Progressive Engineering Inc.

AEROSMITH FASTENING SYSTEMS

Allowable Shear Capacity Thru FPIS
Using Aerosmith 2635SBG Pneumatic Pins
With R-9 ZIP System® R-Sheathing to 54-mil Steel Framing

12/15/2020

Revised on

1/12/2021 - Added ASTM E8 steel stud tensile data and pin verifications (pages 20 through 23). Updated Section 7, 8, 10 and long-term weight information on Page 9, added drawing on page 11.

2020-6266

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1. TITLE

Allowable Shear Capacity Thru FPIS Using Aerosmith 2635SBG Pneumatic Pins With R-9 ZIP System® R-Sheathing to 54-mil Steel Framing

2. OBJECTIVE

To determine the allowable shear capacity of the Aerosmith 2635SBG pin when used to attach R-9 ZIP System® R-Sheathing to 54 mil steel framing, in order to establish the minimum fastening requirements to support various cladding weight. The testing will utilize the procedures defined in ABTG Research Report No. 1503-02 for both short-term loading and long-term loading.

3. TESTED FOR

Aerosmith Fastening Systems
5621 Dividend Road
Indianapolis, IN 46241

4. TESTING ORGANIZATION

Progressive Engineering Inc.

58640 State Road 15
Goshen, IN 46528
www.p-e-i.com

See IAS Evaluation Report TL-178 for ISO 17025 Accreditation

5. TESTING PERSONNEL

Director of Testing	- Jason R. Holdeman
Project Manager	- Jacob Bontrager

6. REFERENCE STANDARDS

ASTM D1761-12 - Standard Test Methods for Mechanical Fasteners in Wood

ABTG Research Report No. 1503-02 - Attachment of Exterior Wall Coverings Through Foam Plastic Insulating Sheathing (FPIS) to Wood or Steel Framing, Updated: August 16, 2018.
See Appendix section of this report for a copy of this document.

7. TESTING EQUIPMENT

A. Tinius Olsen Tension/Compression Machine (PEI No. 144)
B. Digital Micrometer with .00005" Graduations (PEI No. 1082)
C. Digital Calipers with .0005" Graduations (PEI No. 1004)
D. Data Acquisition System (PEI No. 566)
E. Load Cell (PEI No. 873)
F. LVDT (PEI Nos: 1083 & 1200)
G. 1" Dial Indicators (PEI No's 655, 658, 660)
H. Universal Test Machine (PEI No. 1160)

8. TEST SPECIMEN

A. Sheathing

ZIP System® R-Sheathing Type R-9 - Sheathing consisted of a green-faced 7/16" ZIP System Wall Sheathing with 1-1/2" rigid foam insulation board bonded to the back surface for an overall thickness of 2". The insulation board had a fiberglass skin attached to both faces. The sheathing material was provided to PEI by Huber Engineered Woods, LLC cut to the appropriate size. See ICC-ES Evaluation Report No. ESR-3373 and the Appendix of this report for more details.

B. Framing

Steel Stud - 362S162 - 54, 50 ksi studs manufactured by ClarkDietrich. Actual measured yield strength was 55.9 ksi.

C. Fasteners

Aerosmith Pin No. 2635SBG, a 0.100" x 2-1/2" Grip Shank Pin, PT 2000 Plated, with an average measured shank diameter of 0.107" and an average head diameter of 0.306". Lot No. 21367. Aerosmith brought a new unopened box of pins for this testing.

See the Appendix Section for Pin and Steel verification.

9. TEST SPECIMEN CONDITIONING

All test materials were conditioned at lab ambient for at least 1 day prior to testing.

10. TEST SPECIMEN CONSTRUCTION

The samples were constructed by Aerosmith and PEI personnel as directed by the appropriate test standard.

A. Short-Term Load Testing

1. Three (3) pieces of 12" x 16" sheathing material were selected. Additionally, the steel studs were cut to 16" lengths.

2. Three (3) 5/8" holes were drilled thru one stud flange, approximately 1-1/2" in from the ends and near the center for connection points to the test fixture.

3. The steel stud was set on its flange in a test jig and the sheathing was positioned over the opposite flange with the sheathing centered on the flange and set flush with the ends of the stud. A short section of stud was set on each side of the in the test jig to prevent the sheathing from tipping or shifting during fastener installation.

4. Spencer Jessee with Aerosmith Fastening Systems installed a total of two (2) pins per sample, using the FCN90 pneumatic gun and high pressure compressor settings, between 120 and 130 psi, that provided a proper depth of drive resulting in the fastener head tight to the sheathing surface. The fasteners were inset 4" from the edge of the sheathing.

B. Long-Term Load Testing

1. Three (3) pieces of 12" x 16" sheathing material were selected. Additionally, the steel studs were cut to 20" lengths. The studs were cut longer to extend 4" from one edge of the sheathing for dial indicator placement.

2. Two (2) 5/8" holes were drilled thru one stud flange, approximately 1-1/2" in from one end and 5-1/2" in from the other end for connection points to the test fixture.

3. The steel stud was set on its flange in a test jig and the sheathing was positioned over the opposite flange with the sheathing centered on the flange and set flush with the ends of the stud. A short section of stud was set on each side of the in the test jig to prevent the sheathing from tipping or shifting during fastener installation.

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5. Two (2) 20 ga. steel studs were used as weight hangers and were fastened to the face of the sheathing with minimum fastener pentration into the foam. The hangers were aligned and the holes were predrilled and the hangers were fitted for proper alignment and then removed for the test setup.

See attached photographs for details.

11. TEST SET-UP

A. Short-Term Load Testing

The test was performed in a Tinius Olsen test machine on the compression side of the fixed crosshead. The sample was placed into a test fixture on the lower platen the stud oriented vertically. The bottom of the stud rested on a rigid steel plate and the stud flange was bolted to the test fixture at the three (3) predrilled hole locations. The bottom of the foam and sheathing was unsupported. A short steel angle was fastened to the face of the sample, using 1/2" long screws, for deflection measurement. One (1) LVDT was set on the lower platen under the angle, parallel with the long-axis of the stud and inline with the two (2) fasteners into the sheathing to measure the sheathing movement relative to the lower platen. A short steel angle was then fastened to the stud web. A second LVDT was set over the angle, parallel with the long-axis of the stud, to measure any stud or fixture movement relative to the lower platen that will later be subtracted from the sheathing movement to derive the net sheathing displacement.

A 12" long steel angle was set over the top of the sheathing to provide a solid loading surface. The load button on a compression load cell was positioned inline with the vertical line passing through the sheathing fasteners and inset approximately 1/2" from the face of the OSB. The load cell was connected to the fixed crosshead on the test machine.

B. Long-Term Load Testing

A free standing lumber frame was constructed for each sample. The steel stud was bolted to the frame at the two (2) predrilled locations, such that the stud was oriented vertically with the 4" extended section on top. The bottom of the stud rested on a rigid supporting surface. The bottom of the foam and sheathing was unsupported. A dial indicator was then connected to the extended stud and set over the OSB sheathing to measure the sheathing movement relative to the stud. A steel plate was set over the OSB under the dial indicator tip. The testing was performed in a temperature controlled laboratory.

12. TEST PROCEDURE

A. Short-Term Load Testing

Testing was performed in accordance with the ABTG Research Report No. 1503-02. The data acquisition was started, and the specimen was loaded thru the top edge of the sheathing at an approximate rate of 0.20" per minute until a failure was attained, which resulted in no further gain in load. The load and displacement was recorded for the duration of the test, along with a detailed description of the failure.

B. Long-Term Load Testing

Testing was performed in accordance with the ABTG Research Report No. 1503-02. Each of the three (3) samples received a differing amount of weight based on the design load calculated from the short-term load tests. The load was set at 75%, 100% and 125% of the design load. The combined weight of the hanger studs, fasteners, washers, weight bar, and weights was measured for each assembly and adjusted until the target weight was achieved. The dial indicator reading was taken and then the weight was applied to each sample and then a second reading was recorded. The dial indicators were then read daily, with the exception of weekends, until the movement stabilized or 3 months elapsed.

13. TEST RESULTS

Short-Term Load Tests

Sample Identification	Steel Framing	Fastener	Sheathing	Average Load at 0.015"	Average Ultimate Load	Allowable Shear Capacity[1]
Short-Term	54 mil	Two (2) 2635SBG Pins	R-9 ZIP System R-Sheathing	22 lbf	692 lbf	11 lbf

1. The Allowable Shear Capacity is defined by ABTG as the lesser of the average load at 0.015" or the ultimate load divided by a safety factor of 5. This test used two (2) fasteners so the shear capacity is half of the test loads.

Long-Term Load Tests

Sample Identification	Steel Framing	Fastener	Sheathing	Total Slip at End of Test	Test Termination Type	Test Result[2]
75% D.L.	54 mil	Two (2) 2635SBG Pins	R-9 ZIP System R-Sheathing	0.003"	No Tertiary Creep	PASS
100% D.L.	54 mil			0.010"	No Tertiary Creep	PASS
125% D.L.	54 mil			0.012"	No Tertiary Creep	PASS

2. The Long-Term Aging is defined by ABTG as a pass if the total deflection does not exceed 1/8" at the end of the test and the deflection contribution in the last month does not exceed 1/32".

See attached data pages for individual test details.

14. CONCLUSION

Based on the testing performed and the qualification method defined in ABTG Research Report No. 1503-02 an Allowable Shear Capacity for the Aerosmith Pin Part No. 2635SBG and R-9 ZIP System® R-Sheathing over 54 mil steel framing is **11 lbf per fastener**.

The table below provides the allowable cladding weight that can be applied to this system, using the calculation methods found in the previously mentioned ABTG report. The calculation is based on the maximum tributary area for each fastener spacing shown, the field fasteners. The weight of the R-9 ZIP System® R-Sheathing was subtracted from the cladding weight. The cladding connection to the ZIP System is outside the scope of this report.

ZIP Panel Fastener Schedule		Stud Spacing / Allowable Cladding Weight		
Perimeter	**Field**	**12"**	**16"**	**24"**
4"	12"	31.2 psf	22.9 psf	14.7 psf
6"	12"	20.2 psf	14.7 psf	9.2 psf
8"	12"	14.7 psf	10.5 psf	6.4 psf
12"	12"	9.2 psf	6.4 psf	3.7 psf

Progressive Engineering Inc.

Allowable Shear Capacity for Connections through FPIS

Date: 11/16/2020
Client: Aerosmith Fastening Systems
Test: ASTM D1761 Shear Testing
Specimen: ZIP System

Temp.: 71 °F
Humidity: 25% R.H.
Load Rate: 0.20" per minute

Specimen Construction

Sheathing: 7/16" ZIP Panel Sheathing
Fastener: (2) 2635SBG Flat Wire Grip Shank PT 2000 Plated 0.100" x 2-1/2"
Foam: 1-1/2" Thick
Framing: 16 Gauge Steel (54 mil)

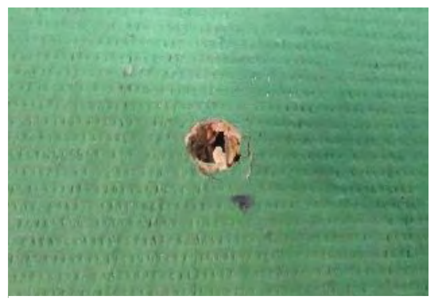
Test Results

Sample	Maximum Load (lbf)	Deflection at Max. Load	Load (lbf) at:				Failure Mode
			.015" Defl.	.125" Defl.	.250" Defl.	.375" Defl.	
1	659	1.075"	19	49	86	159	1
2	559	.771"	20	88	162	249	1
3	857	1.082"	26	77	138	219	1
Average	692	.976"	22	71	129	209	
COV	*22%*	*18%*	*16%*	*28%*	*30%*	*22%*	

1. The foam compressed into the stud around 400 lbf to 500 lbf with fastener rotation/bending in the foam and framing with OSB pull-over starting.

