Structural Testing of the Telling Industries, LLC True-Brace

Report submitted to:
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Structural Testing of the Telling Industries, LLC True-Brace

1 Introduction

Telling Industries produces a line of cold-formed steel framing members and related components including the True-Brace bridging system. The True-Brace is a notched cold-rolled channel that can connect with a cold-formed steel (CFS) stud through the knockouts to provide lateral and rotational restraint. The connections are made without any screws or other clips. The photograph in Figure 1-1 shows a True-Brace and its application.

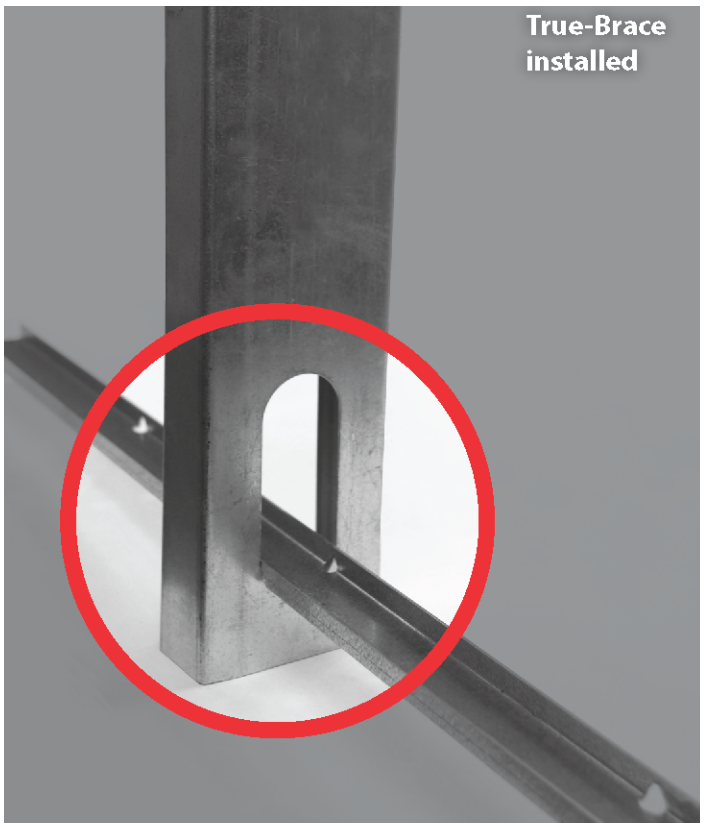

Figure 1-1: Photograph of the True-Brace

Presented in this report are the results of the experimental investigation carried out in May-June 2019 by Telling Industries.

2 Objective

The objective of the work described in this report was to test combinations of the 16 gauge True-Brace with various sizes of CFS members subjected to lateral and rotational loading. These test results can be used to determine allowable loads for these bridging members to be used in an engineered design.

3 Scope

A test matrix was determined based on providing a representative number of tests covering the range of products offered. Listed in Table 3-1 is the test matrix.

Table 3-1: True-Brace Test Matrix

CFS Member Size	# of Lateral Loading Tests	# of Rotational Loading Tests
362S162-33	3	3
362S162-43	3	3
362S162-54	3	3
362S162-68	3	3
600S162-33	3	3
600S162-43	3	3
600S162-54	3	3
600S162-68	3	3

4 Test Specimens

4.1 Specimen Geometry

The photograph in Figure 1-1 shows the True-Brace. The depth matches the width of the knockout in a CFS member.

