COLD-FORMED STEEL RESEARCH CONSORTIUM

Shear Response of Fastened Assemblies of Cementitious Panel to Steel Deck for FastFloor Residential Project

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COLD-FORMED STEEL RESEARCH CONSORTIUM

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CFSRC R-2023-04

CFSRC Information

The Cold-Formed Steel Research Consortium (CFSRC) is a multi-institute consortium of university researchers dedicated to providing world-leading research that enables structural engineers and manufacturers to realize the full potential of structures utilizing cold-formed steel. More information can be found at www.cfsrc.org. All CFSRC reports are hosted permanently by the Johns Hopkins University library in the DSpace collection: https://jscholarship.library.jhu.edu/handle/1774.2/40427.

SDII Information

The Steel Diaphragm Innovation Initiative (SDII) is a collaborative dedicated to innovation in steel building systems. SDII was formed in 2015 to address specific challenges in concrete-filled and bare steel deck diaphragm systems, and SDII's first phase concluded in 2021. In 2022, SDII expanded (Phase II) to broadly address innovation in steel building systems with a specific focus on the performance of steel floor systems. Updates on the activities of SDII are provided at https://steeli.org.

Acknowledgment

The team would like to acknowledge the American Institute of Steel Construction and the Steel Deck Institute for providing funding for this project. In addition, we provide thanks specifically to Thomas Sputo and Devin Huber for their oversight and advice on the work. We would also like to thank David Attanucci and DACS Inc. for donating and shipping the steel deck and USG for donating the structural panels and structural panel fasteners. Finally, we would like to acknowledge all the students in the Thin-walled Structures Group at JHU that helped transport and assemble the specimens and Sophrenia David for providing edits to this report. This testing would not have been possible without the contributions of all these people and organizations.

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1. Introduction

The goal of the FastFloor Residential project is to create a new steel floor system that is lightweight, fast to construct, and nonproprietary. FastFloor Residential strives to achieve this by exploring prototypes such as the one shown in Figure 1, employing 18 gauge 3 in. deep steel deck fastened back-to-back to create a cellular deck, then topped with ¾ in thick cementitious (structural) panel screwed to the steel deck.

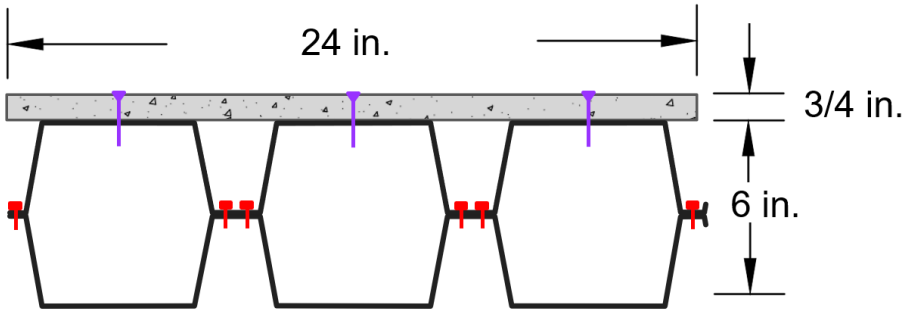


Figure 1. FastFloor Residential prototype cross-section

This report summarizes a series of push-out tests that were conducted in the Thin-Walled Structures Lab at Johns Hopkins University. The push-out tests provide the shear response of the fasteners used to attach the cementitious panel to the steel deck. Repeatability of response, fastener spacing, and installation conditions (overdriven screws) are all explored in the testing.

2. Background

In 2022, a set of four-point bending tests on the FastFloor Residential prototype assembly were performed at the Johns Hopkins University, Thin-Walled Structures Lab, as shown in Figure 2 (see report CFSRC R-2022-03 [1]). The goals for these tests were to understand the behavior of the composite action between the steel deck and cementitious panel, identify the failure modes, and evaluate the strength and stiffness of the composite floor system. At large deflection, the ultimate strength of the composite specimens was controlled by shearing of the fasteners connecting the cementitious panel to the steel deck. This led to the idea of performing push-out testing, to explore the behavior of this assembly in isolation. This report provides the results from the push-out tests.

Figure 2. Four-point bending lab setup [1]

3. Test Matrix and Specimens

Thirty-five push-out specimens were tested with five unique configurations. All specimens used #12-14×3/4 @ 2 in. O.C. Hilti fasteners for the deck-to-deck connections and #8 × 1-5/8 in. Grabber fasteners for the cementitious panel-to-deck connections. For the cementitious panels, 4 ft × 8 ft × ¾ in. structocrete structural panels, provided by USG were employed. The panels were cut into 8 in. × 12 in. specimens for testing. DACS Inc. provided the 18 gage (43 mil) 3 in. deep N-deck used in the specimens. The push-out tests consist of four (two on each side) Grabber fasteners attaching the structocrete panel to the deck. The tested panel to deck fasteners are spaced longitudinally at 6 in. , 4 in. , 2 in., and 1 in., as well as one set of overdriven fasteners at 6 in. spacing, as summarized in Table 1. For all specimens, the deck-to-deck #12 fasteners had 2 in. spacing to prevent slip between the two pieces of deck. The geometry of the specimens and the layout of the fasteners are provided in Figure 3. The 1/16 in. overdriven fastener depth was determined as reasonable based on experience of fastening the floors together from previous testing [1].

Table 1. Test Matrix

Name	Grabber Fastener Spacing (in.)	Overdriven Depth (in.)	Quantity (#)
Set 1	6	--	7
Set 2	4	--	7
Set 3	2	--	7
Set 4	1	--	7
Set 5	6	1/16	7