Test Setup

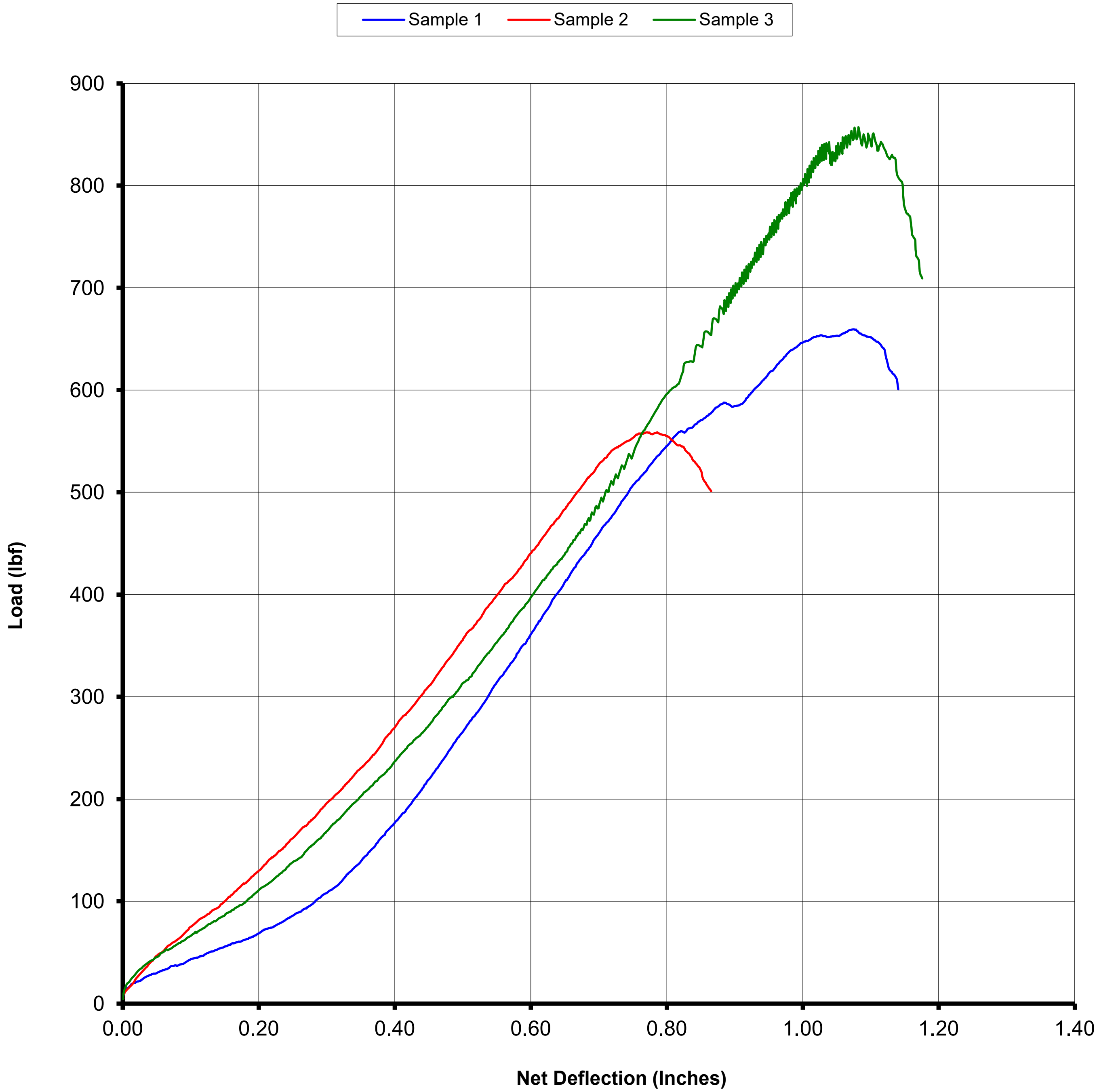
Test Setup



Failure

Progressive Engineering Inc.

Aerosmith Fastening Systems
Short-Term Loading for
Allowable Shear Capacity of 2635SBG Pins
for ZIP System R-Sheathing to 54-mil Steel Framing
Load versus Deflection



Progressive Engineering Inc.

Allowable Shear Capacity (Long-Term Loading)

Date: 11/16/2020
Client: Aerosmith Fastening Systems
Test: Long-Term Loading
Specimen: ZIP System

Specimen Construction

Sheathing: 7/16" ZIP Panel Sheathing
Fastener: (2) 2635SBG Flat Wire Grip Shank PT 2000 Plated 0.100" x 2-1/2"
Foam: 1-1/2" Thick
Framing: 16 Gauge Steel (54 mil)

Allowable Shear Capacity per Fastener:	11 lb

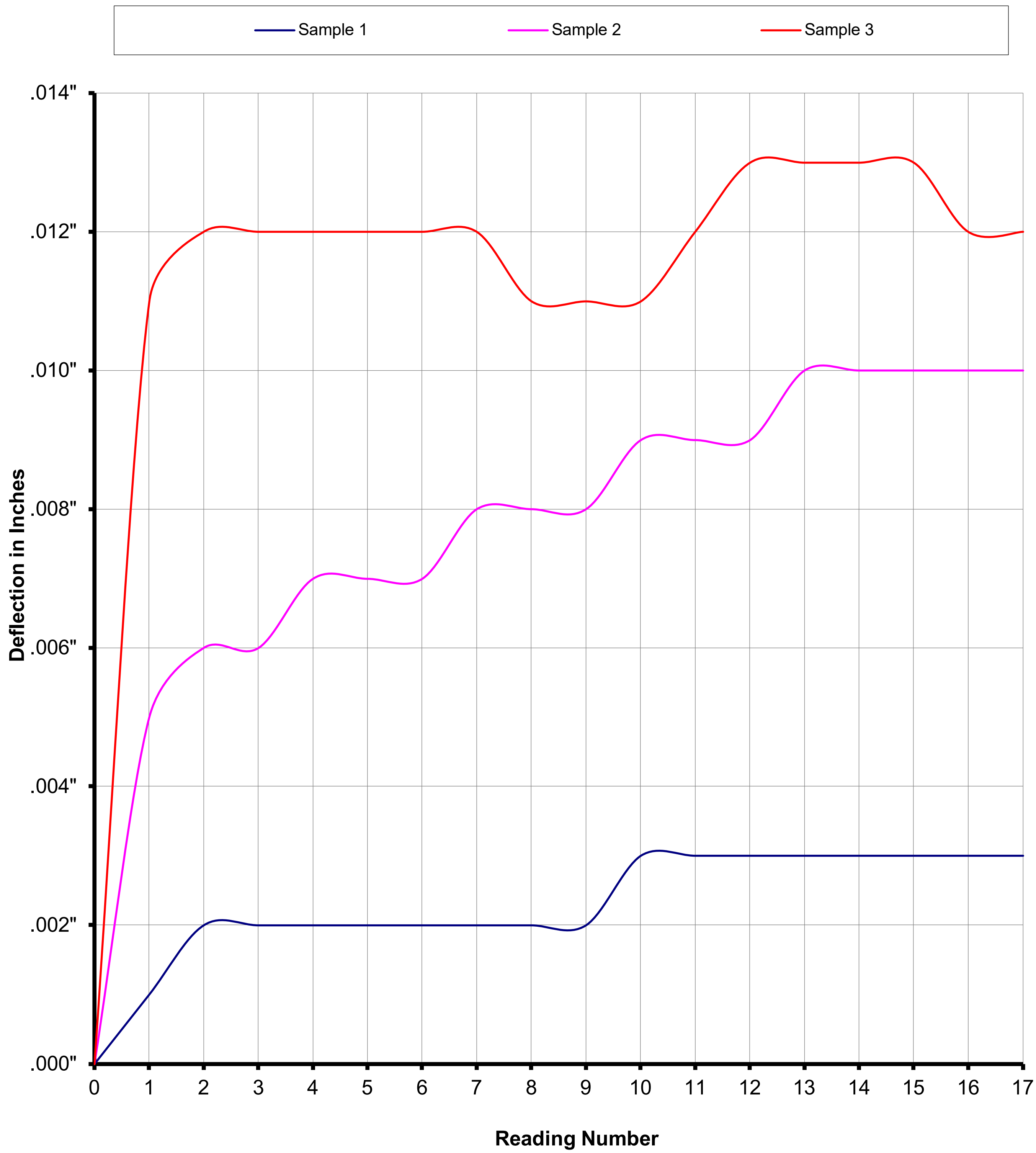
Percent of Capacity:	75%	100%	125%
Total Weight Applied to Sample:	16.570 lb	22.175 lb	27.625 lb

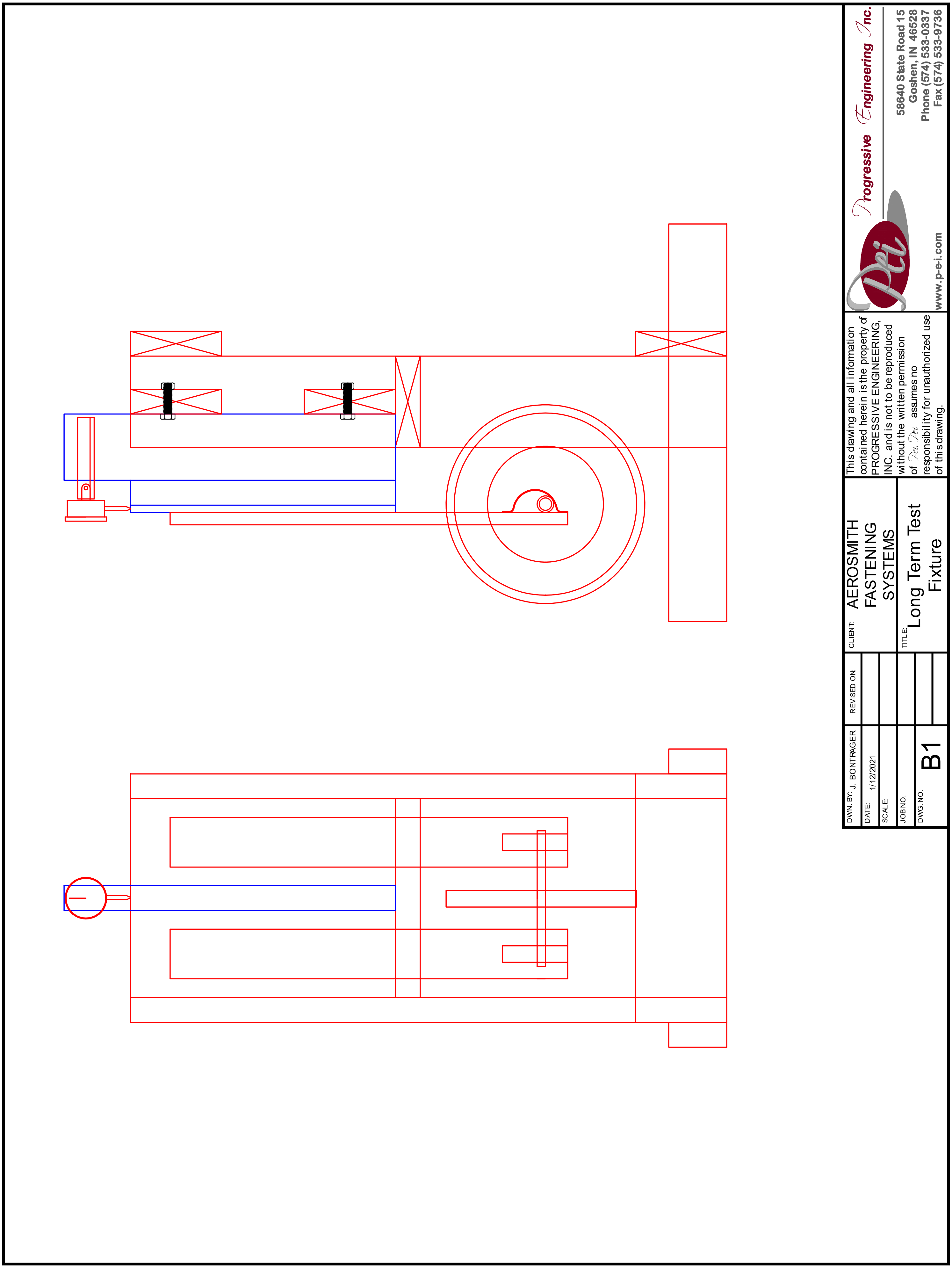
Date	Time	Reading No.	Temp. °F	RH %	Sample 1 Read	Sample 1 Defl	Sample 2 Read	Sample 2 Defl	Sample 3 Read	Sample 3 Defl
11/19/20	7:25	0	74	67	.665"	---	.751"	---	.709"	---
11/19/20	7:37	1	74	67	.664"	.001"	.746"	.005"	.698"	.011"
11/20/20	15:55	2	76	61	.663"	.002"	.745"	.006"	.697"	.012"
11/20/20	23:43	3	76	60	.663"	.002"	.745"	.006"	.697"	.012"
11/23/20	8:08	4	76	63	.663"	.002"	.744"	.007"	.697"	.012"
11/23/20	7:50	5	71	66	.663"	.002"	.744"	.007"	.697"	.012"
11/24/20	7:46	6	76	57	.663"	.002"	.744"	.007"	.697"	.012"
11/25/20	8:15	7	71	63	.663"	.002"	.743"	.008"	.697"	.012"
11/30/20	8:05	8	70	66	.663"	.002"	.743"	.008"	.698"	.011"
12/1/20	8:11	9	66	58	.663"	.002"	.743"	.008"	.698"	.011"
12/3/20	7:45	10	68	58	.662"	.003"	.742"	.009"	.698"	.011"
12/4/20	7:59	11	71	67	.662"	.003"	.742"	.009"	.697"	.012"
12/7/20	7:37	12	68	62	.662"	.003"	.742"	.009"	.696"	.013"
12/9/20	7:23	13	67	62	.662"	.003"	.741"	.010"	.696"	.013"
12/10/20	7:14	14	67	51	.662"	.003"	.741"	.010"	.696"	.013"
12/11/20	7:41	15	68	45	.662"	.003"	.741"	.010"	.696"	.013"
12/14/20	7:25	16	67	48	.662"	.003"	.741"	.010"	.697"	.012"
12/15/20	11:55	17	74	37	.662"	.003"	.741"	.010"	.697"	.012"

Comments / Observations

Test was concluded early due stabilized deflections for all three (3) samples.