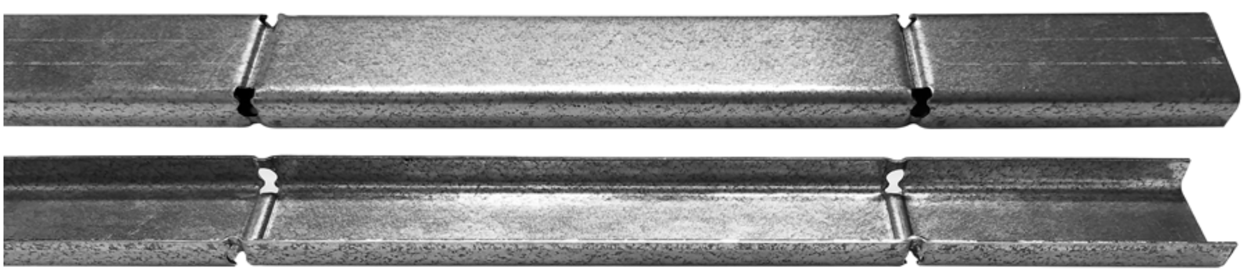

Figure 4-1: Photograph of the True-Brace

4.2 Mechanical Properties

The mechanical properties of the True-Brace specimens were determined from tensile coupons taken from the coil used to make the test specimens. The results of the tensile tests are summarized in Table 4-1. The mechanical properties of the CFS members were not measured.

Table 4-1: Mechanical Properties

Section Designation Thickness	Thickness (in)	Yield Strength (ksi)	Tensile Strength (ksi)	Elongation (%)
True-Brace	0.0554	58	63	32

4.3 Metallic Coating
The metallic coating mass was not measured since it does not impact on the structural performance of the assembly.

5 Test Set-Up and Procedures

5.1 Equipment
The load was applied by a pneumatic actuator manually. Deflections were measured using digital calipers capable of recording to a reading of 0.001 in. There is no record of the load cell or calipers being calibrated.

5.2 Test Standard
The test procedure generally followed AISI S915-15 *Test Standard for Through-the-Web Punchout Cold-Formed Steel Wall Stud Bridging Connectors*.

5.3 Test Set-up and Procedure
The photograph in Figure 5-1 shows the test set-up for the lateral loading tests. The CFS member was 48 in. long and the True-Brace section was 16 in. long. The True-Brace was installed in the CFS member with 8 in. protruding from each end. This was done to simulate the most commonly used configuration. The load was applied to the end of the True-Brace with a pneumatic actuator. The load was measured with a load cell installed in-line with the actuator. The deflection was measured with a digital caliper. The load was increased in increments and paused to record the applied load and corresponding deflection.

The photograph in Figure 5-2 shows the test set-up for the rotational loading tests. The CFS member was 24 in. long and the True-Brace section was 16 in. long. The True-Brace was installed in the CFS member with 8 in. protruding from each end. The load was applied to both ends of the True-Brace with pneumatic actuators. The load was measured with two load cells installed in-line with the actuators. The deflection was measured with digital calipers at each loading point. The load was increased in increments and paused to record the applied load and corresponding deflection.