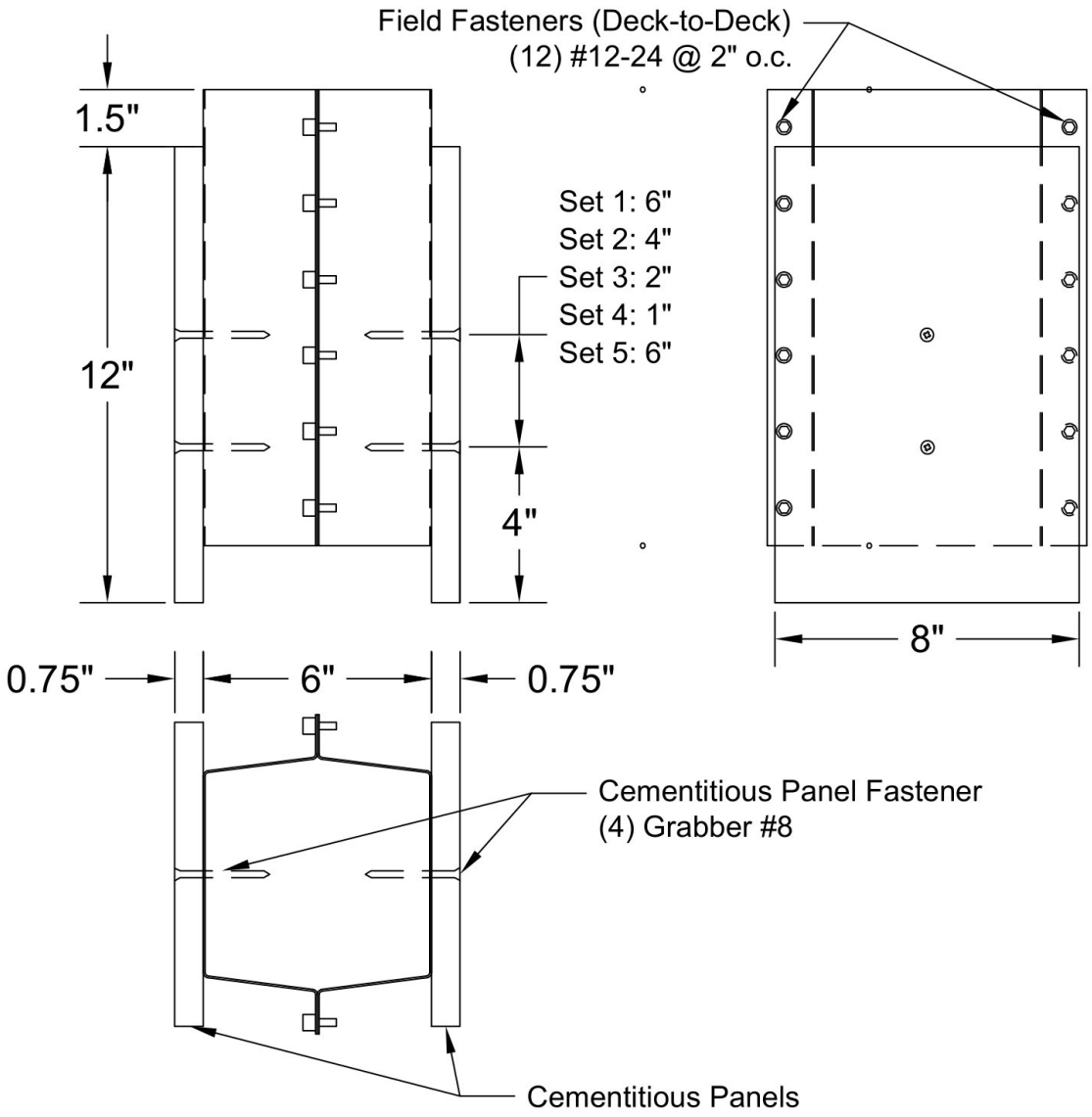


Figure 3. Specimen schematic – elevation, side, and top view

4. Test Setup

The push-out tests were conducted in a 10 kip MTS loading rig, where the bottom of the specimens (cementitious panels) rested on a fixed bottom platen connected to the actuator, and the top of the specimens (steel deck) are in bearing with a steel platen with a ball joint, attached to the load cell, as shown in Figure 4. There was no contact between the steel deck and the bottom platen to ensure all applied loads transferred to the panels and thus placed the #8 Grabber screws in shear. The specimens themselves were symmetrical with the locations of the cementitious panels to prevent eccentric loading of the specimens. As the bottom platen moves up the 4 panel-to-deck fasteners (2 on each side) are placed in shear.

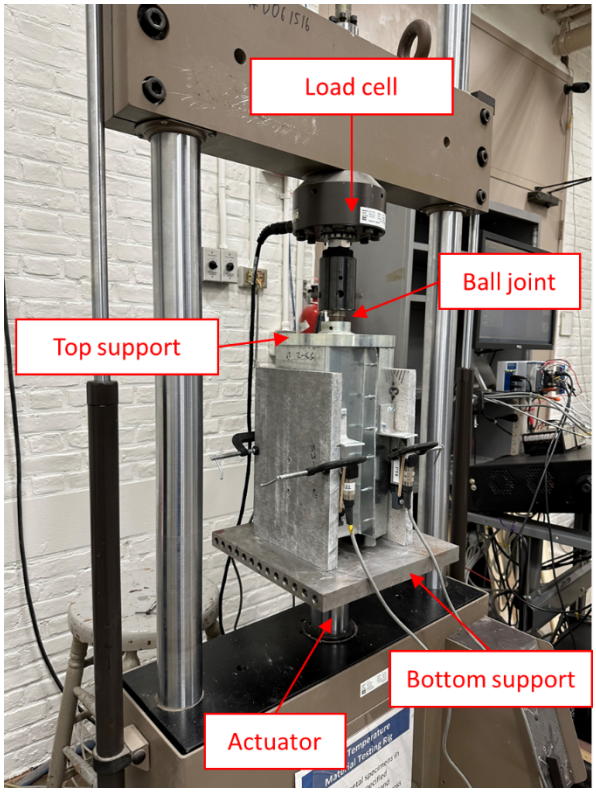


Figure 4. Test rig setup

5. Instrumentation and loading procedure

As shown in Figure 5, four position transducers (PTs) were used to measure the slip between the deck and the structural panel at each corner of the specimen. The PTs were clamped onto the cementitious panels and pressed against angles secured to the deck of the specimen for slip measurement.

The applied load in the tests was controlled using an MTS FlexTest SE controller. A displacement-controlled loading procedure was used at a rate of 0.000278 in/sec. The data acquisition system was a National Instruments NI cDAQ-9174.

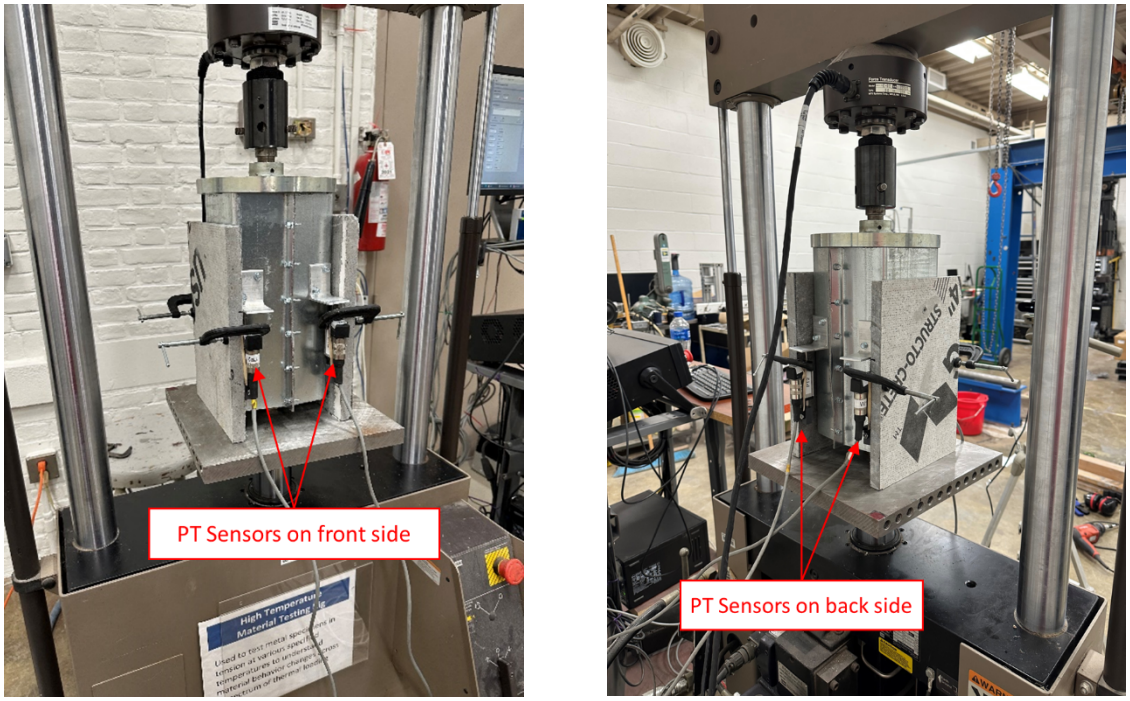


Figure 5. Position transducer locations

6. Material Properties

As reported in [1] and repeated here in Table 2, six coupon tests on the steel deck samples were conducted per ASTM A370-21. The tests were conducted using an MTS Criterion Model 43 tensile testing rig with a 0.001 in/sec load rate. An extensometer with a 1 in. gage length was used for all tests. The extensometer was removed just before the specimen reached 20% strain; therefore, ultimate and fracture strains were calculated using the overall displacement of the MTS crosshead. The yield strength, F_y, was determined using the 0.2% offset method to be 58 ksi. The stress-strain curves from this test are also shown in Figure 6.

Table 2. Coupon test results

Coupon (#)	w (in.)	t (in.)	F_y (ksi)	F_u (ksi)	ε_y (%)	ε_u (%)	$\varepsilon_{Fracture}$ (%)
1	0.502	0.0458	57.87	71.97	0.45	16.7	28.3
2	0.501	0.0461	58.73	74.03	0.47	16.4	25.8
3	0.499	0.0461	58.14	72.14	0.45	16.6	26.1
4	0.501	0.0474	57.65	71.45	0.45	16.6	26.7
5	0.498	0.0475	56.79	71.36	0.46	16.1	23.4
6	0.502	0.0464	59.00	73.46	0.50	16.2	24.8
Mean	0.501	0.0465	58.03	72.40	0.46	16.5	25.9
COV (%)	0.29	1.55	1.37	1.52	3.76	1.39	6.52

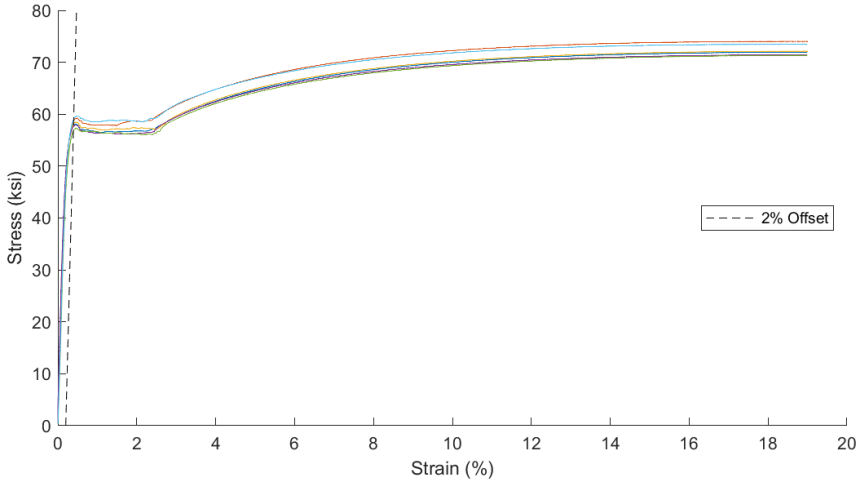


Figure 6. Stress-strain plot of the coupon tests

Separate material tests were not conducted on the structocrete panels or fasteners.