Aerosmith Fastening Systems
Long-Term Loading for
Allowable Shear Capacity of 2635SBG Pins
for ZIP System R-Sheathing to 54-mil Steel Framing
Load versus Deflection




DWN. BY: J. BONTRAGER
DATE: 1/12/2021
SCALE:
JOB NO.
DWG. NO. B1
REVISED ON:
CLIENT: AEROSMITH FASTENING SYSTEMS
TITLE: Long Term Test Fixture
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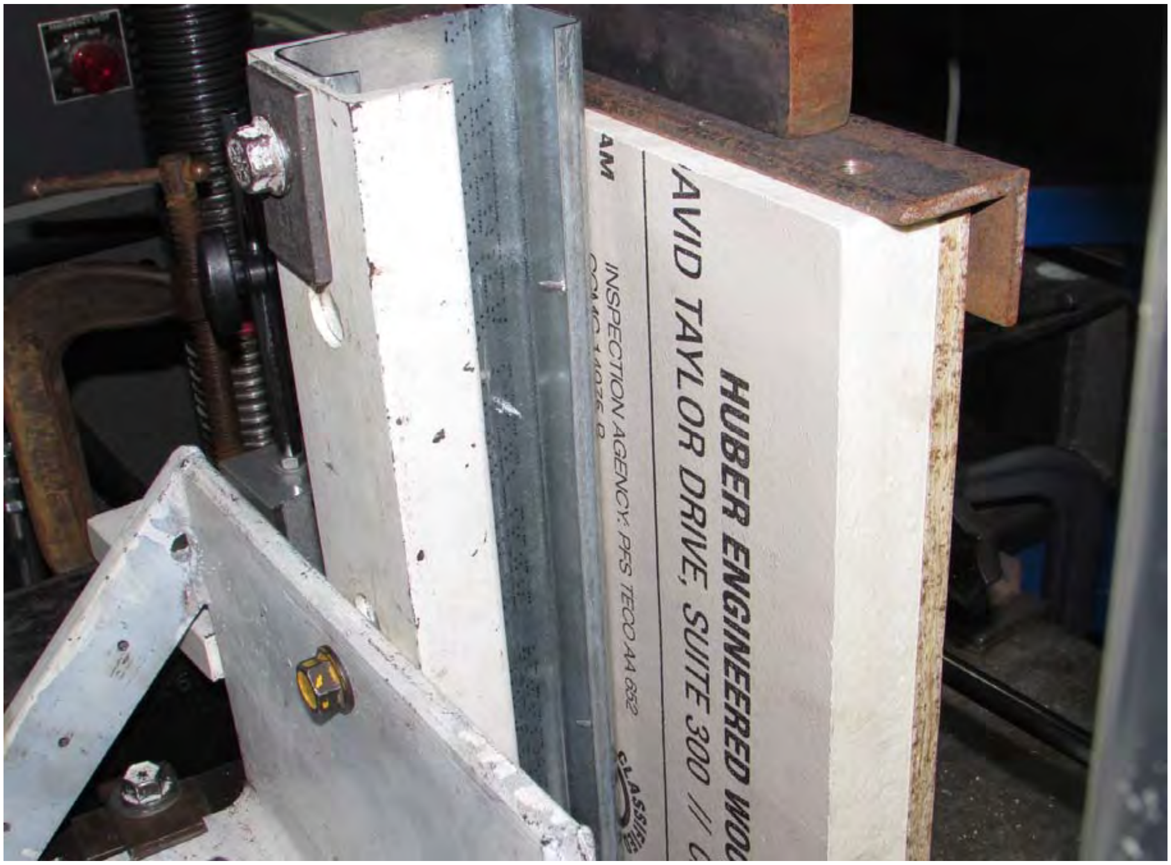
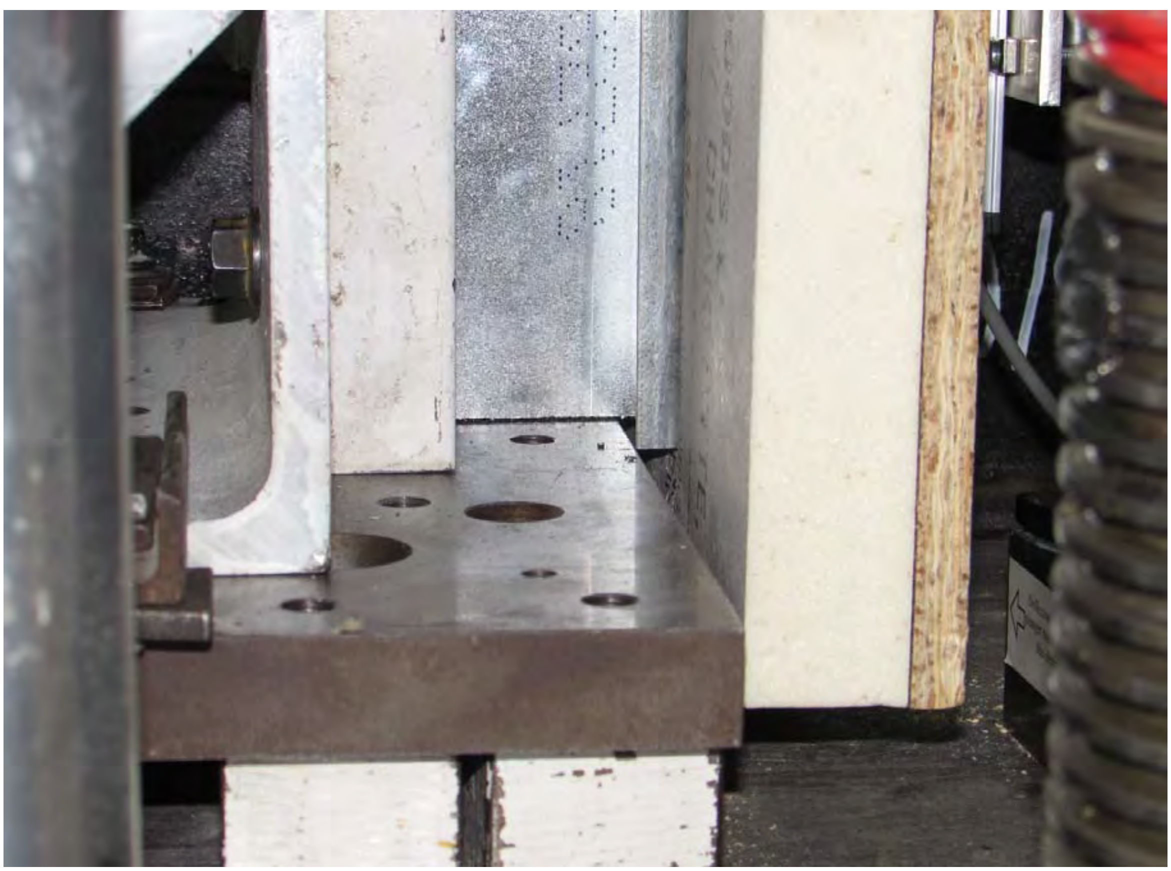
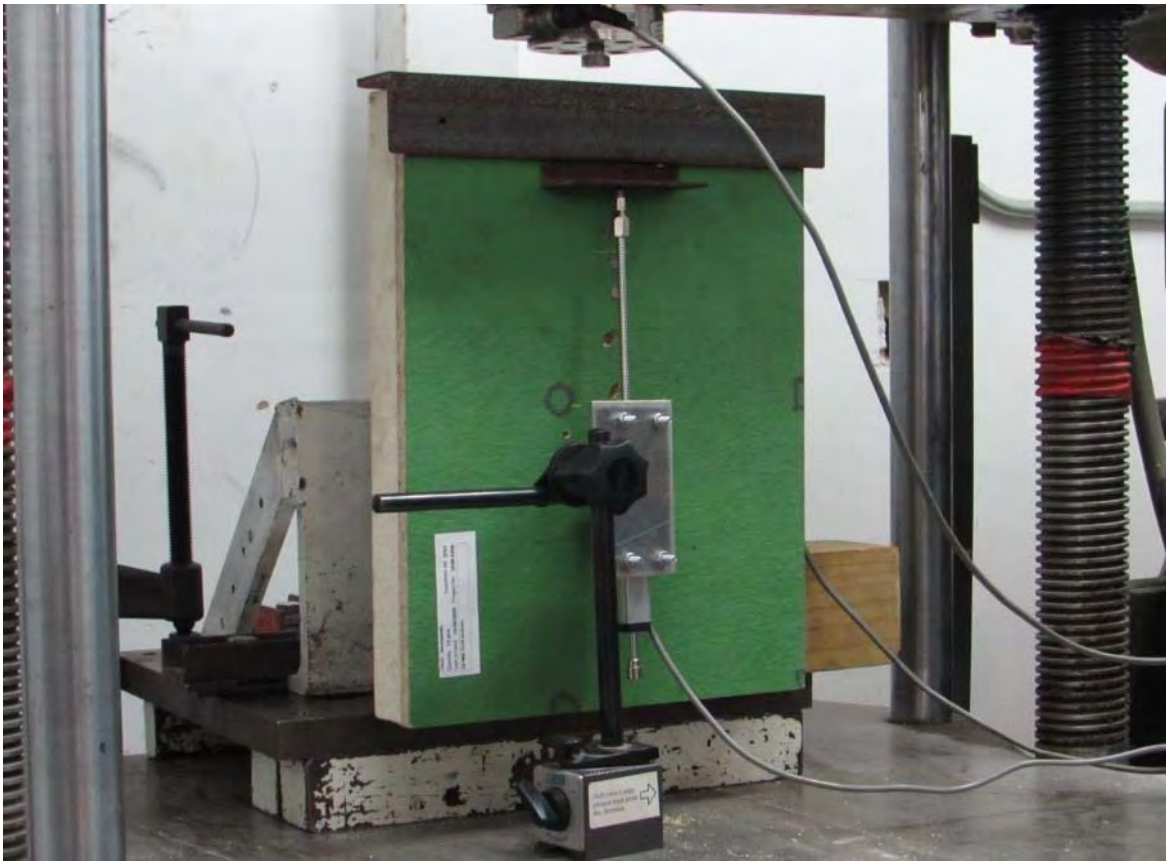


