Ultimate Tensile and Shear Strength

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Tests Completed at: **CEMCO Engineering Laboratory (CEL)**

Pittsburg, CA

IAS Accredited Laboratory TL-316

ICC Accepted Testing Laboratory and Procedures

Test Report No. RD2015005

Reports Prepared For: Good Screws
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Evaluation Subject: Good Screws Self-Drilling Screws

1.0 Scope of Study/Objective

"*GOOD SCREWS*" fasteners are used in engineered connections of cold-formed steel framing, and attachment of drywall and other sheathings to cold-formed steel framing. The screws are used in both exterior and interior conditions. Screw head designs include: Pan-Head, Bugle-head, Modified Truss-head, Hex washer-head, and Wafer-head.

This document provides the ultimate tension and shear capacities of self-drilling framing and drywall screws from **"*GOOD SCREWS*"** manufacturer. Three (3) different size screws were tested in both modes of failure (tension and shear): #8, #10, and # 12. All tests were conducted as per the guidelines and recommendations of ASTM F606, "Standard Test Methods for Determining the Mechanical Properties of Externally and Internally Threaded Fasteners", and AISI S904-08 & 2015, "Standard Test Methods for Determining the Tensile and Shear Strength of Screws". Ultimate capacity values as well as elongation/deformation at peak loads are reported for each specimen.

2.0 CSI Divisions/Uses

05 00 00 – METALS
Section: 05 05 23 - Metal Fastening

06 00 00 - WOOD, PLASTICS AND COMPOSITES
Section: 06 05 23 - Wood, Plastic, and Composite Fastenings

09 00 00 - FINISHES
Section: 09 22 16.23 – Fasteners

3.0 Fasteners/Screws

All test specimens are zinc plated and manufactured to comply with ASTM C954 and ASTM C1002 (for application of gypsum panel products), ASTM C1513 (for connection to cold-formed steel framing), ASTM F1941 (for electro-deposited coating) and ASTM B117 (for salt spray tests).

4.0 Applicable Codes, Standards and Criteria

Current codes, standards and acceptance criteria applicable to and having referenced to the test method/ tested component-assembly:

AISI Manual, Cold-Formed Steel Design, 2015 Edition - Test Standard AISI S904-08 & 2015, Standard Test Method for Deter-mining the Tensile and Shear Strength of Screws

ASTM F606-14 - Standard Test Methods for Determining the Mechanical Properties of Externally and Internally Threaded Fasteners

AISI Standard, North American Specification for the Design of Cold-Formed Steel Structural Members, 2008 & 2012 Edition - Section F, Tests for Special Case.

5.0 Installation

The screws must be installed perpendicular to the work surface, using a variable speed screw driving tool set not to exceed 4,000 rpm. The screw must penetrate through the supporting steel with a minimum of three exposed full threads protruding past the back side of the supporting cold-formed steel.

6.0 Test Results – Tension Load

Table 1 (Test Report No. RD2015005 – Table 4.2.1) summarizes the ultimate tension load capacity results from the various size screws tests. The elongations of specimens at peak loads are also reported. Mean values for each type along with test coefficient of variation are also calculated.

Table 1 - Ultimate Tension Capacities of GOOD SCREWS Fasteners

SCREW TYPE AND SIZE	*TEST ID*	*Peak Load (lbs.)*	*Elongation at ΔPeak Load (in.)*	*Average Peak Load (lbs.) with Coefficient of Variation*
# 8 x 1 ½"	*t1*	2146.53	0.060	**2159.29** with 0.53 % C.V.
	t2	2176.31	0.055	
	t3	2171.44	0.064	
	t4	2150.96	0.053	
	t5	2148.82	0.055	
	t6	2161.67	0.062	
# 10 x 2"	*t1*	2981.29	0.067	**3049.18** with 2.15 % C.V.
	t2	3132.94	0.071	
	t3	3114.82	0.082	
	t4	2976.12	0.066	
	t5	2998.08	0.069	
	t6	3091.82	0.087	
# 12 x 1 ½"	*t1*	4193.94	0.084	**4197.50** with 1.23 % C.V.
	t2	4257.26	0.091	
	t3	4213.59	0.082	
	t4	4231.87	0.084	
	t5	4196.18	0.084	
	t6	4092.16	0.077	

7.0 Test Results – Shear Load

Table 2 (Test Report No. RD2015005 – Table 4.3.1) summarizes the ultimate shear load capacity results from the various size screws tests. Half the value of the maximum load recorded is taken as the ultimate shear capacity of a screw since the test setup involved two screws per specimen simultaneously. The shear deformations of specimens at peak loads are approximated by the measurements of the cross head movement. Mean values for each type along with test coefficient of variation are also calculated.