7. Test Results

Herein we provide the load-deformation response, peak strength and initial stiffness, and characterization of the failure mode. The load is provided on a per fastener basis (total load divided by 4) the displacement is based on the slip recorded by the four PT sensors. All recorded data is provided in Figure 7.

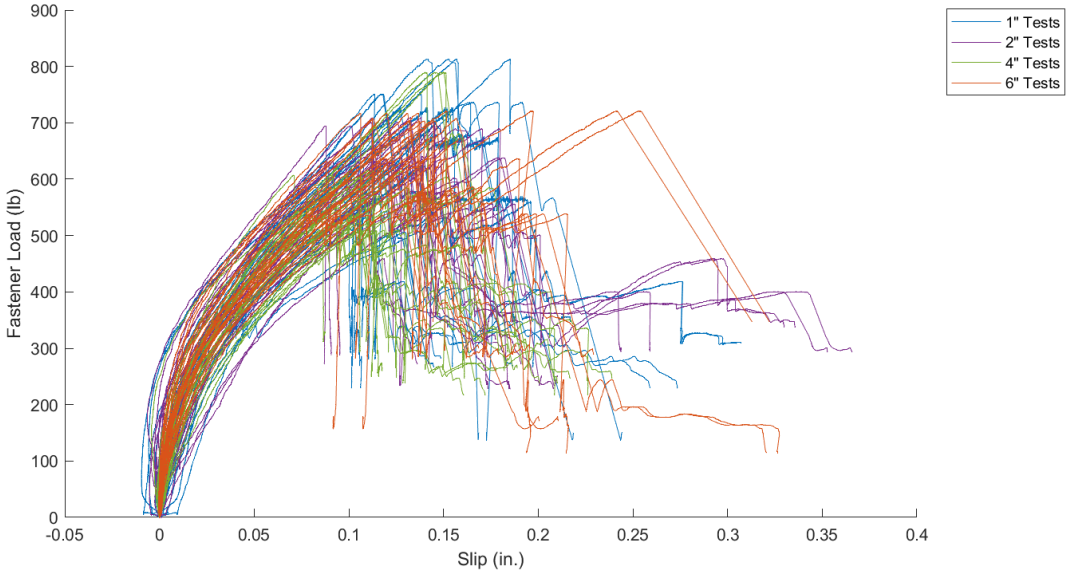


Figure 7. Load-displacement based on the actuator load cell and all PT Sensors for different spacings

If we average the two PT sensors on each piece of structocrete, thereby providingn the average slip per panel then the overall load-displacement plot is provided in Figure 8.

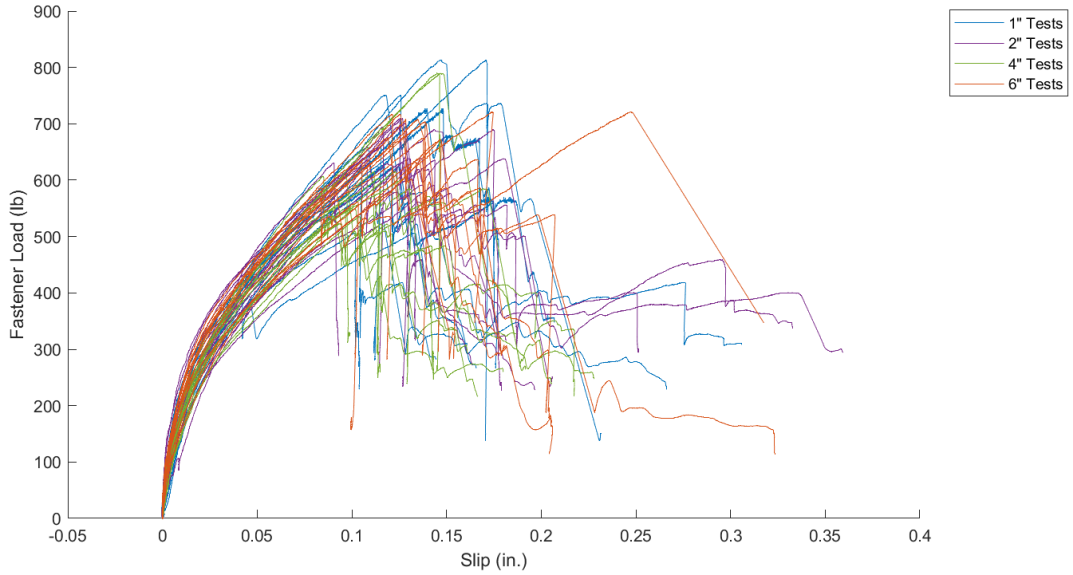


Figure 8. Load-displacement based on the actuator load cell and averaged PT sensors for different spacings

Per Table 1, Set-5 provides a series of tests where the fasteners are overdriven by 1/16 in. These tests are compared with Set-4 in Figures 9 and 10.

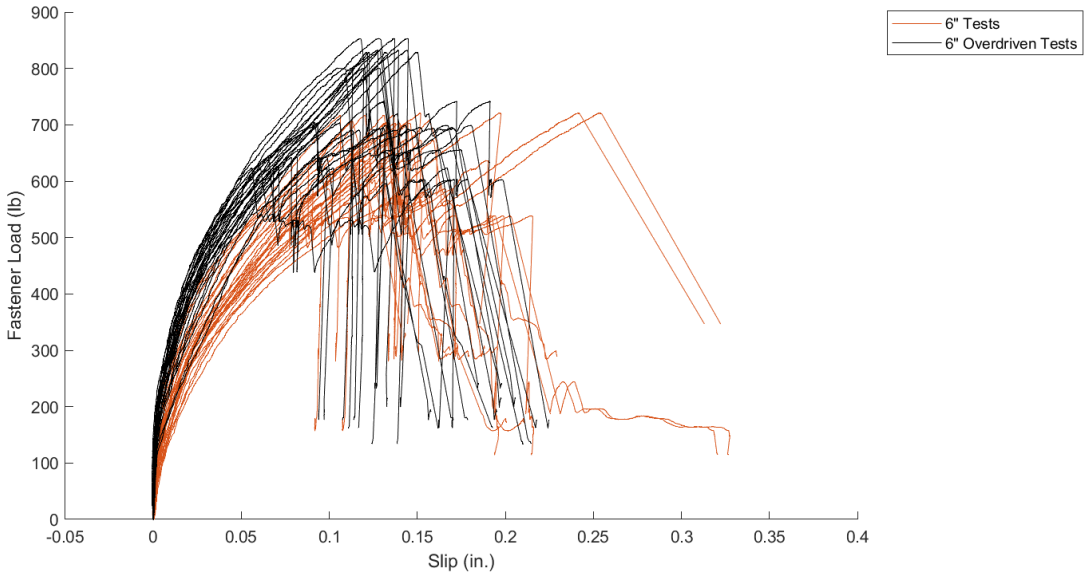


Figure 9. Load-displacement response of Set-5 overdriven with Set-1 for all PT data