Test Setup Side View - Load distributed along top of ZIP Panel

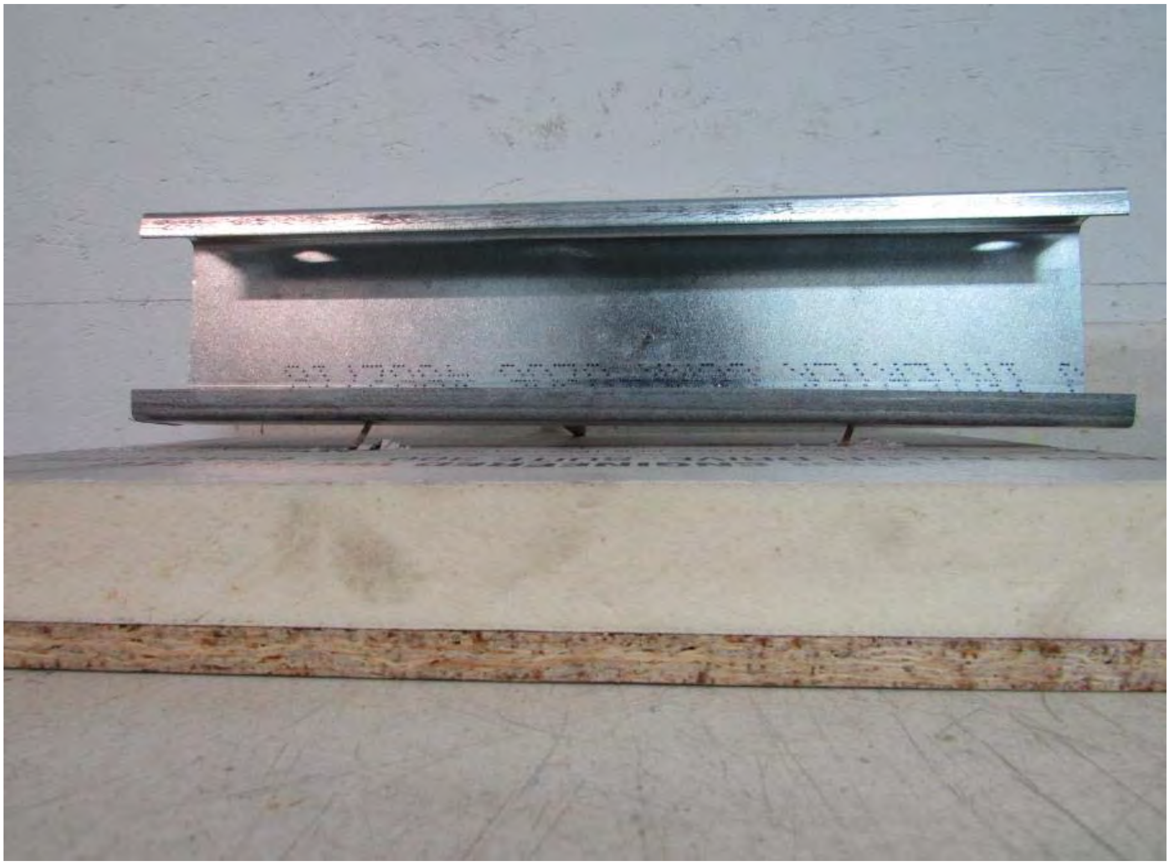


Test Setup Side View - Framing Supported, ZIP Panel Unsupported

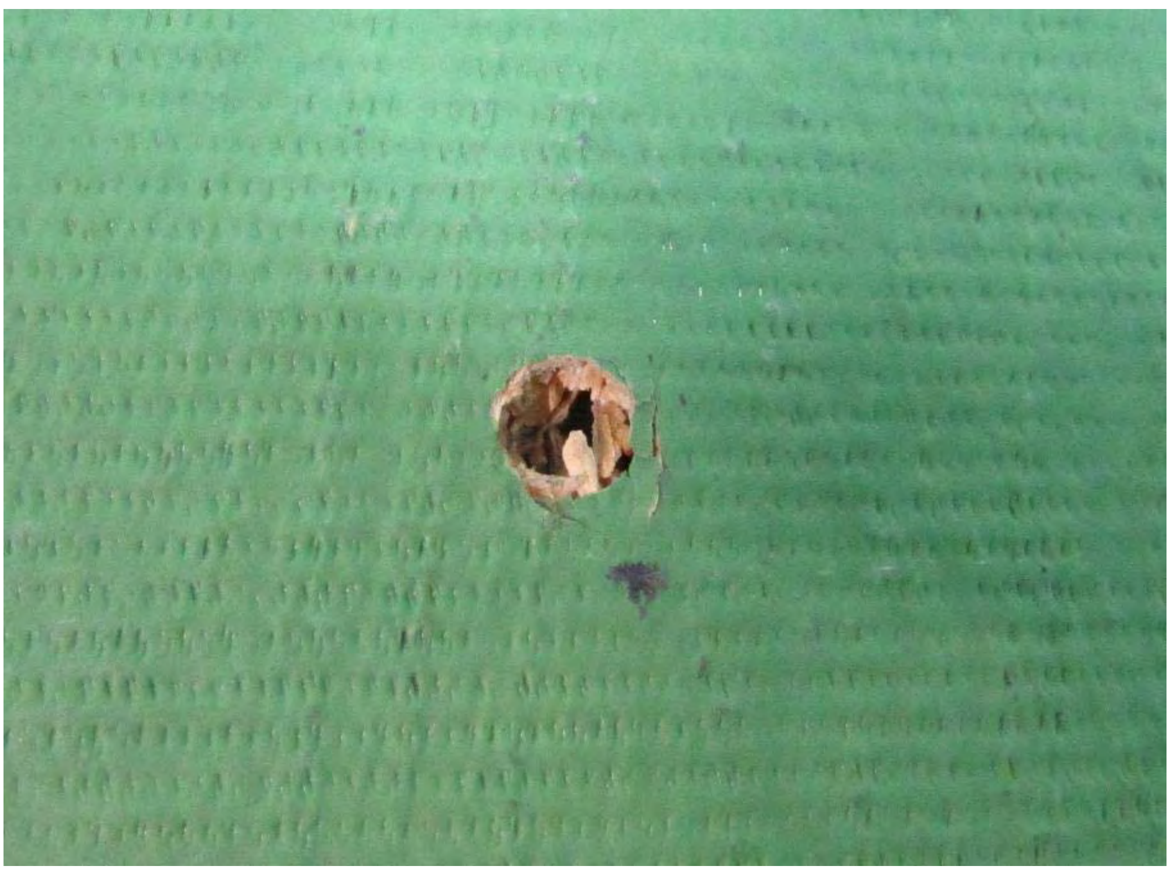


Typical Allowable Shear Capacity for Connections through FPIS Test Setup

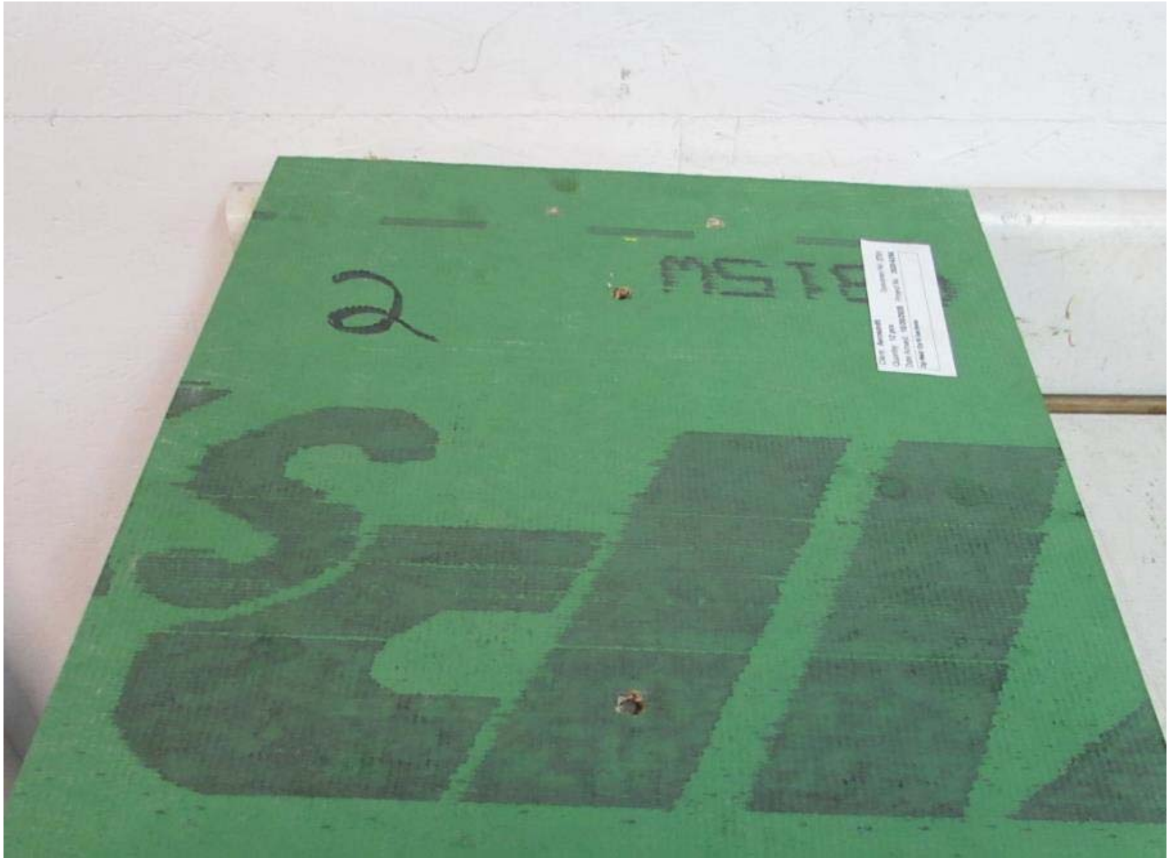
Typical Allowable Shear Capacity for Connections through FPIS Test Setup



Sample 1 Failure (Sheathing Pull-over Pin Head)

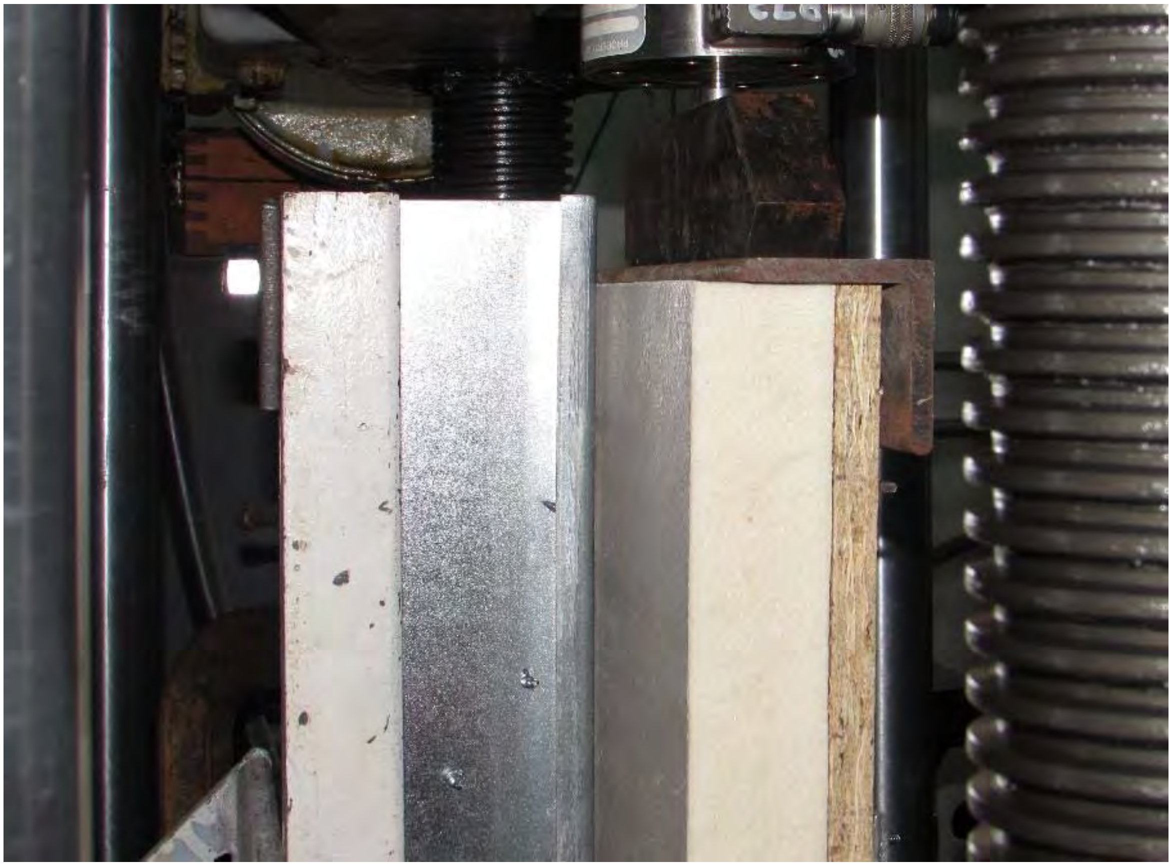


Sample 1 Failure (Sheathing Pull-over Pin Head)



Sample 2 Failure (Sheathing Pull-over Pin Head)

Sample 2 Failure (Sheathing Pull-over Pin Head)

