov} = 1.5 t_1 d w F_{u1}$

Tension in Screws (S136 Clause E4.4.3): The nominal tensile resistance of the screw is taken as P_{ts}.

Combined Shear and Pull-Over (S136 Clause E4.5.1)

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

$$\frac{\bar{Q}}{P_{ns}} + 0.71 \frac{\bar{T}}{P_{nov}} \leq 1.10\phi \text{ where, } \Phi = 0.55$$

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

1. 0.724 mm ≤ t_1 ≤ 1.13 mm **2.** #12 and #14 self-drilling screws with or without washers **3.** d_w ≤ 19.1 mm **4.** F_{U1} ≤ 483 MPa **5.** $t_2 / t_1 \geq 2.5$

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}.

Combined Shear and Pull-Out (S136 Clause E4.5.2)

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

$$\frac{\bar{Q}}{P_{ns}} + \frac{\bar{T}}{P_{not}} \leq 1.15\varphi \text{ where, } \Phi = 0.50$$

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

1. 0.754 mm ≤ t_1 ≤ 1.84 mm **2.** #8, #10, #12 or #14 self-drilling screws with or without washers **3.** F_{u2} ≤ 834 MPa **4.** $1.0 \leq F_{U1} / F_y \leq 1.62$

SYMBOLS

d = Nominal screw diameter

dw = Larger of the screw head diameter or washer diameter

$\mathbf{F_{u1}}$ = Tensile strength of member in contact with screw head

$\mathbf{F_{u2}}$ = Tensile strength of member not in contact with screw head

$\mathbf{P_{nov}}$ = Nominal pull-over resistance per screw

$\mathbf{P_{ss}}$ = Nominal shear resistance of screw as reported by manufacturer or determined by independent laboratory testing

$\mathbf{P_{ts}}$ = Nominal tension resistance of screw as reported by manufacturer or determined by independent laboratory testing

$\bar{\mathbf{Q}} = \mathbf{V_f}$ = Factored shear force in connection

$\mathbf{t_1}$ = Thickness of member in contact with screw head

$\mathbf{t_2}$ = Thickness of member not in contact with screw head

$\mathbf{t_c}$ = Lesser of depth of penetration and thickness $\mathbf{t_2}$

$\bar{\mathbf{T}} = \mathbf{T_f}$ = Factored tensile force in connection

Combined Shear and Tension (S136 Clause E4.5.3)

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

$$\frac{\bar{Q}}{P_{ss}} + \frac{\bar{T}}{P_{ts}} \leq 1.3\varphi \text{ where, } \Phi = 0.40$$

Rupture (S136 Clause E5)

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

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Table 3: Factored Resistances of Screwed Connections (kN)
Using the Tables: For shear loading, the lesser of ΦP_{ss} or ΦP_{ns} governs. For tension loading the lesser of ΦP_{ts}, ΦP_{not} or ΦP_{nov} governs. Check P_{ss} and P_{ts} for different screw types or manufacture. Interaction equations also needs to be checked where there are combined forces.

#6 SCREW	ΦP_{ss} = 1.34 kN					ΦP_{ts} = 2.29 kN					Φ = 0.40				
Tilting and Bearing (ΦP_{ns})						Tension									
						Pull-Out (ΦP_{not})					Pull-Over (ΦP_{nov})*				
t_1 \ t_2	33	43	54	68	97	33	43	54	68	97	33	43	54	68	97
33	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
43	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
54	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
68	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
97	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_{ss} = 1.78 kN					ΦP_{ts} = 2.75 kN					Φ = 0.40				
Factored Shear Resistance (kN)						Factored Tensile Resistance (kN)									
						Pull-Out (ΦP_{not})					Pull-Over (ΦP_{nov})*				
t_1 \ t_2	33	43	54	68	97	33	43	54	68	97	33	43	54	68	97
33	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
43	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
54	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
68	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
97	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_{ss} = 2.49 kN					ΦP_{ts} = 3.44 kN					Φ = 0.40				
Factored Shear Resistance (kN)						Factored Tensile Resistance (kN)									
						Pull-Out (ΦP_{not})					Pull-Over (ΦP_{nov})*				
t_1 \ t_2	33	43	54	68	97	33	43	54	68	97	33	43	54	68	97
33	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
43	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
54	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
68	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
97	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

* 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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#12 SCREW	ΦP_{ss} = 3.56 kN				ΦP_{ts} = 4.94 kN					Φ = 0.40				
Factored Shear Resistance (kN)						Factored Tensile Resistance								
						Pull-Out (ΦP_{not})					Pull-Over (ΦP_{nov})*			
t_1 \ t_2	33	43	54	68	97	33	43	54	68	97	33	43	54	58	97
33	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
43	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
54	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
68	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
97	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_{ss} = 4.63 kN				ΦP_{ts} = 7.22 kN					Φ = 0.40				
Factored Shear Resistance (kN)						Factored Tensile Resistance								
						Pull-Out (ΦP_{not})					Pull-Over (ΦP_{nov})*			
t_1 \ t_2	33	43	54	68	97	33	43	54	68	97	33	43	54	58	97
33	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
43	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
54	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
68	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
97	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.

Note: The product information and the data in this report was provided by the Canadian Sheet Steel Building Institute (CSSBI).

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MONTREAL
525 AVENUE EDWARD VII
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One Caldari Road
Concord ON L4k 3Z9
Tel: (905) 738 9267
(800) 668 2154
Fax (514) 738 5712

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Calgary AB T1Y 5K7
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(800) 665 2013
Fax (403) 248 0288

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Edmonton AB T6B 3G7
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(800) 563 1751
Fax (780) 450 3378

VANCOUVER
7715 Anvil Way
Surrey BC V3W 6A2
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(800) 818 2666
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sales@bmp-group.com • www.bmp-group.com

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