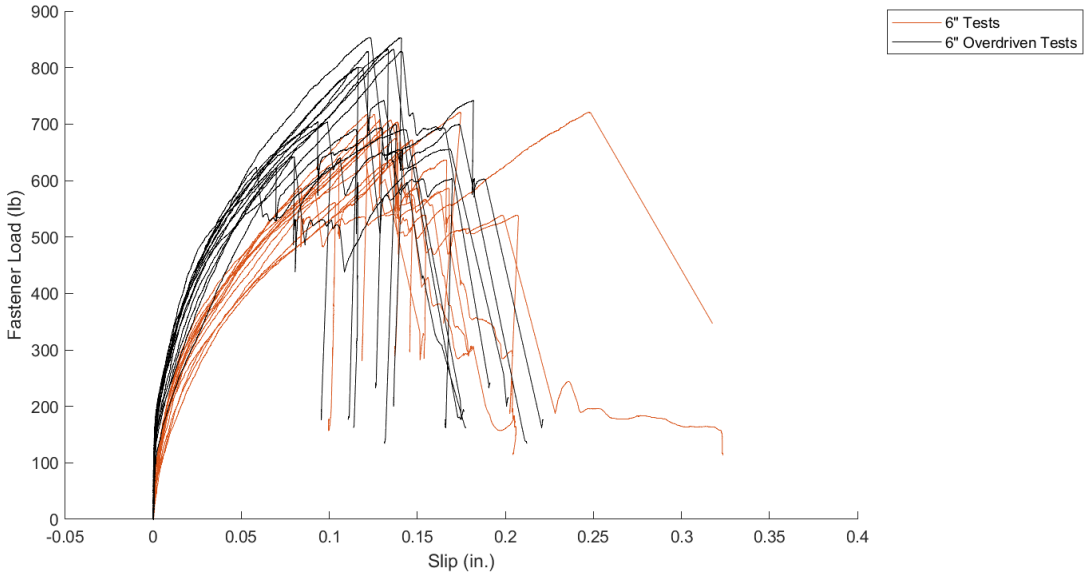


Figure 10. Load-displacement response of Set-5 overdriven with Set-1 for averaged PT data

Baed on the data we determined the peak strength and the secant stiffness (at 40% of ultimate) for each test. Figure 11 provides the load and secant stiffness as a function of fastener spacing. Mean of the data is indicated with a line and a whisker plot is used to show one standard deviation from mean. The strength and stiffness of each specimen can be found below in Tables 3 through 7. Table 8 provides a summary of all the strength and stiffness results.

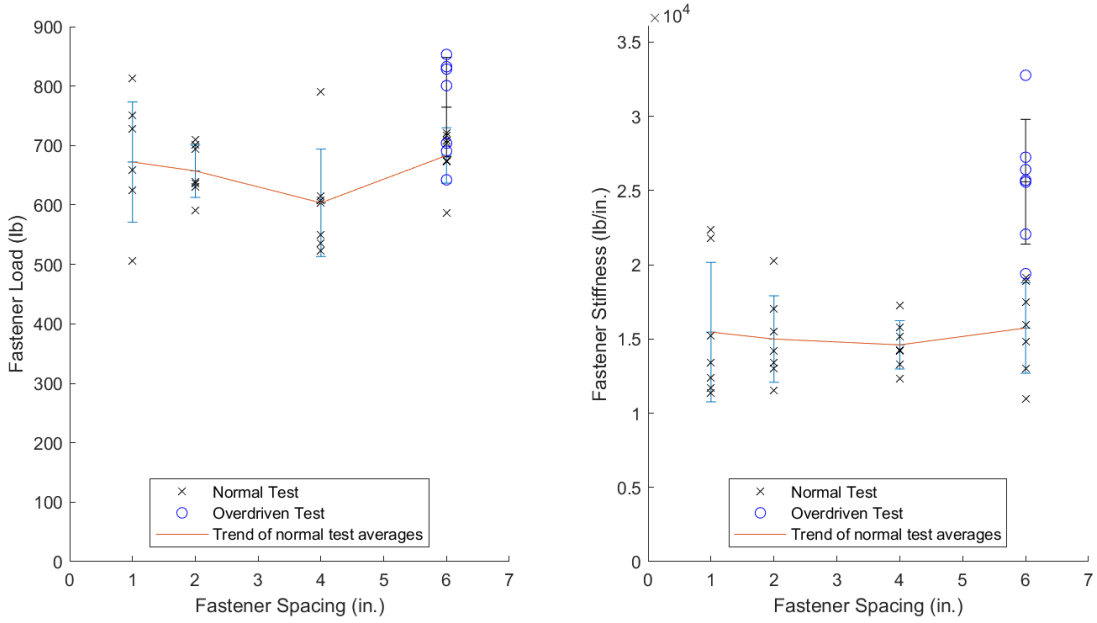


Figure 11. Load and stiffness as a function of fastener spacing

Table 3. Strength and Stiffness of 6 in. Spacing

Test #	Ultimate Load (lb)	Stiffness at 40% Ultimate Load (kip/in.)
1	506.6	22.4
2	727.4	11.7
3	624.6	21.8
4	658.7	13.4
5	751.2	12.4
6	813.1	11.4
7	624.3	15.2
Mean	672.3	15.5
CV	38.0%	30.4%

Table 4. Strength and Stiffness of 4 in. Spacing

Test #	Ultimate Load (lb)	Stiffness at 40% Ultimate Load (kip/in.)
1	635.9	14.2
2	591.2	13.4
3	700.7	20.2
4	630.7	15.5
5	709.5	13.0
6	694.5	11.6
7	638.3	17.1
Mean	657.3	15.0
CV	6.8%	19.4%

Table 5. Strength and Stiffness of 2 in. Spacing

Test #	Ultimate Load (lb)	Stiffness at 40% Ultimate Load (kip/in.)
1	607.3	15.8
2	615.5	15.2
3	603.8	17.2
4	535.4	14.2
5	790.1	12.3
6	549.5	13.3
7	523.6	14.2
Mean	603.6	14.6
CV	15.0%	11.1%

Table 6. Strength and Stiffness of 1 in. Spacing

Test #	Ultimate Load (lb)	Stiffness at 40% Ultimate Load (kip/in.)
1	674.4	18.9
2	587.0	19.1
3	707.7	17.5
4	721.2	14.8
5	703.5	13.0
6	716.8	16.0
7	672.4	11.0
Mean	683.3	15.7
CV	35.9%	19.4%

Table 7. Strength and Stiffness of 6 in. Spacing with Overdriven Fasteners

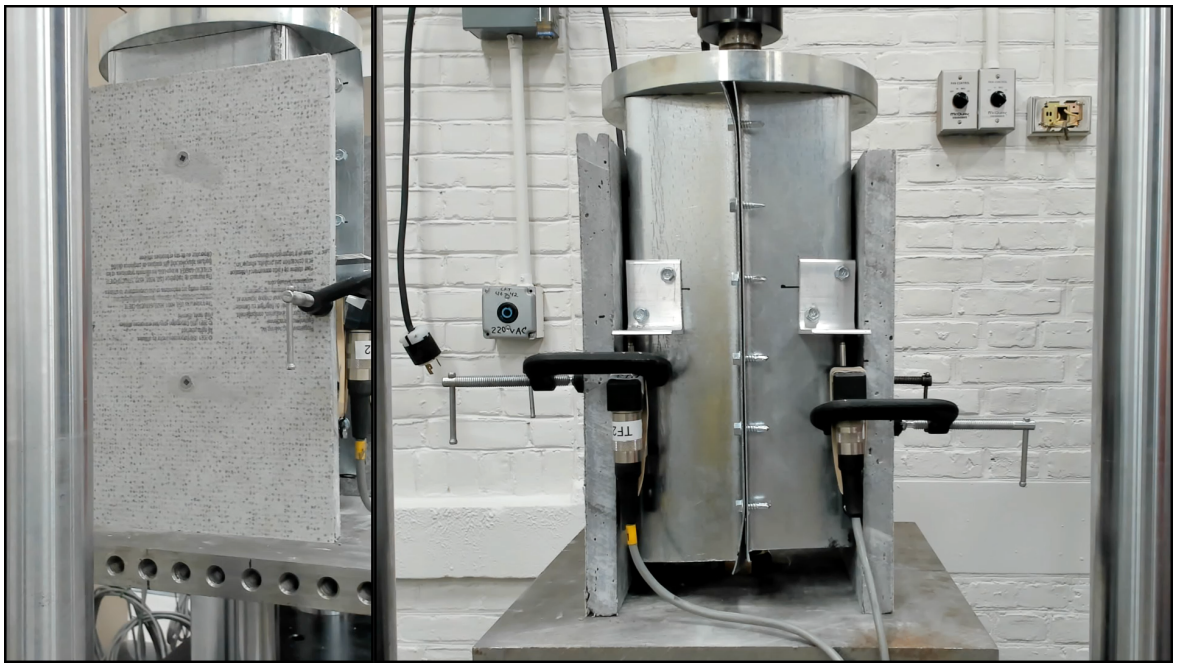
Test #	Ultimate Load (lb)	Stiffness at 40% Ultimate Load (kip/in.)
1	642.3	19.4
2	800.8	25.6
3	853.2	22.1
4	828.7	26.4
5	832.5	27.2
6	690.6	25.7
7	703.9	32.8
Mean	764.6	25.6
CV	10.9%	16.4%