Table 2 Ultimate Shear Capacities of GOOD SCREWS Fasteners

SCREW TYPE AND SIZE	*TEST ID*	*Peak Load* (lbs.)*	*Deformation at ΔPeak Load (in.)*	*Average Peak Load** (lbs.) with Coefficient of Variation*
# 8 x 1 ½"	*t1*	3452.31	0.239	**1570.48** with 6.21 % C.V.
	t2	3182.65	0.229	
	t3	2841.12	0.209	
	t4	3100.71	0.234	
	t5	3127.96	0.234	
	t6	3276.20	0.223	
# 10 x 2"	*t1*	4644.85	0.223	**2226.41** with 3.35 % C.V.
	t2	4517.34	0.242	
	t3	4562.76	0.254	
	t4	4411.69	0.233	
	t5	4237.38	0.232	
	t6	4253.84	0.232	
# 12 x 1 ½"	*t1*	5952.61	0.247	**2907.58** with 2.36 % C.V.
	t2	5747.55	0.276	
	t3	5829.29	0.247	
	t4	5677.71	0.269	
	t5	5464.60	0.266	
	t6	5478.62	0.255	

**** peak load attained from two screws in shear***

***** average peak load calculated for one screw***

8.0 Summary Report RLSENG-8-2-2015

This report presents an analysis of Good Screws shear and tensile strength screw test data reported in CEMCO Engineering Laboratory (CEL) Report No. RD2015005. The CEL test program was conducted to provide capacity data for three Good Screws sizes: No. 8, No. 10 and No. 12. *Additionally*, using the measured screw strengths and the provisions of AISI S100-12, Section E4 (Screw Connections), connection strength values for the three Good Screws screw sizes are recommended. Recommended screw strengths are also compared to values for similar screw sizes offered by other manufacturers.

9.0 Test Data

Measured peak screw shear and tensile strengths (as reported in CEL Report No. RD2015005) are provided. The coefficient of variation (C.V. = standard deviation divided by the average) values in both tables were remarkably low for all screw sizes and under both loading conditions. Interestingly, AISI S100-12, Chapter F, Section F1.1(c), notes that V_P (the C.V. of test results) shall not be taken less than 6.5% - a value greater than the largest C.V. for any screw type and size tested.

For the shear tests, the maximum difference between an individual test and its associated average was 10.2%. Similarly for the tension tests, the maximum difference between an individual test and its associated average was 2.75%.

10.0 Analysis of Test Data

Table 3 (Report No. RLSENG-8-2-2015 - Table 6) compares average measured peak screw strengths with the computed peak strengths (see Table below) based on material properties. The measured-to-computed peak strengths show that the measured shear strengths are at least 40% more than the computed values, and the measured tensile strengths at least 20% greater than computed values.

Table 3 Comparison of measured to computed screw strength

Fastener	Measured Strength, lb.		Maximum Computed Strength, lb.		P_{-TEST}/P_{-COMP}	
	Shear ($P_{ss-TEST}$)	Tensile ($P_{ts-TEST}$)	Shear ($P_{ss-COMP}$)	Tensile ($P_{ts-COMP}$)	Shear	Tensile
No. 8	1582	2159	1083	1805	1.46	1.20
No. 10	2219	3049	1386	2310	1.60	1.32
No. 12	2846	4198	2025	3374	1.41	1.24

Notes:
1. Maximum computed strength.
2. Measured strengths from Tables 1 and 2 (Test Report No. RD2015005 Tables 4.2.1 and 4.3.1)

In accordance with AISI S100-12, Section E.4, the available allowable (ASD) and design (LRFD) strengths of screw connections may be determined using a safety factor (Ω) of 3.00 and resistance factor (ϕ) of 0.50, respectively. AISI also permits determination of available strengths based on tests, with Ω and ϕ determined in accordance with Chapter F, Section F1. Ω and ϕ determined in accordance with Section F1 need not exceed 3.0 and 0.5, respectively.