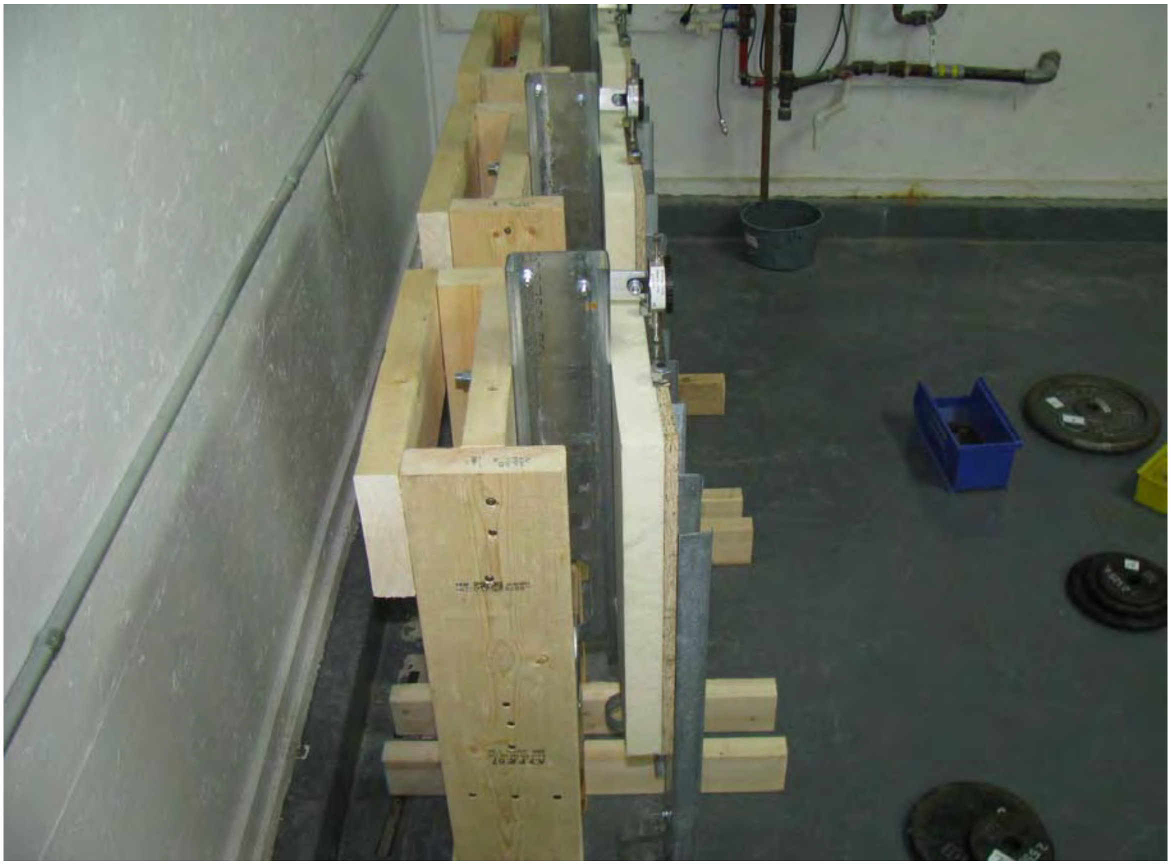


Sample 3 Near Failure (Sheathing Pull-over Pin Head)

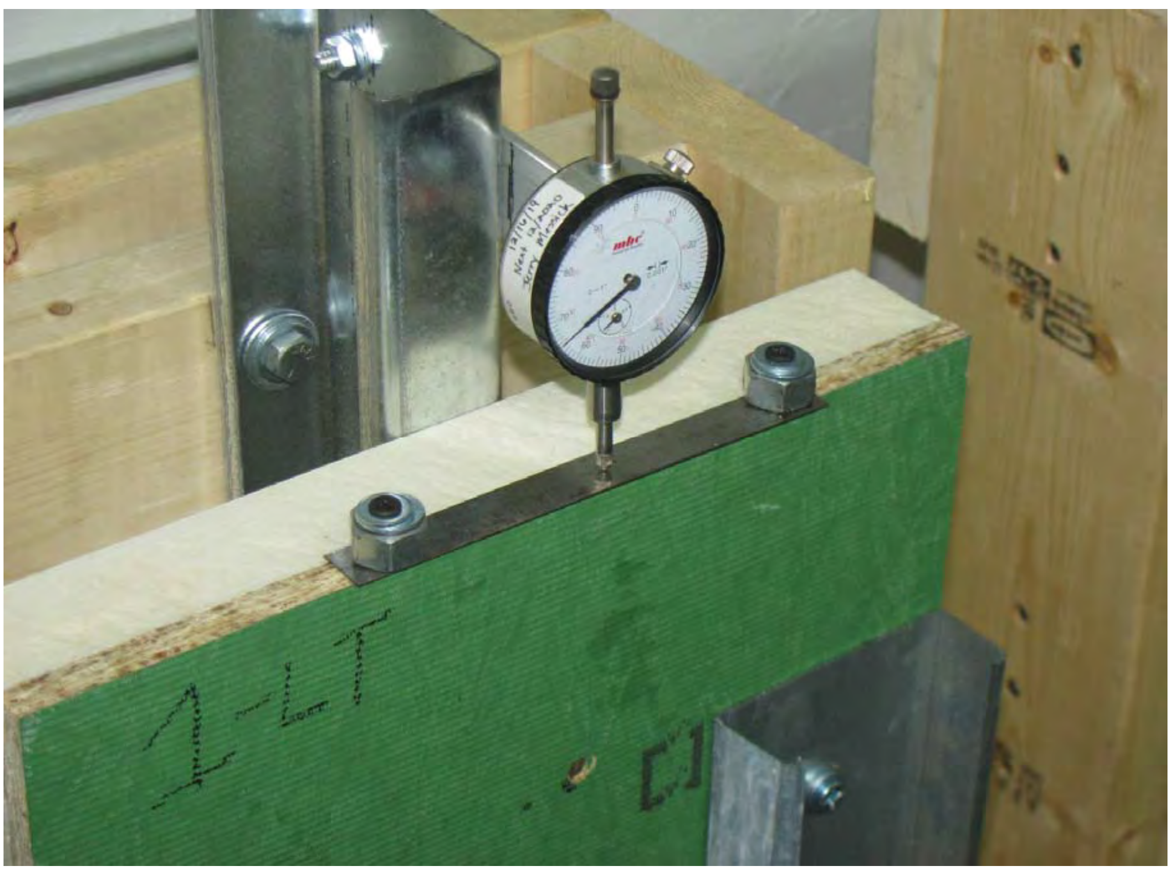

Sample 3 Failure (Sheathing Pull-over Pin Head)

Long Term Test Samples

Long Term Test Samples



Side view of test samples (Only the stud is supported)



Close-up of deflection gauge

APPENDIX

AEROSMITH FASTENING SYSTEMS

2020-6266

Progressive Engineering Inc.

ASTM E8-16a Tensile Test (Rectangular)

Date: 1/11/2021
Client: AeroSmith Fastening
Specimen: **Coupons cut from stud**

Temperature: 66°F
Humidity: 20% R.H.
Load Rate (in/min): 0.125

Specimen No.	Sample Width	Sample Thick.	Cross-Sectional Area (in²)	Load at 0.2% offset (lbf)	Max Load (lbf)	Yield Strength 0.2% offset (ksi)	Ultimate Strength (ksi)	Elongation at Break (%)	Failure Mode
20-6266-1	0.509"	0.0555"	0.02825	1,565	1,987	55.4	70.3	30.5%	b
20-6266-2	0.505"	0.0555"	0.02803	1,575	1,985	56.2	70.8	30.9%	b
20-6266-3	0.502"	0.0554"	0.02781	1,563	1,959	56.2	70.4	32.9%	b
Average	**0.505"**	**0.0555"**	**0.02803**	**1,568**	**1,977**	**55.9**	**70.5**	**31.5%**	

Failure Codes

a - Specimen broke perpendicular to edge near center of reduced section.
b - Specimen broke at an angle near center of reduced section.
c - Perpendicular break between radius and center of reduced section
d - Specimen broke at an angle between radius and center of reduced section
e - Specimen broke at an angle near radius.
f - Specimen broke perpendicular to edge near radius.
g - Specimen broke perpendicular to edge near grips.

Tensile test coupons cut from stud

Tensile test coupons after failure

Progressive Engineering Inc.

Fastener Measurements

Date: 1/12/2021
Client: Aerosmith Fastening Systems

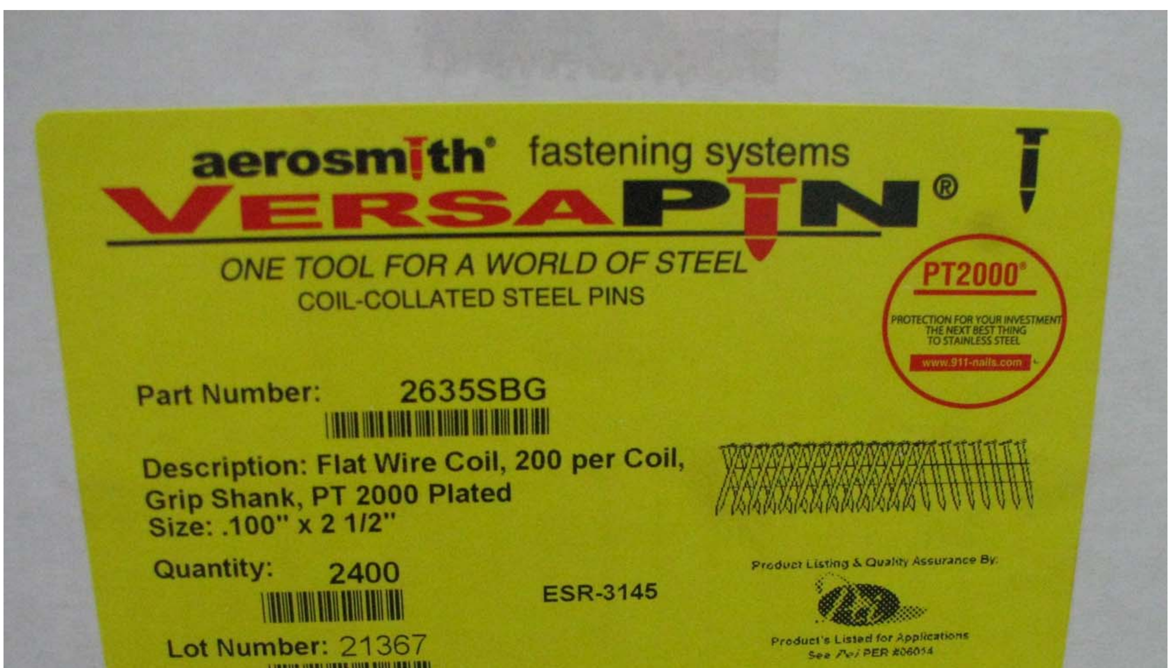
Specimen: 2635SBG Flat Wire Coil, Grip Shank PT200 Plated 0.100" x 2-1/2" Pins

Fastener	Head Diameter	Shank / Thread Dia.	Length
1	0.303"	0.107"	2.543"
2	0.301"	0.105"	2.538"
3	0.304"	0.106"	2.537"
4	0.308"	0.107"	2.535"
5	0.306"	0.108"	2.550"
6	0.308"	0.109"	2.544"
7	0.307"	0.107"	2.534"
8	0.308"	0.106"	2.539"
9	0.310"	0.108"	2.537"
10	0.307"	0.108"	2.533"
Average:	**0.306"**	**0.107"**	**2.539"**

Comments / Observations:

Ten (10) fasteners were randomly selected by Jacob Bontrager of PEI and measured as indicated above using a digital caliper.

Aerosmith Pin No. 2635SBG



Aerosmith Pin No. 2635SBG

Foam Plastic Applications for Better Building

Attachment of Exterior Wall Coverings Through Foam Plastic Insulating Sheathing (FPIS) to Wood or Steel Wall Framing

ABTG Research Report No. 1503-02

Conducted for the Foam Sheathing Committee (FSC)
of the American Chemistry Council

Report Written by:

Applied Building Technology Group, LLC
appliedbuildingtech.com

Report Date:

Final Report: March 27, 2015
Updated: August 16, 2018

Table of Contents

Introduction:

Improved energy efficiency is a major focus in building design and construction with the evolution of the energy code and the requirements therein. Foam plastic insulating sheathing (FPIS) is one of many products used, due to its increased thermal performance values while also providing advanced protection of the building envelope when used alone or in combination with conventional sheathing and wall cavity insulation. Consequently, the use of FPIS as continuous exterior insulation is seeing increased recognition in the market for compliance with the energy codes, such as in the *International Energy Conservation Code* (*IECC*). The code compliant use of FPIS for energy code applications also requires consideration of other factors such as appropriate methods for connection of claddings through FPIS materials of various thicknesses and various substrates (see Figures 1a, 1b, 1c, 2a, 2b(1), 2b(2), and 2c. This research report addresses this need by reviewing current knowledge supporting solutions that are now recognized in the 2015 and 2018 editions of the *International Building Code* (*IBC*) and the *International Residential Code* (*IRC*) (see Appendix B for provisions now included in the 2018 version of the code which is more comprehensive and detailed than the 2015 versions).