Table 8. Summary of Strength and stiffness for each set of tests

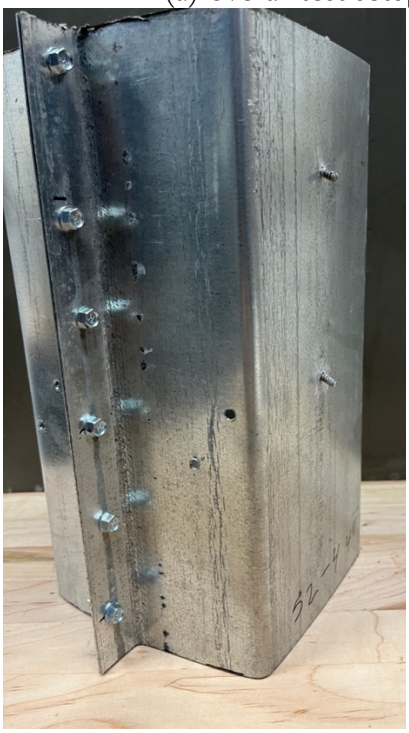
Fastener Spacings	Average Ultimate Load (lb)	Average Stiffness at 40% Ultimate Load (kip/in.)
6 in. Spacing	672.3 [1.00]*	15.5 [1.00]
4 in. Spacing	657.3 [0.97]	15.0 [0.97]
2 in. Spacing	603.6 [0.90]	14.6 [0.94]
1 in. Spacing	683.3 [1.02]	15.7 [1.01]
6 in. Spacing Overdriven	703.9 [1.05]	25.6 [1.65]

*Bracketed numbers are a ratio of the value shown to the equivalent 6 in. spacing value

The overall behavior in the tests is provided in Figure 12. As the panels are pushed up the screws tilt and bear against the cementitious panel and the steel plate. Some minor withdrawal of the head into the panel is also observed. At approximately 0.1 in. of slip the first tilted screw shears. The screw shear generally occurs approximately ¼ in. from the deck to panel interface as shown in Figures 12 (b) and (d). This screw shear location is approximately 1/3rd the depth of the panel.



(a) overall test setup, shown at maximum displacement (note tilting)



(b) post-test, panel removed

(c) typical Grabber #8 fastener

(d) post-test, panel removed, close-up

Figure 12. Observed failure in specimens and fastener detail

8. Discussion

The tested panel-to-deck assembly has relatively high variation in shear strength and stiffness as reported; however, little trend is observed with fastener spacing. Thus, we conclude that strength and stiffness are simply additive, at least for spacing greater than 1 in. apart.

It is not uncommon to find overdriven fasteners in the field. This work shows that over-driving by 1/16 in. is not problematic. In fact, the strength and initial stiffness increase (see Set-5 Table 8), while the decrease in displacement at peak load is only modestly reduced due to overdriving.

Average tested shear capacity of the assembly, per screw, is 655 lb. Grabber reports a nominal shear strength of 1045 lb in shear for their #8 fastener (Grabber product #290 utilized for USG structural panels, see appendix) utilized with USG structural panel. The actual screw shear strength is not reported for this #8, but a similar #8 for cementitious panels (Grabber product #268 utilized for cement board screws self-drilling) reports a nominal screw shear strength of 1694 lb. Thus, the pushout condition in this test setup, appears to be more severe than pure shear. The fastener assembly is depicted in Figure 13. Under relative shear between the panel and the deck, the fastener tilts and must resist shear, bending, and prying action creating tension on the fastener. This is a more detrimental configuration than pure shear, but it is hypothesized that the push out test conditions are better aligned with actual conditions in a prototype floor system; however, further comparisons are needed.

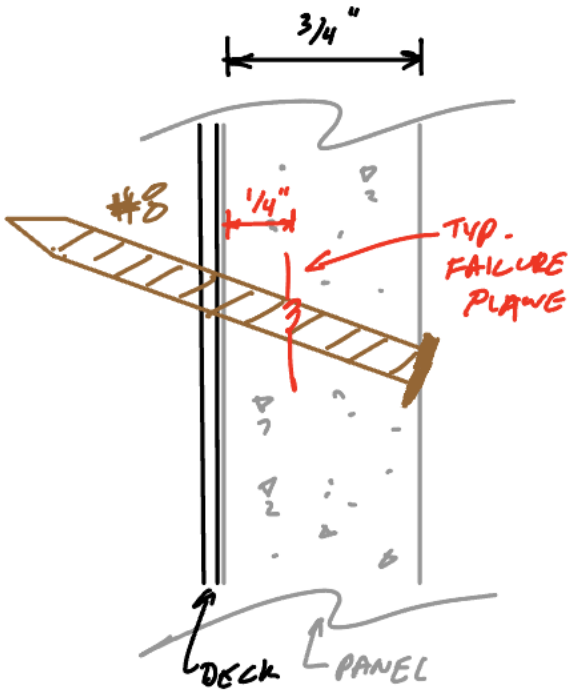


Figure 13. Schematic and postulated freebody diagram for fastener at failure

The results from the testing may be utilized in design methods to assess the degree of realized composite action and provide predictions of flexural strength. This work remains to be done.

9. Conclusions

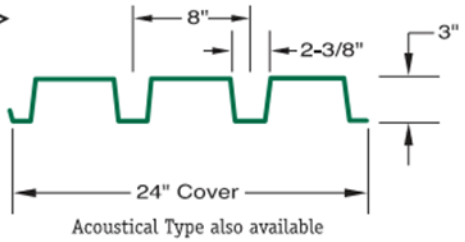
Experimental shear performance for #8 fasteners connecting 3/4 in. cementitious panel to 18 gage deck a measured in a small-scale push-out test are provided. The results are not sensitive to fastener spacing. In the assembly the observed fastener stiffness is approximately 15 kip/in., and fastener strength 655 lb with coefficients of variation of approximately 20% for both stiffness and strength. The results are intended for use in further development of the FastFloor residential prototypes.

10. References

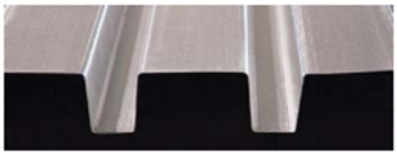
[1] Caswell, H. L., Torabian, S., and Schafer, B. W. (2022). "FastFloor residential testing report." Cold-Formed Steel Research Consortium. http://jhir.library.jhu.edu/handle/1774.2/67741

TYPE "N" ROOF DECK *(LONG SPAN)*

FM APPROVED



Acoustical Type also available



Type "N"

Helpful Hint: Type "N" deck is used when the support spacing exceeds the recommended spacing for "B" type deck.

Type "N Acoustical" (long span perforated)

Section Properties (Fy=33 ksi)

Gage	Design Thickness	Weight (psf) Ptd	Galv	Ip(In^4)	In(In^4)	Sp(In^3)	Sn(In^3)
22	.0295	2.01	2.05	0.6152	0.8158	0.3604	0.4129
20	.0358	2.58	2.65	0.7921	1.0216	0.4748	0.5311
18	.0474	3.20	3.40	1.1625	1.3695	0.7027	0.7502
16	.0598	4.10	4.25	1.5909	1.7448	0.9132	0.958
14	.0747	5.12	5.35	2.126	2.186	1.1704	1.2091
12	.1046	7.17	7.40	3.0732	3.0732	1.6874	1.6923

- Section properties calculated in accordance with AISI specifications

Acoustical Data: Type "N Acoustical"

Absorption Coefficients						NRC
125	250	500	1000	2000	4000	
.20	.30	.68	.81	.46	.38	.55