Using the recommended maximum safety factor of 3.0 and AISI equations for the connection shear (AISI S100, Section E4.3) and tensile strengths (AISI S100, Section E4.4), Table 4 (Report No. RLSENG-8-2-2015 – Table 7) gives the Good Screws allowable connection strengths for the three screws sizes tested. The bold-faced values in Table 4 indicate values for what are considered commonly specified CFS properties.

11.0 Allowable Good Screws Connection Strength ($P_{ASD\text{-}GS}$)

The CFS properties listed in Table 4 (Report No. RLSENG-8-2-2015 - Table 7) are organized to match tabulated values in SSMA's screw connection capacities table (SSMA-2013, Product Technical Guide – ICC-ES ESR 3064P, p. 60).

Table 4 Allowable Good Screws connection strength (PASD-GS)

CFS Properties				Good Screw Allowable Connection Strength ($P_{ASD\text{-}GS}$), lb.								
				No. 8 Screw			No. 10 Screw			No. 12 Screw		
Designated Thickness, mils	Design Thickness, in.	F_y, ksi	F_u, ksi	Nom. Dia.	Nom. Head Dia.		Nom. Dia.	Nom. Head Dia.		Nom. Dia.	Nom. Head Dia.	
				0.164 in.	0.272 in.		0.190 in.	0.340 in.		0.216 in.	0.340 in.	
				Shear $P_{s\text{-}ASD}$	Pull-Out $P_{t\text{-}ASD}$	Pull-Over $P_{v\text{-}ASD}$	Shear $P_{s\text{-}ASD}$	Pull-Out $P_{t\text{-}ASD}$	Pull-Over $P_{v\text{-}ASD}$	Shear $P_{s\text{-}ASD}$	Pull-Out $P_{t\text{-}ASD}$	Pull-Over $P_{v\text{-}ASD}$
18	0.0188	33	33	48	29	84	52	33	105	55	38	105
27	0.0283	33	33	89	43	127	96	50	159	102	57	159
30	0.0312	33	33	103	48	140	111	55	175	118	63	175
33	**0.0346**	**33**	**45**	164	72	212	177	84	265	188	95	265
43	**0.0451**	**33**	**45**	244	94	276	263	109	345	280	124	345
54	**0.0566**	**50**	**65**	496	171	500	534	198	625	569	225	625
68	**0.0713**	**50**	**65**	527	215	630	740	249	788	805	284	788
97	**0.1017**	**50**	**65**	527	307	720	740	356	1016	949	405	1124
118	**0.1242**	**50**	**65**	527	375	720	740	435	1016	949	494	1372
54	0.0566	33	45	344	118	346	370	137	433	394	156	433
68	0.0713	33	45	474	149	436	523	173	545	557	196	545
97	0.1017	33	45	527	213	622	740	246	778	890	280	778
118	0.1242	33	45	527	260	720	740	301	950	949	342	950
Nominal Shear Strength, lb.				1582			2219			2846		
Nominal Tension Strength, lb.				2159			3049			4198		

Notes:
1. Safety factor = 3.0
2. Allowable strength is determined in accordance with the provisions of AISI S100, Section E4.

12.0 References

(1) Test Oversight and Analysis Report: **Reynaud Serrette, Ph.D., Report No. RLSENG-8-2-2015**
(2) Third Party Review: **Dean Peyton, DHP Engineering, P.S.** (see page 6)

13.0 Comparison of Good Screws Screw Strength to Other Published Values for Similar Screws

Finally, Table 5 (Report No. RLSENG-8-2-2015 - Table 10) compares the strength of Good Screws with values published in four different manufacturer ICC-ES evaluation service reports (ESR).

Table 5 Comparison of Good Screws Screw Strength to Other Published Values for Similar Screws