Technical Need:

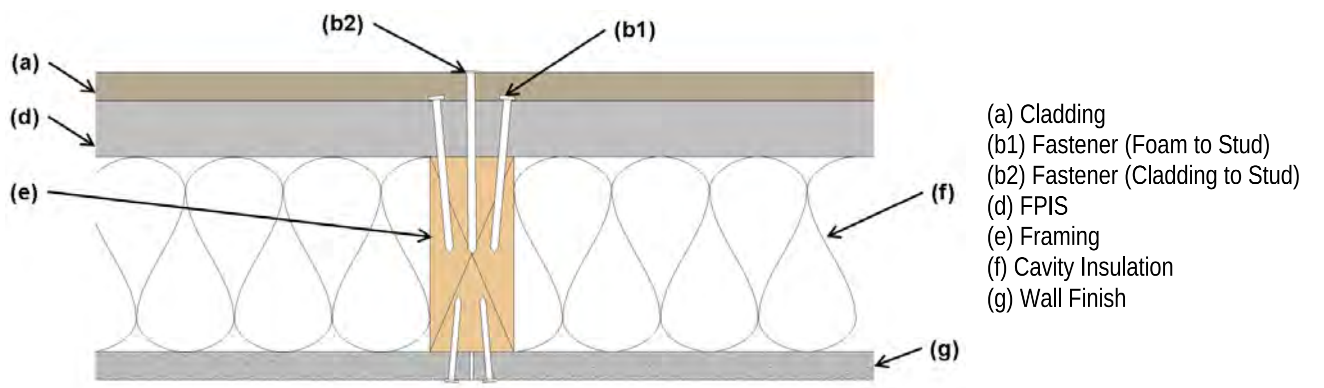


Figure 1a: Plan View – Direct Cladding Attachment through FPIS to Wood Stud

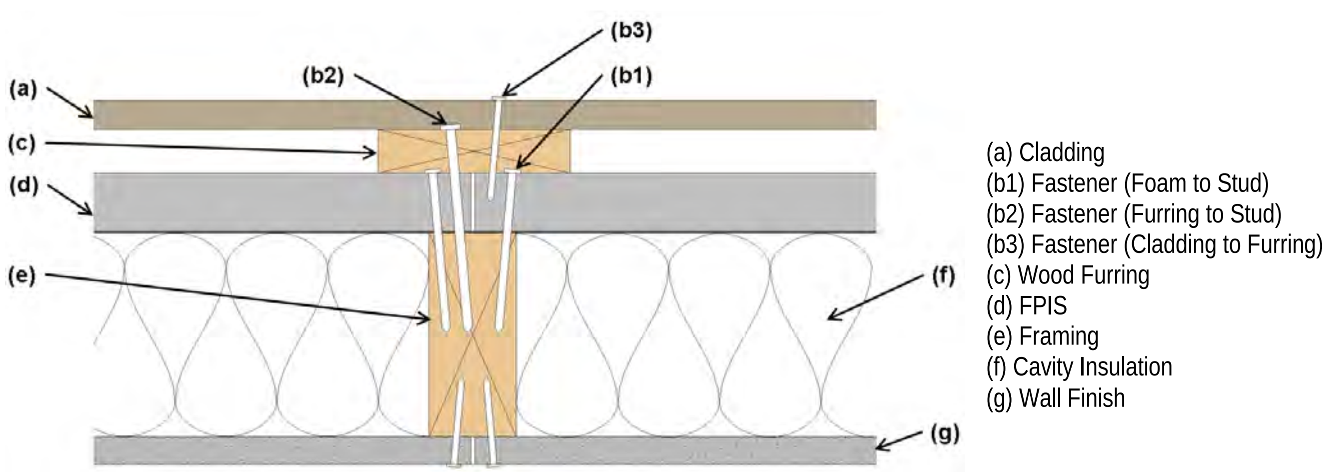
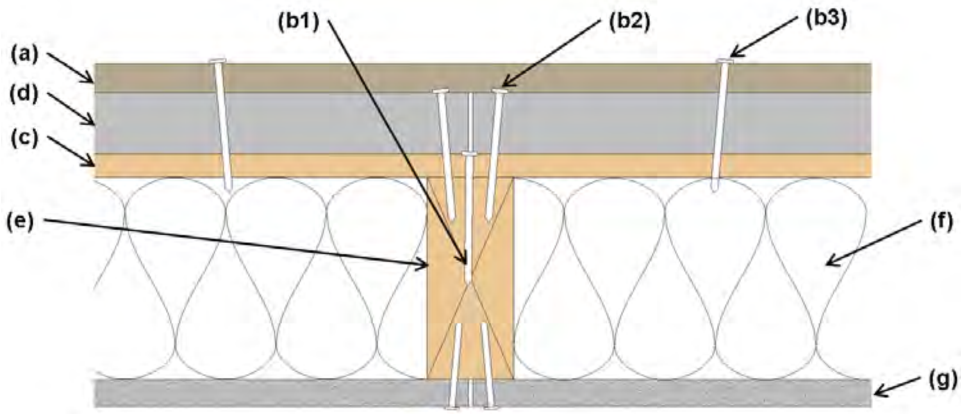
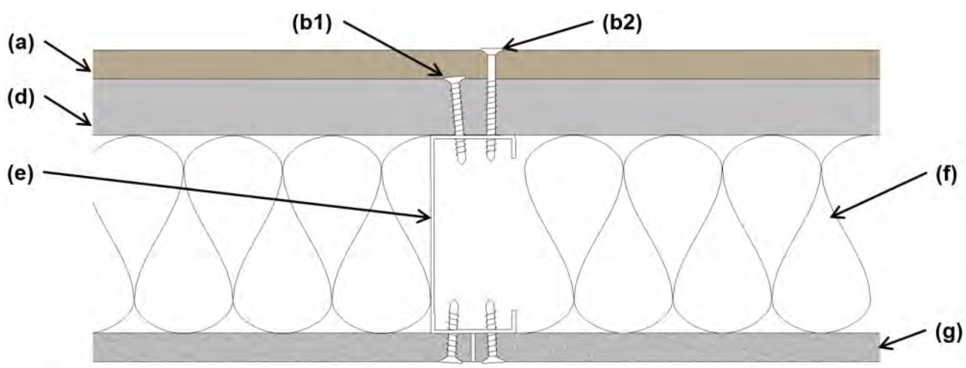


Figure 1b: Cladding Attachment through Furring to Wood Stud



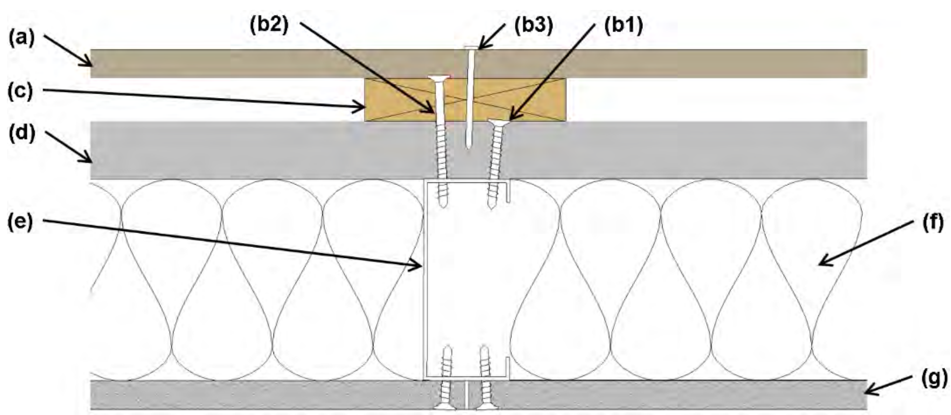
(a) Cladding
(b1) Fastener (WSP to Stud)
(b2) Fastener (Foam to Stud)
(b3) Fastener (Nail or Screw)
(Cladding to WSP)
(c) WSP
(d) FPIS
(e) Framing
(f) Cavity Insulation
(g) Wall Finish

Figure 1c: Cladding Attachment Direct to Wood Structural Panels (WSP) with Wood Stud



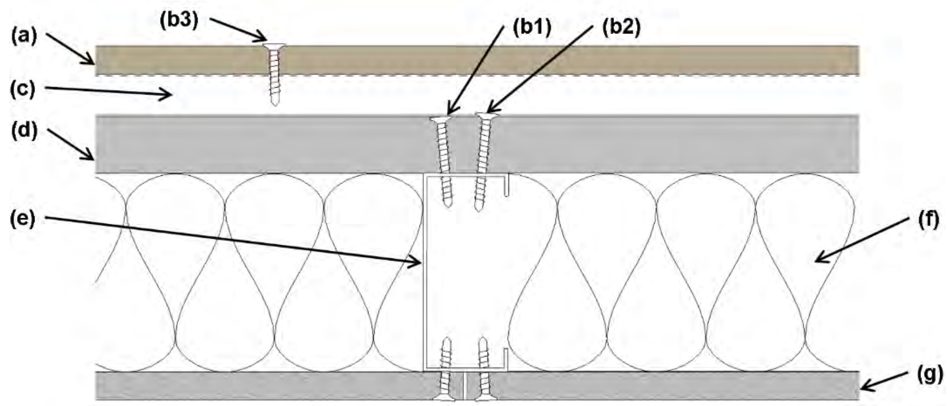
(a) Cladding
(b1) Fastener (Foam to Stud)
(b2) Fastener (Cladding to Studl)
(d) FPIS
(e) Framing
(f) Cavity Insulation
(g) Wall Finish

Figure 2a: Plan View – Direct Cladding Attachment through FPIS to Steel Stud



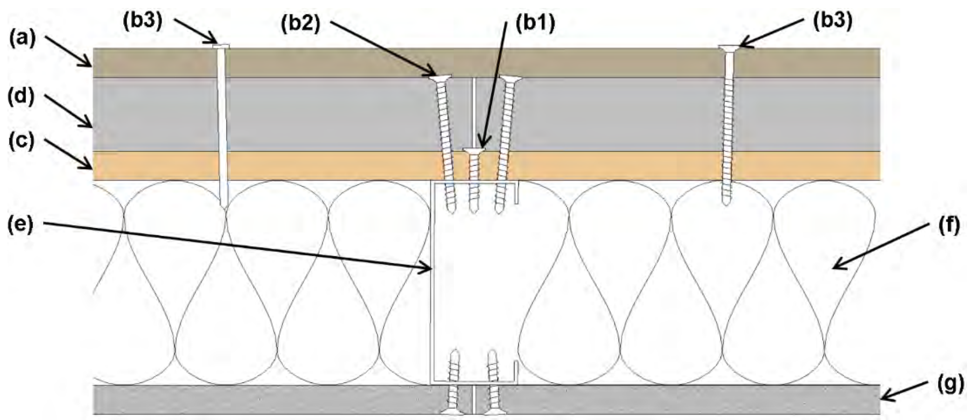
(a) Cladding
(b1) Fastener (Foam to Stud)
(b2) Fastener (Furring to Stud)
(b3) Fastener (Cladding to Furring)
(c) Wood Furring
(d) FPIS
(e) Framing
(f) Cavity Insulation
(g) Wall Finish

Figure 2b(1): Cladding Attachment Through Wood Furring aligned Parallel to Steel Stud



(a) Cladding
(b1) Fastener (Foam to Stud)
(b2) Fastener (Hat Channel to Stud – fasten alternate or both flanges at each stud location)
(b3) Fastener (Cladding to Hat Channel)
(c) Hat Channel Furring
(d) FPIS
(e) Framing
(f) Cavity Insulation
(g) Wall Finish

Figure 2b(2): Cladding Attachment Through Hat Channel Furring aligned Perpendicular to Steel Stud



(a) Cladding
(b1) Fastener (WSP to Stud)
(b2) Fastener (Foam to Stud)
(b3) Fastener (Cladding to WSP - screw or nail permitted)
(c) WSP
(d) FPIS
(e) Framing
(f) Cavity Insulation
(g) Wall Finish

Figure 2c: Cladding Attachment Direct to Wood Structural Panels (WSP) with Steel Stud

The need is summarized in the following question: "How does one design the attachments for cladding materials through foam sheathing?"

While the connection of cladding through FPIS has been practiced for many decades, there has been a lack of engineering guidance to design connections through foam sheathing to support the weight of cladding of various types (for typical weights of cladding materials see Appendix A). As shown in Figures 1a, 1b, 1c, 2a, 2b(1), 2b(2), and 2c, common methods for making these attachments includes direct attachment of the cladding through the foam sheathing to the stud below or the indirect attachment of cladding to furring that is fastened through the foam sheathing to the stud below. In typical practice, direct attachments are used for foam sheathing thicknesses of generally less than 2" thick. Furring attachments have been preferred for foam typically 2" or more in thickness, for practical reasons. However, both methods can be used for any thickness of foam, provided appropriate fasteners are available and used. This research report provides the technical basis for making these connections in a code compliant manner and also serves to explain the technical basis for prescriptive connection provisions now included in the *IBC* and *IRC* (refer to Appendix B). A step-by-step procedure for complying with these new code provisions is found in a separate code compliance research reports (DRR No. 1303-04 for wood framing and 1707-02 for steel framing).