Gage	Span Cond	Max SDI Const Sp	Uniform Total Load in Pounds Per Square Foot (Dead and Live)										
			9'-0"	9'-6"	10'-0"	10'-6"	11'-0"	11'-6"	12'-0"	12'-6"	13'-0"	13'-6"	14'-0"
22	One	11'-3"	57	51	46	42	38	35	32				
20		12'-9"	76	68	61	55	49	44	40	36	33	31	
18		15'-5"	111	98	85	75	67	59	53	48	44	40	37
16		18'-0"	145	130	113	99	88	78	70	63	57	52	47
14		20'-10"	187	168	148	129	114	101	90	81	73	66	60
12		25'-0"				183	160	141	125	112	101	91	83
22	Two	13'-3"	70	62	56	51	46	42	39	36	33	31	
20		15'-0"	88	79	71	64	59	54	49	45	42	39	36
18		18'-2"	122	109	98	89	81	74	68	63	58	54	50
16		22'-0"	155	139	125	114	103	95	87	80	74	68	64
14		24'-7"	194	174	157	143	130	119	109	101	93	86	80
12		29'-6"				199	182	166	153	141	130	120	112
22	Three or More	13'-3"	87	78	70	64	58	53	49	45	42	38	36
20		15'-0"	110	99	89	81	73	67	62	57	52	49	45
18		18'-2"	152	136	123	112	102	93	85	79	73	67	62
16		22'-0"	194	174	157	142	129	118	109	100	93	86	80
14		24'-7"			197	178	163	149	137	126	116	108	100
12		29'-6"							191	176	162	151	140

Notes:
1. Load tables are calculated using section properties based on the steel design thickness shown in the Steel Deck Institute (SDI) design manual.
2. Loads shown in the shaded areas are governed by the live load deflection not in excess of 1/240 of the span. A dead load of 10 psf has been included.

DACS inc.
900 Port Centre Parkway, Portsmouth, VA 23704
Toll-Free: **866.286.6215** | Fax: 757.393.9461 | dacsinc.com
sdi member

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Figure A1-1. Steel deck datasheet

SURFACE FINISH

Follow the contract documents, floor finish, and roofing system manufacturer's recommendations for the application of finished flooring and roofing systems. Note that most floor finishes will require an underlayment over 3/4" STRUCTO-CRETE® Brand Structural Panels. Before the application of any finishing materials, ensure that all panels are properly fastened, with the fastener head driven flush or slightly below the surface of the panels.

CEILING CONSTRUCTION

For fire- and sound-rated assemblies, the installed ceiling must comply with the UL-listed design and USG recommendations. Follow the contract documents and the ceiling manufacturer's instructions for the ceiling installations. USG Sheetrock® Brand Firecode® C Panels (UL Type C), USG Sheetrock® Brand EcoSmart Panels Firecode® (UL Type ULIX™) or a plaster ceiling should be applied to resilient channels that are fastened to the joists. A drywall or acoustical suspended ceiling system may also be used to enhance sound performance. For a complete list of UL designs visit USGStructuralUL.com or see the *USG Structural Panel Fire and Acoustic Manual* (SCP100).

PRODUCT DATA

Sizes and Packaging: 3/4 in x 4 ft x 8 ft (19 mm x 1,220 mm x 2,440 mm). 3/4" STRUCTO-CRETE® Brand Structural Panels are packaged in 20-piece pallets that each weigh approximately 3,400 lb (1,542 kg) and 14 pallets ship via each flat-bed truckload (12 pallets in Canada).

Product Codes:

Item Number	Product
102038	3/4" STRUCTO-CRETE® Brand Structural Panels T&G - 3/4 in x 4 ft x 8 ft (19 mm x 1,220 mm x 2,440 mm)
102039	3/4" STRUCTO-CRETE® Brand Structural Panels SQ - 3/4 in x 4 ft x 8 ft (19 mm x 1,220 mm x 2,440 mm)

Availability: 3/4" STRUCTO-CRETE® Brand Structural Panels are sold through any distributor that carries USG products. Email usgstructural@usg.com for technical questions, availability and dealers in your area, or search USG Where to Buy for availability near you.

Handling: 3/4" STRUCTO-CRETE® Brand Structural Panels weigh approximately 170 lb (77 kg) and are intended to be handled by two people. Each 20-piece pallet of 3/4 in x 4 ft x 8 ft (19 mm x 1,220 mm x 2,440 mm) 3/4" STRUCTO-CRETE® Brand Structural Panels weigh approximately 3,400 lb (1,542 kg). Do not exceed the destination's capacity when loading full pallets or loose panels on vehicles, trailers, or placing them in storage. Use forklifts which are adequate to carry the pallet load with a minimum rating of 5,000 lb (2,268 kg) and 96 in (2,440 mm) width. Leave a minimum 2 in (50.8 mm) gap between pallet and forklift backrest and always pick the load up from the **groove** side of the pallet to avoid damage to the **tongue** side of the panels.

Storage: 3/4" STRUCTO-CRETE® Brand Structural Panels shall be stored above ground in a dry, ventilated space in a horizontal position and uniformly supported. Stack pallets a maximum of 4 high with a minimum of 4 in (102 mm) clear space around the perimeter of the product on a flat, stable surface capable of supporting the weight of the material.

Jobsite: Pallets are to be stored flat on a stable surface capable of supporting the weight. Stock individual panels flat on risers a maximum 4 ft (1,220 mm) o.c. with end supports within 12 in (305 mm) of panel ends. Individual panels must never be stored in an upright position, on their edges leaning against a wall or other vertical support. Leave pallets banded until panels are ready to be installed. Place full pallet of STRUCTO-CRETE® Brand Structural Panels or other heavy material on top of un-banded unit(s) to be left overnight or for extended period to minimize the potential for panel warp.

Typical Construction Equipment Loads

Equipment	Capacity	Max Weight Allowed
Drywall Cart	10 – 5/8 in x 4 ft x 12 ft Gypsum panels	1,200 lb (544 kg)
	7 – 3/4 in x 4 ft x 8 ft 3/4" STRUCTO-CRETE® Brand Structural Panels	1,200 lb (544 kg)
Rolling Trash Cart		1,000 lb (453 kg)
Rolling Scaffold (Baker)		750 lb (340 kg)

3/4" STRUCTO-CRETE® Brand Structural Panels must be covered when stored in unprotected areas to avoid damage and panels freezing together from excessive moisture and freezing temperatures. If panels become frozen together within a unit, the unit needs to be brought to a temperature above 32°F (0°C) to allow the ice to melt naturally. Salt, fertilizer, other de-icing agents, or direct artificial heat should not be used at any time.

Figure A1-2. Structural panel datasheet 1

PRODUCT DATA

Sizes and Packaging: 3/4" x 4' x 8' (19mm x 1220mm x 2440mm) panels. Each panel weighs approximately 170 lbs. (77kg) and is intended to be handled by two people. USG Structural Panel Concrete Subfloors are packaged in 20 piece units.

Availability: USG Structural Panel Concrete Subfloors are sold through any USG distributor. Email usgstructural@usg.com for information on availability and a dealer in your area.

Storage: USG Structural Panel Concrete Subfloors are shipped in 20 piece units. Panels should be stored in a horizontal position and uniformly supported. Panels must be covered when stored in unprotected areas.

Excessive moisture and freezing temperatures may result in panels sticking together within the units. Therefore, care should be taken to ensure units of USG Structural Panel Concrete Subfloors are not exposed to excessive moisture, ice and snow. In the event that panels do become frozen together within a unit, the unit needs to be brought to a temperature above 32°F (0°C) to allow the ice to melt naturally. Salt, fertilizer or other de-icing agents should not be used at any time. Covering the units completely with tarps or similar coverings is an easy way to avoid panels freezing together.

Maintenance: USG Structural Panel Concrete Subfloors do not require any regular maintenance except to remove standing water and repair damage from abuse. Any cracked or broken panels should be replaced with sound USG Structural Panel Concrete Subfloor that are secured following the fastening schedule prescribed in the original installation documents. The replacement panels must be a minimum of 24" (610mm) wide and must span a minimum of two supports. If not, the replacement panel must be fully blocked on all sides. See *USG Structural Panel Concrete Subfloor Installation Guideline* (form SCP14) for additional information.

