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 $t_2 / t_1 \le 1.0$,

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 $t_2 / t_1 \ge 2.5$,

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}.

SYMBOLS

d = Nominal screw diameter

dw = Larger of the screw head diameter or washer 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_{ss} = Nominal shear resistance of screw as reported by manufacturer or determined by independent laboratory testing

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

$\overline{Q} = V_f$ = 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

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.

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

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.** $t_2 / t_1 \ge 2.5$

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.

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

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.** $1.0 \le F_{U1/} F_y \le 1.62$

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.

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

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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