Applicability Limits:
Because the engineering analysis method and test data addressed in this research report was limited in scope, the application of the findings of this research report are limited to FPIS products in compliance with the following material standards:

- Expanded polystyrene (EPS) manufactured in compliance with *ASTM C578*

- Extruded polystyrene (XPS) manufactured in compliance with *ASTM C578*
- Polyisocyanurate (Polyiso) manufactured in compliance with *ASTM C1289*

Additionally, all FPIS products covered in this report have a minimum compressive strength of 15 psi, although solutions for a lesser compressive strength are feasible.

The following FPIS products satisfy the applicability limits of this research report:

- Atlas Roofing Corporation – "Energy Shield®", "Energy Shield® Pro", "Energy Shield® Pro2", "RBoard®", "RBoard® Pro", "Stucco Shield®", "ThermalStar® Chrome", "ThermalStar® XTR and "ThermalStar® T&G"
- Dow Chemical Company – "STYROFOAM™", "TUFF-R™", "Super TUFF-R™", "THERMAX™", "THERMAX™ (ci) Exterior", "THERMAX™ Heavy Duty", "THERMAX™ Light Duty", "THERMAX™ White Finish", "THERMAX™ Metal Building Board" and "Isocast™ R Thermal"
- GAF – "EnergyGuard™ POLYISO INSULATED SHEATHING"
- Hunter Panels – "Xci Foil", "Xci CG", "Xci Class A", "Xci 286" and "Xci Ply"
- Johns Manville – "AP Foil Faced Foam Sheathing"
- Owens Corning – "FOAMULAR®"
- Rmax Operating, LLC – "R-Matte® Plus-3", "Durasheath®-3", "TSA-FA-3", "Thermasheath®-3", "Thermasheath®-SI", "Thermasheath®-XP", "TSX-8500", "TSX-8510", "TSX-8520", "TSP-3" and "ECOMAXci®"

Also, this research report is limited to applications with light-frame construction (wood and cold-formed steel) meeting certain limitations (e.g., wood specific gravity 0.42 minimum and steel thickness 0.033 mil min). While similar solutions are available for connections to masonry and concrete construction, they generally involve the use of proprietary types of concrete/masonry fasteners. This research and testing serving as the basis for this research report used only commodity types of standardized fasteners commonly used in light-frame wood and steel construction (e.g., nails, lag screws, and self-drilling tapping screws, gun nails, etc.).

The development of prescriptive solutions based on the design methodology is included in the 2015 and 2018 editions of the *IRC* and *IBC* (refer to Appendix B). These code-based prescriptive solutions and limitations of use also represent the limitations of use of the design methodology. Other matters of design, such as out-of-plane wind loading, should be considered as normally required in design of cladding attachment and should also comply with or be equivalent to the cladding manufacturer's installation requirements.

Analysis Methodology and Test Data:

Wood Framing

The test data and analysis methodology are addressed in detail in the following two key references:

- *NYSERDA* (2010)
- *Baker/DOE* (2014)

For cladding connections to wood framing through foam sheathing of thicknesses up to 4", the wood shear connection design equations (e.g., "yield equations") from the *NDS* (AWC, 2015) were used with inclusion of a "gap" factor in accordance with the technical basis of the yield equations as reported in *TR-12* (AWC, 2014). In addition, based on findings from the later Baker/DOE (2014) study, the design approach first developed in the *NYSERDA* (2010) study was modified to use an adjustment factor, KD (diameter coefficient), of 3.0 instead of the 1.5 factor proposed in the NYSERDA (2010) study and the 2.2 factor included in the *NDS*. This change was made to control short-term joint slip to less than 0.015" and long-term creep to a low value (e.g., < $^1/_8$") and is consistent with test data and recommendations made in the *Baker/DOE* (2014) study. Otherwise, the design shear analysis followed exactly the procedure outlined in the *NDS* and *TR12* for connections with gap. It should be noted that the "gap" factor in *TR12* was first proposed by the USDA Forest Products Laboratory in confirmatory testing and evaluation of the *NDS* yield equations (refer to *TR12* for documentation).

Based on this background, the following limitations and conditions of use should be used when considering the design of these connections.
The installation and design of dowel-type fasteners shall comply with AWC/NDS Chapter 12 with the additional requirements below for connections including a layer of FPIS sandwiched between the connected parts. Connections shall be made snug without gaps or excessive deformation of materials.

Allowable withdrawal design values. Withdrawal design values for dowel-type fasteners (i.e., nails and screws) shall be determined in accordance with AWC/NDS Section 12.2. Where dowel-type fasteners are installed through FPIS, the specified fastener length shall be sufficient to provide the design penetration into wood framing.

Reference lateral design values. Reference lateral (shear) design values for dowel-type fasteners shall be determined in accordance with AWC/NDS Section 12.3 with the following modifications and limitations where the connection includes a layer of FPIS sandwiched between the connected parts:

1. The reduction term, R_d, in accordance with AWC/NDS Table 12.3.1B shall not be less than 3.0.
2. The yield limit equations in accordance with AWC/TR12 Table 1-1 which include a gap parameter, g, equal to the thickness of FPIS sandwiched between connected parts, shall be used in lieu of the yield limit equations in AWC/NDS Table 12.3.1A.
3. The FPIS material shall have a minimum compressive strength of 15 psi in accordance with FPIS material types designated in ASTM C 578 or ASTM C 1289.
4. The minimum fastener embedment in wood materials with a minimum specific gravity of 0.42 shall be 1 inch.

Note: *The use of a minimum R_d value of 3.0 is intended to control long-term deflection and limit initial deflection to not more than 0.015 inches for dowel-type fasteners of ¼-inch diameter or less. With application of the R_d value of 3.0, the resulting safety margins relative to ultimate lateral capacity are typically greater than 5. The 15 psi limit on FPIS materials is based on the use of $R_d = 3.0$ as derived from test data. Greater or lesser foam compression strength values may result in greater or lesser R_d values which may be determined from comparison of results of testing with the analysis procedure. Similarly, different minimum requirements for wood materials and embedment in wood members receiving the fastener, such as use of nail-base sheathing, shall be determined by testing in accordance with the testing provisions described in the following section.*

Steel Framing

For cladding connections to steel framing, a similar approach was taken. However, provisions in the AISI design specification for cold-formed steel (AISI, 2012) are based on connections without a “gap”. Therefore, the testing and analysis reported in *NYSERDA* (2010) focused on the development of a “gap reduction factor” to account for joints that were tested with various thickness of foam sheathing (up to 4" thick) located between the connected parts. As a result, factors were developed to ensure control of joint slip in a similar fashion to that described above for wood framing. The gap reduction factors and their application to screw fastener shear equations in AISI (2012) are included in the *NYSERDA* (2010) study.

It should be noted that the design methodology was focused on controlling short-term and long-term slip with joints containing a layer of foam sheathing meeting the applicability limits previously described. Therefore, ultimate capacity of these joints has a relatively large safety factor compared to the design shear capacity using the above described methods. In general, observed safety factors are well above 5 for the constant dead load condition, which is a far different loading condition than snow, wind, seismic, etc.

The prescriptive solutions found in the 2015 editions of the *IBC* and *IRC* are based on the above analysis approaches for the various conditions as described in the code (refer to Appendix B).

The installation and design of screw type connections shall comply with AISI S100-12 Section E4 with the additional requirements outlined below for connections including a layer of FPIS sandwiched between the connected parts. Where screw fasteners are installed through FPIS, the fastener length shall be sufficient to provide a minimum of three threads penetration through the cold-formed steel member receiving the fastener tip. Connections shall be made snug without gaps or excessive deformation of materials.

Tension allowable design values. Nominal tension design values for screw connections shall be determined in accordance with AISI S100-12 Section E4.4 and divided by a safety factor of not less than 3.0 to derive an allowable design tension value.

Shear allowable design values. Nominal shear strength design values for screws shall be determined in accordance with AISI S100 Section E4.3.1 and divided by a safety factor of not less than 3.0 to derive an allowable shear design value. Where the connection includes a layer of FPIS sandwiched between the connected parts, the following additional requirements and limitations shall apply:

1. The FPIS material shall have a minimum compressive strength of 15 psi (104 kPa) in accordance with ASTM C 578 or ASTM C 1289.
2. For connections using #8 or #10 screws, AISI S 100 Eq. 4.3.1-1 [$P_{ns} = 4.2 (t_2{}^3 d)^{1/2} F_{u2}$] shall be multiplied by one of the following gap effect reduction factors, G_r, as applicable:

    a. For #10 screw in 54 mil (0.054 in. (1.370 mm)) and 50 ksi (345 MPa) steel:
    $G_r = 0.17 – 0.0048\ r$
    b. For #10 screw in 43 mil (0.043 in. (1.09 mm)) and 33 ksi (228 MPa) steel:
    $G_r = 0.19 – 0.0066\ r$
    c. For #8 or #10 screw in 33 mil (0.033 in. (0.838 mm)) and 33 ksi (228 MPa) steel
    $G_r = 0.16 – 0.0064\ r$

    where,
    G_r = Gap effect reduction factor for use with AISI S 100 Eq. E4.3.1-1
    r = d_{sep}/d
    d_{sep} = Separation between connected steel parts caused by thickness of FPIS
    d = Nominal screw diameter
    = 0.164 in. (4.17 mm) for #8 screws
    = 0.190 in. (4.83 mm) for #10 screws

3. The value of r shall not exceed 21 and the FPIS thickness (d_{sep}) shall not exceed 4 inches (102 mm).
4. For 0< r <2, calculated G_r in accordance with Item #2 does not need to be less than (1-r/2).
5. A larger steel thickness and screw size than indicated in Item #2 for the respective Gr equations shall be permitted provided the P_{ns} value calculated in accordance with AISI S100 Eq. 4.3.1-1 uses the screw size and steel thickness as indicated in Item #2 for the respective G_r equations.
6. The material against the screw head shall be minimum 33 mil and 33 ksi steel, minimum 3/8-inch thick wood or wood-based material with a specific gravity of not less than 0.42, or equivalent.

Note: *The use of the gap reduction factors and a minimum safety factor of 3.0 is intended to control long-term deflection and limit short-term deflection to not more than 0.015-inches based on evaluation of test data to develop and confirm the design methodology. With application of the gap reduction factors to control deflection, the resulting safety factors are typically much greater than 3. The 15 psi limit on FPIS materials is associated with the test data upon which the gap reduction factor equations are based. Different gap reduction factor equations than provided above may be determined for other FPIS compression strength by fitting equations to test results obtained in accordance with the testing provisions described in the following section.*

Testing

It should also be noted that the limitations inherent in the prescriptive requirements of the building codes as described above do not preclude additional testing that one may want to conduct in order to justify the use of other fastener types, sizes or geometries, material selections, or the addition of other materials such a drainage mats or sheathing materials. Where such testing is desired, the following discussion can provide guidance on how the testing should be set up.

Testing to Determine Allowable Shear Capacity of Connections through FPIS

1. General. Connection assemblies shall be tested for shear resistance and slip (stiffness) in accordance with this section. A minimum of 3 specimens shall be constructed for each configuration of materials and tested in accordance with ASTM D1761 and Section 4.
A minimum of 3 additional identical specimens shall be constructed and tested for long-term creep effects in accordance with Section 5. Shear allowable design values shall be determined from test results in accordance with Section 6. The results shall be applicable to the fasteners of the same type with a minimum bending yield strength and ductility as tested.

2. Specimen construction. The specimen as shown in Figures 3 and 4 shall consist of a minimum 12"x16" portion of wall with framing, FPIS, and a siding or furring material as applicable. Fasteners connecting the siding or furring to the 12"x16" wall portion (into framing members or structural sheathing) shall be located a minimum of 4-inches from the edges of the specimen and installed using appropriate tools and techniques for the type of fastener (e.g., clutched screw gun, hammer, etc.). Other building components, connection configurations, and specimen sizes shall be tested in similar manner without restraint of applicable failure modes. Connections shall be snugged to remove any voids between connected parts with minimal compression of FPIS.

Figure 3. Typical short-term shear test set-up

Figure 4. Typical long-term shear load (creep) test set-up

3. Test set-up. The test set up shall apply shear load to the connection configuration in a manner that does not alter the behavior of the connection from that which would occur in end use. One suitable test set-up is shown in Figure 3. The test specimen body (frame) shall be restrained from rotating (due to the eccentricity of load path through the specimen) without interfering with the behavior of the furring or siding connection to the specimen body (refer to Figure 3).