TEST DATA

Physical and Mechanical Properties	Test Standard	Approximate Values Standard (Metric)
Moment capacity (3/4" (19mm) thick panel)	ASTM C1185, Sec. 5	1,585 lb-in/ft (588 N-m/m)
Bending stiffness (3/4" (19mm) thick panel)	ASTM C1185, Sec. 5	315,000 lb-in²/ft (3kN-m²/m)
Concentrated load	ASTM E661	550 lbs (2.45 kN) static 0.108" (2.7mm) max. deflection @ 200 lbs (0.89 kN)
Fastener lateral resistance[a]	ASTM D1761, Sec. 10.2	> 210 lbf (0.93 kN) dry > 160 lbf (0.71 kN) wet
Density[b]	ASTM C1185	75 lbs./ft³ (1,201 kg/m³)
Weight at 3/4" (19mm) thickness	ASTM D1037	5.3 lbs./ft² (26 kg/m²)
pH value	ASTM D1293	10.5
Linear variation with change in moisture (25% to 90% relative humidity)	ASTM C1185, Sec. 8	<0.10 %
Thickness swell	ASTM D1037, B	max. 3.0 %
Freeze / thaw resistance	ASTM C1185	Passed (50 cycles)
Mold resistance	ASTM D3273 ASTM G21	10 0
Water absorption[c]	ASTM C1185, Sec. 5.2.3.1	<15.0 %
Noncombustibility	ASTM E136-12 (unmodified) CAN/ULC-S114	Passed Passed
Surface-burning characteristics (flame spread/smoke developed)	ASTM E84 CAN/ULC-S102	0/0
Long-term durability	ASTM C1185, Sec. 13	min. 75% retention of physical properties
Water durability	ASTM C1185, Sec. 5	min. 70% retention of physical properties

(a) Fastener lateral resistance measured with #8, 1-5/8" (41mm) Hi-Low screw.
(b) Density measured at equilibrium conditioning per Section 5.2.3.1., 28 days after manufacturing.
(c) Absorption measured from equilibrium conditioning followed by immersion in water for 48 hours.

Figure A1-3. Structural panel datasheet 2

Ultimate tensile strengths – pullover (tension), lb (kN)[1,2,3,4,5,6,7]

Screw designation	Washer or head diameter in.	Thickness of steel member in contact with the screw head, ga (in.)						
		22 (0.030)	20 (0.036)	18 (0.048)	16 (0.060)	14 (0.075)	12 (0.105)	10 (0.135)
Hex Washer Head (HWH)								
#8	0.335	675 (3.00)	815 (3.63)	1000 (4.45)	1000 (4.45)	1000 (4.45)	1000 (4.45)	1000 (4.45)
#10	0.399	805 (3.58)	970 (4.31)	1290 (5.74)	1370 (6.09)	1370 (6.09)	1370 (6.09)	1370 (6.09)
#12-14	0.415	835 (3.71)	1010 (4.49)	1340 (5.96)	1680 (7.47)	2100 (9.34)	2325 (10.34)	2325 (10.34)
#12-24	0.415	835 (3.71)	1010 (4.49)	1340 (5.96)	1680 (7.47)	2100 (9.34)	2940 (13.08)	3780 (16.81)
1/4 in.	0.500	1010 (4.49)	1220 (5.43)	1620 (7.21)	2030 (9.03)	2530 (11.25)	3540 (13.75)	4560 (20.28)
Phillips Pan Head (PPH)								
#7	0.303	615 (2.74)	735 (3.27)	980 (4.36)	1000 (4.45)	1000 (4.45)	1000 (4.45)	1000 (4.45)
#8	0.311	630 (2.80)	755 (3.36)	1000 (4.45)	1000 (4.45)	1000 (4.45)	1000 (4.45)	1000 (4.45)
#10	0.364	740 (3.29)	885 (3.94)	1180 (5.25)	1370 (6.09)	1370 (6.09)	1370 (6.09)	1370 (6.09)
Phillips Truss Head (PTH)								
#8	0.411	830 (3.69)	1000 (4.45)	1000 (4.45)	1000 (4.45)	1000 (4.45)	1000 (4.45)	1000 (4.45)
#10	0.433	875 (3.89)	1050 (4.67)	1390 (6.18)	1390 (6.18)	1390 (6.18)	1390 (6.18)	1390 (6.18)
Phillips Pancake Head (PPCH)								
#10, #12	0.409	830 (3.69)	995 (4.43)	1325 (5.89)	1370 (6.09)	1370 (6.09)	1370 (6.09)	1370 (6.09)
Phillips Flat Truss Head (PFTH)								
#10	0.364	740 (3.29)	885 (3.94)	1180 (5.25)	1475 (6.56)	1840 (8.18)	2170 (9.65)	2170 (9.65)

1 The lower of the ultimate pullout, pullover, and tension fastener strength of screw should be used for design.
2 Load values based upon calculations done in accordance with Section J4 of the AISI S100.
3 AISI S100 recommends a safety factor of 3.0 be applied for allowable strength design, a Φ factor of 0.5 be applied for LRFD design or a Φ factor of 0.4 be applied for LSD design.
4 ANSI/ASME standard screw head diameters were used in the calculations and are listed in the tables.
5 Phillips Bugle Head (PBH) and Phillips Wafer Head (PWH) styles are not covered by this table because they are not intended for attachment of steel to steel.
6 The load data in the table is based upon sheet steel with F_u = 45 ksi. For F_u = 55 ksi steel, multiply values by 1.22. For F_u = 65 ksi steel, multiply values by 1.44.
7 Refer to Section 3.6.2.5 for drilling capacities.

Nominal ultimate fastener strength of screw

Screw designation	Nominal diameter (in.)	Nominal fastener strength			
		Tension, P_{ts} lb (kN)[1]		Shear, P_{ss} lb (kN)[2,3]	
#6-20	0.138	1000	(4.45)	890	(3.96)
#7-18	0.151	1000	(4.45)	890	(3.96)
#8-18	0.164	1000	(4.45)	1170	(5.20)
#10-12	0.190	2170	(9.65)	1645	(7.32)
#10-16	0.190	1370	(6.09)	1215	(5.40)
#10-18	0.190	1390	(6.18)	1645	(7.32)
#12-14	0.216	2325	(10.34)	1880	(8.36)
#12-24	0.216	3900	(17.35)	2285	(10.16)
1/4 in.	0.250	4580	(20.37)	2440	(10.85)

1 The lower of the ultimate pullout, pullover, and tension fastener strength of screw should be used for design. The Pullout and Pullover tables in this section have already been adjusted where screw strength governs.
2 The lower of the ultimate shear fastener strength and shear bearing should be used for design. The Shear Bearing table in this section has already been adjusted where screw strength governs.
3 AISI S100 recommends a safety factor of 3.0 be applied for allowable strength design, a Φ factor of 0.5 be applied for LRFD design or a Φ factor of 0.4 be applied for LSD design.

Torsional strength[1,2]

Size	Min. torsional strength in-lb (Nm)	
6-20	24	(2.7)
7-18	38	(4.3)
8-18	42	(4.8)
10-12	61	(6.9)
10-16	61	(6.9)
10-18	61	(6.9)
10-24	65	(7.3)
12-14	92	(10.4)
12-24	100	(11.3)
1/4-14	150	(17.0)
1/4-20	156	(17.6)

1 Based on screw only. Does not consider base material limitations.
2 Values in table are ultimate torsional strengths. To obtain maximum setting torque, multiply values in table by 0.66.

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Figure A1-4. Hilti fasteners datasheet

Fastener Drive Bits

Fastener selection is based on several criteria and will affect framing type, framing flange size, minimum end distance for fastener insertion, and driver/drive bit used. Only USG recommended fasteners should be used and must be inserted according to the fastener pattern specified.

Framing Type[1]	Fastener Manufacturer	Fastener Part Number	Fastener Description[3]	Drive Bit Part Number
332 mil (20 ga) CFS	Grabber Construction Products, Inc.	CM10178JBWRG	#10 x 1-7/8" Flat Head DRIVALL® Pilot Point Self-Drilling Screw	T2178LN LOX® #2 (178 mm)[5]
43 mil (18 ga) CFS	Grabber Construction Products, Inc.	CGH8158LG	#8 x 1-5/8" Winged Flat WaferHead Self-Drilling Screw	T2178LN LOX® #2 (178 mm)[5]
54 mil (16 ga) — 97 mil (12 ga) CFS	Grabber Construction Products, Inc.	CGH8158LG	#8 x 1-5/8" Winged Flat WaferHead Self-Drilling Screw	T2178LN LOX® #2 (178 mm)[5]
	Simpson Strong-Tie Company, Inc.	CBSDQ158S	#8 x 1-5/8" Winged Self-Drilling Screw	BIT2SU #2 (Undersized sq.)
1/4" (6.4 mm) A36 HRS"	Grabber Construction Products, Inc.	CC12250LRG	#12 x 2-1/2", Winged Self-Drilling Screw	T3178LN LOX® #3 (178 mm)[6]
	Simpson Strong-Tie Company, Inc.	TBG1260S	#12 x 2-3/8", Flat Head, Strong-Drive® TB Wood-to-Steel Screw	BIT3SU #3 (Undersized sq.)
	Muro North America, Inc.	RSM645WFL-GY	M6.0 x 45 mm Winged Self-Drilling Screw	#3 SQ
1/8 in (3.2 mm) — 1/2 in (13 mm) A36 HRS	Aerosmith® Fastening	5324HPG	0.145 x 1-1/4" Helical PowerPin®	Tool Setting and Load will vary based on steel thickness and hardness
	DeWalt - Engineered by Powers, Inc.	50458-PWR	0.157 in x 1-1/4" CSI Spiral Drive Powder Actuated Pin	
	Hilti, Inc	X-U 32 MX	0.157 in x 1-1/4" Knurled Shank Powder Actuated Fastener	
SPF Lumber	Grabber Construction Products, Inc.	C8200L2M	#8 x 2", Flat Head, Type 17, Nibs, GrabberGard®	T2178LN LOX® #2 (178 mm)[5]
	SENCO Brands, Inc.	GL24AABF	8d Ring Shank Nails[4]	N/A