Figure 5-1: Photograph of the Lateral Loading Test Set-Up

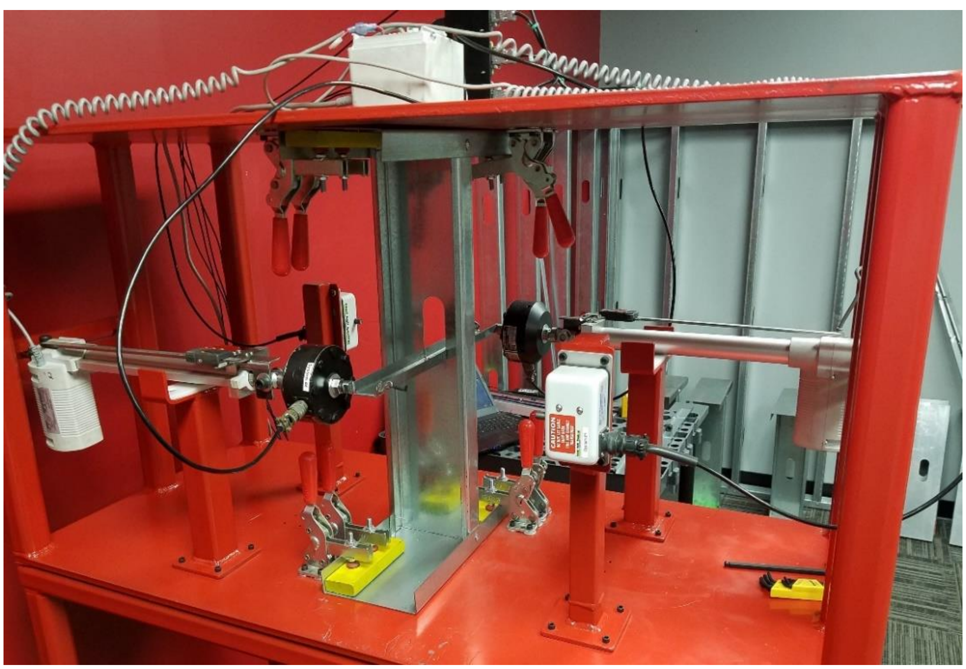

Figure 5-2: Photograph of the Rotational Loading Test Set-Up

6 Test Results and Analysis

6.1 Failure Mode

The photograph in Figure 6-1 shows the failure of a specimen under lateral loading, and the photograph in Figure 6-2 shows the failure of a specimen under rotational loading. In both cases the True-Brace disengaged from the CFS member at the ultimate load.

Figure 6-1: Photograph of Failure Mode for Lateral Loading

Figure 6-2: Photograph of Failure Mode for Rotational Loading

6.2 Calculation of the Safety Factor

The tested strengths are required to be reduced by a safety factor, Ω, determined in accordance with the provisions of section K1 of AISI S100. Since the web of the CFS member failed not the

True-Brace, the statistical data and Beta factor for "Other Member Limit States" was used. The first step is to determine the resistance factor using Eq. 6-1 reproduced from S100.

$$\phi = C_{\phi}(M_m F_m P_m) e^{-\beta_o \sqrt{V_M^2 + V_F^2 + C_P V_P^2 + V_Q^2}} \quad \text{Eq. K2.1.1-2}$$

where,

C_{φ}	=	1.52 (for LRFD)
M_m	=	1.0
F_m	=	1.0
P_m	=	1.0
β_0	=	2.5
V_M	=	0.10
V_F	=	0.05
C_P	=	$(1 + 1/n)m/(m-2)$ for $n \geq 4$, for n=3 use 5.7
n	=	number of tests
m	=	degrees of freedom = n-1
V_P	=	COV of test results ≥ 0.065
V_Q	=	0.21 (for LRFD)

Once the resistance factor is determined using Eq. 6-1, the corresponding safety factor is calculated as follows:

$$\Omega = 1.6/\varphi \quad \text{Eq. K2.1.2-2}$$

6.3 Material Reduction Factor

AISI S100 requires that the calculation of allowable loads consider the difference between the material properties of the test specimens and the properties used in design (i.e. thickness and yield strength). The failure mode was associated with the web of the CFS member being deformed at the point of loading by the True-Brace until the two members disengaged. This is illustrated in Figure 6-1 and 6-2. Unfortunately, only mechanical properties were measured for the True-Brace material, not the CFS members.

6.4 Analysis of Test Results - Strength

The test results listed in Table 6-1 are for the lateral loading. The ultimate load (lbs) is the maximum recorded load. The allowable load is the average ultimate load from the three tests divided by the safety factor.

Table 6-1: Lateral Loading Strength

CFS Member	Ultimate Load							Safety Factor	Allowable Load (lbs)
	Test #1 (lbs)	**Test#2 (lbs)**	**Test #3 (lbs)**	**Test #4 (lbs)**	**Test #5 (lbs)**	**Average (lbs)**	**COV**		
362S125-33	262	250	261			258	0.026	2.141	120
362S125-43	495	502	495			497	0.008	2.141	232
362S125-54	-	-	851	912	910	891	0.039	2.141	416
362S125-68	1315	1292	1306			1304	0.009	2.141	609
600S125-33	454	433	470			452	0.041	2.141	211
600S125-43	595	637	648			627	0.045	2.141	293
600S125-54	-	907	869	958	916	913	0.04	2.063	442
600S125-68	1266	1167	1065			1166	0.086	2.309	505

The test results listed in Table 6-2 are for the rotational loading. The ultimate load (lbs) is the average of the maximum loads recorded by the two load cells attached to either end of the True-Brace sample. The allowable load (in-lbs) is the average ultimate load from the three tests divided by the safety factor multiplied by the 16 in. lever arm of the True-Brace sample.