ESR	Manufacturer	Fastener Size	Fastener Strength				Ratio of GS-to-OTHERS Fastener Strength	
			OTHERS		Good Screws (GS)			
		w/tpi	P_{ss}, lb.	P_{ts}, lb.	P_{ss}, lb.	P_{ts}, lb.	$P_{ss\text{-}GS}/P_{ss\text{-}OTHER}$	$P_{ts\text{-}GS}/P_{ts\text{-}OTHER}$
1408 Jan 2014	PrimeSource	No. 8-18	1274	1974	1570	2159	1.24	1.09
		No. 10-16	1484	1158	2219	3049	1.50	2.63
		No. 12-14	2077	2603	2846	4198	1.37	1.61
		No. 12-24	2447	4200	2846	4198	1.16	1.00
2196 Dec 2014	Hilti	No. 8-18	1170	1000	1582	2159	1.35	2.16
		No. 8-18S	1570	1915	1582	2159	1.01	1.13
		No. 10-12	1645	2170	2219	3049	1.35	1.41
		No. 10-12S	1905	1915	2219	3049	1.16	1.59
		No. 10-16	1215	1370	2219	3049	1.83	2.23
		No. 10-18	1845	1390	2219	3049	1.20	2.19
		No. 12-14	1880	2325	2846	4198	1.51	1.81
		No. 12-24	2285	3900	2846	4198	1.25	1.08
1271 Aug 2015	Grabber	No. 8-18	1403	1894	1582	2159	1.13	1.14
		No. 10-15	1910	2455	2219	3049	1.16	1.24
		No. 12-14	2814	2534	2846	4198	1.01	1.66
3528 Jul 2015	InterCorp	No. 8-18 (PMTH)	1523	2051	1582	2159	1.04	1.05
		No. 10-16	1934	3102	2219	3049	1.15	0.98
		No. 12-14	2089	4129	2846	4198	1.36	1.02
						Maximum	1.83	2.63
						Minimum	1.01	0.98

Notes:
1. All screws are hex washer head (HWH) except where otherwise noted.
2. PMTH = Phillips Modified Truss Head.

14.0 Conclusion

An analysis of Good Screws screw test data was presented. Based on this analysis, the following conclusions were reached for the Good Screws No. 8, No.10 and No. 12 screws:

1. The shear (Pss) and tensile (Pts) strength of the tested screws exceeded the values published in SSMA 2012 Product Technical Guide.
2. Good Screws allowable connection strengths determined in accordance with AISI S100 equal or exceed published SSMA values.
3. The shear and tensile strength of Good Screws equal or exceed the values published in ICC- ES ESR reports of four national manufacturers – with the exception of one screw size from one manufacturer where the Good Screw tensile strength was 98% of the manufacturer's value.

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February 11, 2016

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DHP Engineering, PS has performed a review of the testing and analysis results as summarized in the report titled "Good Screws Fasteners – Screw Tension and Shear Tests – TL-316" dated August 2015 by CEMCO Engineering Laboratory and the analysis report "Shear and Tensile Strength of Good Screws Fasteners - RLSENG-8-2-2015" by Reynaud Serrette, Ph.D. Our review of this information involved an understanding of the testing protocol, video observations, test set up discussions with the test director, and review of the analysis results with Reynaud Serrette. The certified testing facility was CEMCO Engineering Laboratory (CEL) and the analysis was provided by Dr. Reynaud Serrette.

The purpose of this testing is to provide certified Good Screws design data that can be efficiently used by engineering designers. Current engineering practitioners commonly defer to the Steel Stud Manufacturers Association (SSMA) table for the design capacity of screws in cold formed steel connections. Engineer's plans specify screws must meet the minimum loads listed for respective screw size and connected material as listed in the SSMA Allowable Screw Connection Capacity table.

The SSMA Allowable Screw Connection Capacity table lists allowable loads based on modes of failure as associated with either the capacity of the screw itself or the materials connected. The potential for failure within the materials joined by the screw is calculated per the American Iron and Steel Institute Specification for the design of cold formed steel. The calculated material failure governs when the screw itself is stronger than the connected parts. However, as the material thickness and strength properties increase the screw itself may be become the first mode of failure.

The SSMA has provided maximum screw capacities in their table based on their foot notes as follows:

> ***10.*** *Screw shear strength is the average value, and the tension strength is the lowest value listed in the CFSEI Tech Note (F701-12).*
> ***11.*** *Higher values for screw strength (Pss, Pts), may be obtained by specifying screws from a specific manufacturer.*

This testing of Good Screws has confirmed that their screws meet or exceed all values given in the current SSMA allowable design tables. Our review indicates that Good Screws could be substituted for any conditions that the SSMA table allows. Further, if a design engineer would specify Good Screws for their project, they would be able to economize their design, as Good Screws will provide more capacity than other industry manufactures for connection conditions as noted in this report.

Sincerely,
DHP Engineering, PS