Table Notes:

1. **CFS** = cold-formed structural steel **HRS** = hot-rolled structural steel **Lumber** = specific gravity 0.42 or greater.
   Gauge/thickness of steel, fastener end distance, and joist flange width is identified for each fastener and are minimums. Framing gauge, size, and type is determined by the engineer, architect, or design professional.
2. 33 mil (structural 20 ga) is for gravity loads only.
3. Any length of the same fastener is approved provided a minimum of 3 threads penetrate the steel framing.
4. SENCO 8d ring shank nails are manufactured with a length of 2-3/8 in., head diameter of 0.266 in. and a shank diameter of 0.113 in. Equivalent 8d ring shank nails meeting these dimensional requirements may be utilized when approved by the engineer or designer of record.
5. Grabber SuperDrive® 75 uses the 178mm LOX® #2 drive bit. They also offer a 3" LOX® #2 drive bit for hand held drill use, Part # 3002L.
6. Grabber SuperDrive® 75 uses the 178mm LOX® #3 drive bit. They also offer a 3" LOX® #3 drive bit for drill use, Part # 3003L.

General Note:
In accordance with PER-13067 (Subfloor) and PER-14076 (Roof Deck), the minimum screw pattern is 6 in. (153 mm) o.c. along the perimeter and 12 in. (305 mm) o.c. in the field of the panels. Refer to PER-15092 for Foundation Wall fastener schedules.

Made in Delavan, WI, USA

A qualified architect or engineer should review and approve calculations, framing, and fastener spacing for all projects.

PRODUCT INFORMATION
See usg.com for the most up-to-date product information.

DANGER
The following are warnings when installing the panels: Causes skin irritation. Causes serious eye damage. May cause an allergic skin reaction. May cause respiratory irritation. May cause cancer by inhalation of respirable crystalline silica. Do not handle until all safety precautions have been read and understood. Avoid breathing dust. Use only in a well-ventilated area, wear a NIOSH/MSHA approved respirator. Wear protective gloves/ protective clothing/eye protection. If swallowed, inhaled, or skin irritation occurs get medical attention. If on skin: Wash with plenty of water. If in eyes: Rinse cautiously with water for several minutes. Remove contact lenses and continue rinsing. Wash contaminated clothing before reuse. Dispose of in accordance with local, state, and federal regulations. For more information call Product Safety: 800 507-8899 or see the SDS at usg.com
KEEP OUT OF REACH OF CHILDREN.

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SAFETY FIRST!
Follow good safety/industrial hygiene practices during installation. Wear appropriate personal protective equipment. Read SDS and literature before specification and installation.

800 USG.4YOU
800 (874-4968)
usg.com/structocrete

Manufactured by
United States Gypsum Company
550 W Adams Street
Chicago, IL 60661

3/4" STRUCTO-CRETE® Brand Structural Panels MSRP based upon full truckload delivered to jobsite:
Subfloor: $5.10/sf
Roof Deck: $6.00/sf
Xtra Strength: $6.00/sf

SCP297287-USA-ENG/6-22
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IT'S YOUR WORLD. BUILD IT.®

Figure A1-5. Grabber® fasteners datasheet from USG

GRABBER CONSTRUCTION PRODUCTS

"The Professional's Choice"™

Cement Board

Product #290

GRABBER® USG® Structural Panel fastener (1 OF 2)

Designed for USG Structural Panels.

Finish - GRABBERGARD

Wafer Head

Drill Point

LOX #2

APPLICATIONS

- For attachment of sheathing, siding, OSB or plywood to steel.

PRODUCT FEATURES

- The USG Structural Panel screw has "reamer nibs" under the head to ease countersinking and leave smooth clean edges.
- Wings allow the screw to drill into the metal without clogging the threads and racking/lifting the material before it penetrates through the metal.

SPECIFICATIONS

- Gauge - #8
- Length – 1-1/4" to 2-3/8"
- Head Type – Thin Wafer
- Recess Type – LOX® #2
- Thread Type – Single Lead
- Finish –GRABBERGARD
- Head diameter - .362 inch
- GRABBER screws are manufactured in an ISO 9001 and ISO 14001 certified and approved factory, and are approved by ICC ESR report ESR-4223.

INSTALLATION GUIDELINES

- Use a standard screwgun with a depth-sensitive nose piece. Suggested screwgun specification for optimal performance – 4 amps minimum and RPM range of 0 to 4,000.
- Proper depth setting is paramount in this application.
- Overdriving may result in failure of the fastener or stripout of the work surface.
- The fastener must penetrate beyond the metal a minimum of three thread pitches.

Figure A1-6. Grabber® fasteners datasheet (1of 2)

GRABBER CONSTRUCTION PRODUCTS

"The Professional's Choice"™

Cement Board

Product #290

GRABBER® USG® Structural Panel fastener (2 OF 2)

PRODUCT SIZES AND ORDERING INFORMATION

Catalog No.	Gauge/Length	Length Metric	Quantity Per Carton	Weight Per Carton
CGH8114LG	#8x1-1/4"	32 mm	1 M	
CGH8158LG	#8x1-5/8"	41 mm	1 M	
CGH8238LG	#8x2-3/8"	63 mm	1 M	
GH8114LG	#8x1-1/4"	32 mm	5 M	32.00(lbs)
GH8158LG	#8x1-5/8"	41 mm	4 M	30.00(lbs)
GH8238LG	#8x2-3/8"	63 mm	3 M	30.00(lbs)

*Collated screw packaging option available on selected items.

PRODUCT DIMENSIONS (MILLIMETERS)

Gauge	B Head Dia	Recess Depth	W Gauging Width	d Shank Dia	d1 Minor Dia	d2 Major Dia	TPI
#8	7.77	1.80	#2	3.28	2.85	4.05	18
	8.18	2.46		3.32	3.05	4.25	

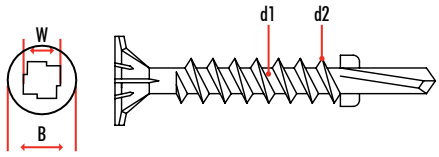
STANDARD CORROSION TEST RESULTS

Finish	Test	Standard/Protocol	Results
GRABBERGARD	Salt Spray Results	ASTM B117	1,000 hours, no red rust
GRABBERGARD	Kesternich Results	DIN 50018, 2.0L	15 cycles, no red rust

Pull-out and Shear Test Data**

Screw Gauge	Metal Gauge	Tension (lbs.)	Shear (lbs.)
#8	14	450	1012
	16	442	955
	18	340	1045

**GRABBER fasteners are not categorized as structural bolts. The figures listed above are ultimate average values achieved under independent laboratory conditions, and apply to GRABBER Line fasteners only. An appropriate safety factor must be determined by a qualified professional for design purposes.



DRILLING CAPACITY

Screw Gauge	Drill Point	Max Panel Thickness	Steel Thickness Gauge Range
8	3	0.100-0.140	20-12

All GRABBER® screw products are manufactured in facilities that are ISO 9001 certified. The fasteners comply with ASTM C1513 and are listed in ICC ESR-4223. ©2012 GRABBER Construction Products, Inc. GRABBER®, STREAKER®, DRIVALL®, LOX®, GRABBERGARD® and SCAVENGER® are registered trademarks of Grabber Construction Products, Inc.

Figure A1-7. Grabber® fasteners datasheet (2 of 2)