Table 6-2: Rotational Loading Strength

CFS Member	Ultimate Load							Safety Factor	Allowable Moment (in-lbs)
	Test #1 (lbs)	**Test#2 (lbs)**	**Test #3 (lbs)**	**Test #4 (lbs)**	**Test #5 (lbs)**	**Average** (lbs)	**COV**		
362S162-33	18.69	15.80	15.35			16.6	0.109	2.542	105
362S162-43	34.48	32.43	35.55			34.2	0.046	2.141	255
362S162-54	61.37	54.09	62.77			59.4	0.078	2.240	424
362S162-68	80.11	89.85	82.91			84.3	0.059	2.141	630
600S162-33	20.96	17.50	19.61			19.4	0.090	2.346	132
600S162-43	37.40	31.09	33.58			34.0	0.093	2.375	229
600S162-54	46.21	38.88	32.91	49.01	50.87	43.6	0.172	2.571	271
600S162-68	56.10	47.08	48.05			50.4	0.098	2.424	333

6.5 Analysis of Test Results - Stiffness

The test results listed in Table 6-3 are for the lateral loading. The stiffness (lbs/in) is the recorded load at approximately 0.4 of the ultimate divided by the corresponding defection at that load level. The available stiffness is the average from the three tests.

Table 6-3: Lateral Loading Stiffness

CFS Member	Stiffness (at 0.4 Pult)															
	Test #1			Test #2			Test #3			Test #4			Test #5			Avg.
	(lbs)	(in)	(lbs/in)	(lbs)	(in)	(lbs/in)	(lbs)	(in)	(lbs/in)	(lbs)	(in)	(lbs/in)	(lbs)	(in)	(lbs/in)	(lbs/in)
362S162-33	155	0.30	517	159	0.50	318	146	0.60	243							359
362S162-43	205	0.40	513	221	0.40	553	196	0.40	490							518
362S162-54	345	0.60	575	-	-	-	355	0.80	444	381	0.40	953	460	0.50	920	723
362S162-68	517	0.80	646	524	0.40	1310	535	0.50	1070							1009
600S162-33	151	0.30	503	155	0.30	517	150	0.30	500							507
600S162-43	264	0.50	528	199	0.40	498	263	0.50	526							517
600S162-54	-	-	-	403	0.60	672	355	0.70	507	352	0.40	880	306	0.40	765	706
600S162-68	516	0.60	860	535	0.60	892	500	0.60	833							862

The test results listed in Table 6-4 are for the rotational loading. The stiffness is the recorded load at approximately 0.4 of the ultimate divided by the corresponding defection at that load level. The deflection in radians (Rad) is the measured deflection at the end of the True-Brace sampled divided by the lever arm, which in these tests was 8 in. The available stiffness is the average from the three tests.

Table 6-4: Rotational Loading Stiffness

CFS Member	Rotational Stiffness (at 0.4 Pult)									
	Test #1			Test #2			Test #3			Average
	(lbs)	(in)	(lbs/Rad)	(lbs)	(in)	(lbs/Rad)	(lbs)	(in)	(lbs/Rad)	(lbs/Rad)
362S162-33	9.952	1.276	62.4	8.838	1.293	54.7	7.784	1.304	47.8	54.9
362S162-43	16.04	1.265	101	14.74	1.311	89.9	14.87	1.294	91.9	94.4
362S162-54	20.41	1.298	126	19.60	1.279	123	23.90	1.280	149	132.6
362S162-68	30.99	1.239	200	30.62	1.223	200	33.91	1.296	209	203.2
600S162-33	16.56	0.787	168.3	9.650	1.320	58.5	9.33	1.150	64.9	97.2
600S162-43	18.06	1.050	137.6	13.33	1.135	94.0	12.39	1.180	84	105.2
600S162-54	17.32	1.210	114.5	12.96	1.225	84.6	18.34	1.181	124.2	107.8
600S162-68	24.30	1.324	146.8	24.02	1.242	154.7	11.43	1.234	74.1	125.2