4. Test procedure (short term loading). A universal testing machine or other suitable testing equipment shall be used to apply the force to the attached material (see Figure 3). Load and displacement data shall be recorded for displacements up to 3 inches or until failure occurs. A displacement rate of not more than 0.2 inches per minute shall be used.

5. Test procedure (long term loading). For long term loading tests (see Figure 4), specimens shall be similarly restrained in a test rack and weights shall be suspended from the attached component as shown in Figure 4**.** The amount of constant weight (shear force) applied to one of the three specimens shall be determined as the number of fasteners sharing shear load multiplied by the allowable single fastener design value determine in accordance with Section 6 based on tests in accordance with Section 4. The other two identical test specimens shall be constructed and tested with an amount of weight 25% greater and 25% less than that used for the first specimen. The test duration shall be a minimum of 3-months or until such a time that continuing displacement ceases to occur and equilibrium is established. A dial gauge shall monitor movement over the duration of the test and readings shall be taken at least weekly. Ambient conditions during the test period shall be recorded and the ambient temperature during the test shall be maintained at room temperature, but not less than 70ºF.

6. Criteria for shear allowable design values. The test load value for a single fastener at 0.015-inch displacement shall be determined by dividing the average applied load at 0.015-inch displacement (based on tests per Section 4) by the number of fasteners securing the siding or furring to the test specimen body. The shear allowable design value shall be the lesser of the single faster average test load at 0.015-inch displacement or the single fastener minimum peak load divided by a safety factor of 5. In addition, the shear allowable design value shall not be greater than the load per fastener for which total long term deflection by testing per Section 5 does not exceed 1/8-inch and the deflection contribution during the final month of testing does not exceed 1/32-inch.

Conclusion:

A connection design methodology has been developed for the attachment of cladding to light-frame wood and steel framing through foam sheathing materials meeting the specified applicability limits and up to 4" thick. The design methodology applies to direct cladding attachment and also wood furring or steel furring (e.g., hat channel) as shown in Figures 1a, 1b, 1c, 2a, 2b(1), 2b(2), and 2c**.**The development of prescriptive solutions based on the design methodology is included in the 2015 and 2018 editions of the *IRC* and *IBC* (refer to Appendix B). These prescriptive solutions and limitations of use also represent the limitations of use of the design methodology. Other matters of design, such as out-of-plane wind loading, should be considered as normally required in design of cladding attachment and should also comply with or be equivalent to the cladding manufacturer’s installation requirements.

References:

1. *AWC (2015). National Design Specification for Wood Construction (NDS)* – 2015 Edition, American Forest & Paper Association.
2. *AWC (2014). General Dowel Equations for Calculating Lateral Connection Values* (2014), *TR-12*, American Forest & Paper Association.
3. *AISI (2012). North American Cold-Formed Steel Specification* – 2012 Edition, *S100*, American Iron & Steel Institute (*AISI S100* standard).
4. *NYSERDA (2010). Fastening Systems for Continuous Insulation, Final Report 10-11, April 2010*, New York State Energy Research and Development Authority (NYSERDA), Albany, NY. April 2010. (1/21/14).
5. *Baker, P./DOE* (2014). Initial and Long-Term Movement of Cladding Installed Over Exterior Rigid Insulation Prepared by the Building Science Corporation for the National Renewable Energy Laboratory on behalf of the U.S. Department of Energy’s Building America Program, September, 2014.
6. *ASCE/SEI 7* (2010). *Minimum Design Loads for Buildings and Other Structures* – 2010 Edition, American Society of Civil Engineers/Structural Engineering Institute.

Appendix A:
Weights of Cladding Materials

Cladding manufacturer's data should be consulted for the unit weight of specific cladding materials. For the cladding weight categories described in the IBC and IRC connection provisions based on this Research Report, typical examples are as follows:

3 psf cladding weight category: wood lap siding, vinyl siding, fiber cement siding (most types), panel siding, etc.
11 psf: 3-coat Portland cement stucco (see calculation below)
18 psf: medium weight adhered masonry veneer
25 psf: heavy adhered masonry veneer

Weight of Portland Cement Plaster (Stucco)

On wood framing, three-coat plaster is typically installed over metal lath to a $^7/_8$" nominal thickness. A typical plaster mixture weighs about 142 lbs. per cubic foot, roughly the same as mortar, and this amount of material would cover about 13.7 sq. ft. at $^7/_8$" thick. The metal lath may add a small additional amount of weight, so the end result is that three-coat stucco weighs about 10.4 lbs. per sq. ft. (psf) installed.
(source: Portland Cement Association [PCA] website: http://www.cement.org/for-concrete-books-learning/materials-applications/stucco/faqs

Typical weight of softwood dimensional framing materials are as follows (1x3, 1x4, 2x3, and 2x4 are common furring choices):

Nominal Size *(in x in)*	**Actual Size**		
	(in x in)	*(mm x mm)*	**Weight** *(lb/ft)*
1 x 3	3/4 x 2 1/2	19 x 64	0.47
1 x 4	3/4 x 3 1/2	19 x 89	0.64
2 x 3	1 1/2 x 2 1/2	38 x 64	0.94
2 x 4	1 1/2 x 3 1/2	38 x 89	1.28

*Weight is based on softwood lumber having a weight of 35 lbs./ft.^{3}
(source: http://www.engineeringtoolbox.com/softwood-lumber-dimensions-d_1452.html)

Design Example:

Given

Foam Sheathing Thickness: 4"
Cladding Material: Fiber cement lap siding
Design Wind Speed/Exposure: 90/B
Seismic Design Category: B (exempt)
Wood Framing: 2x6 at 24" o.c.

Solution

STEP 1: Use 1x3 (min) wood furring (vertical orientation over studs per Figure 1b). Direct siding attachment using Table 1a (without furring per Figure 1a) could also be considered in similar fashion, but direct cladding attachment is generally more feasible for foam sheathing thicknesses not in excess of about 2 inches.

STEP 2: Consult siding manufacturer data for siding weight (2.3 psf) and add 0.24 psf for furring.
Total = 2.54 psf (Use 3 psf).

Note: The material weight for the 1x3 furring in the table above is listed as 0.47 pounds per lineal foot. At 24" o.c., this equates to 0.24 pounds per square foot.

STEP 3: Using Table 1b (and column for 3 psf siding weight), min 1x3 wood furring at 24" o.c. attached to studs can be attached with a ¼" diameter lag screw at 24" o.c. through furring and foam sheathing and penetrating framing a minimum of 1½". Other fastening solutions in Table 1b are also possible.

STEP 4: Check to ensure the allowable wind pressure resistance of the selected furring and attachment schedule (Step 3) is capable of resisting the allowable stress design wind load required by the building code (refer to Section 5.5). For direct cladding attachments (or the cladding attachment to furring), the allowable wind load resistance of the specific cladding material is usually specified by the cladding manufacturer or the building code (if specifically addressed in the code). In this example which uses 1x3 furring spaced at 24"oc and attached with a ¼" diameter lag screw at 24"oc along the furring, Table 1c is used to determine an allowable wind pressure resistance of 23.4 psf for the furring and its attachment (building codes generally do not address furring wind load resistance prescriptively). Consulting the 2018 IRC Table R301.2(2), this will satisfy the components and cladding allowable stress wind load for wind speeds of at least 120 mph (and slightly less than 130 mph) for wind Exposure B (suburban/wooded terrain) for buildings with a mean roof height up to 30 feet. For other wind exposure and building height conditions, refer to IRC Table R301.2(2) or an allowable stress design wind load calculated in accordance with ASCE 7. To gain greater wind load resistance, the fastener spacing in the furring could be decreased (providing more support than needed for the cladding weight per Step 3 above).

STEP 5: The minimum length of fastener required is 0.75" (furring) + 4" (foam) + 1.5" (penetration) = 6.25". Select a 6½" or 7" lag screw. Note: Add length for thickness of additional sheathing material layer behind foam, if included. Verify furring provides adequate thickness for siding fastener per code or siding manufacturer's installation instructions. If needed, specify a thicker furring (i.e., 2x4) or an appropriate siding fastener for use in ¾"-thick furring.

STEP 6: Ensure installation follows the practices required in Section 6.

Appendix B:
Prescriptive Code Requirements

The following code excerpts are from the 2018 editions of the IRC and IBC as justified by the test data and engineering analysis methodology presented in this Research Report. In addition, a provision added by others to the 2015 edition of the IRC allows connection directly to wood structural panels with certain limitations and is included at the end of this appendix due to its relevance.

2018 IRC Section R703.15 Cladding attachment over foam sheathing to wood framing. Cladding shall be specified and installed in accordance with Section R703, the cladding manufacturer's approved instructions including any limitations for use over foam plastic sheathing, or an approved design. In addition, the cladding or furring attachments through foam sheathing to framing shall meet or exceed the minimum fastening requirements of Section R703.15.1, Section R703.15.2, or an approved design for support of cladding weight.

Exceptions:

1. Where the cladding manufacturer has provided approved installation instructions for application over foam sheathing, those requirements shall apply.
2. For exterior insulation and finish systems, refer to Section R703.9.
3. For anchored masonry or stone veneer installed over foam sheathing, refer to Section R703.7.

R703.15.1 Direct attachment. Where cladding is installed directly over foam sheathing without the use of furring, cladding minimum fastening requirements to support the cladding weight shall be as specified in Table R703.15.1.

TABLE R703.15.1
CLADDING MINIMUM FASTENING REQUIREMENTS FOR DIRECT ATTACHMENT OVER FOAM PLASTIC SHEATHING TO SUPPORT CLADDING WEIGHT[a]

CLADDING FASTENER THROUGH FOAD SHEATHING	CLADDING FASTENER TYPE AND MINIMUM SIZE[b]	CLADDING FASTENER VERTICAL SPACING (inches)	MAXIMUM THICKNESS OF FOAM SHEATHING[c] (inches)							
			16″ o.c. Fastener Horizontal Spacing				24″ o.c. Fastener Horizontal Spacing			
			Cladding Weight:				Cladding Weight:			
			3 psf	11 psf	18 psf	25 psf	3 psf	11 psf	18 psf	25 psf
Wood Framing (minimum 1-1/4 -inch penetration)	0.113″ diameter nail	6	2.00	1.45	0.75	DR	2.00	0.85	DR	DR
		8	2.00	1.00	DR	DR	2.00	0.55	DR	DR
		12	2.00	0.55	DR	DR	1.85	DR	DR	DR
	0.120″ diameter nail	6	3.00	1.70	0.90	0.55	3.00	1.05	0.50	DR
		8	3.00	1.20	0.60	DR	3.00	0.70	DR	DR
		12	3.00	0.70	DR	DR	2.15	DR	DR	DR
	0.131″ diameter nail	6	4.00	2.15	1.20	0.75	4.00	1.35	0.70	DR
		8	4.00	1.55	0.80	DR	4.00	0.90	DR	DR
		12	4.00	0.90	DR	DR	2.70	0.50	DR	DR
	0.162″ diameter nail	6	4.00	3.55	2.05	1.40	4.00	2.25	1.25	0.80
		8	4.00	2.55	1.45	0.95	4.00	1.60	0.85	0.50
		12	4.00	1.60	0.85	0.50	4.00	0.95	DR	DR

For SI: 1 inch = 25.4 mm, 1 pound per square foot = 0.0479 kPa, 1 pound per square inch = 6.895 kPa.

DR = Design required.

o.c. = on center

a. Wood framing shall be Spruce-pine-fir or any wood species with a specific gravity of 0.42 or greater in accordance with AWC NDS.

b. Nail fasteners shall comply with ASTM F 1667, except nail length shall be permitted to exceed ASTM F 1667 standard lengths.

c. Foam sheathing shall have a minimum compressive strength of 15 psi in accordance with ASTM C 578 or ASTM C 1289.

R703.15.2 Furred cladding attachment. Where wood furring is used to attach cladding over foam sheathing, furring minimum fastening requirements to support the cladding weight shall be as specified in Table R703.15.2. Where placed horizontally, wood furring shall be preservative-treated wood in accordance with Section R317.1 or naturally durable wood and fasteners shall be corrosion resistant in accordance Section R317.3.

TABLE R703.15.2
FURRING MINIMUM FASTENING REQUIREMENTS FOR APPLICATION OVER FOAM PLASTIC SHEATHING TO SUPPORT CLADDING WEIGHT[a,b]

FURRING MATERIAL	FRAMING MEMBER	FASTENER TYPE AND MINIMUM SIZE	MINIMUM PENETRATION INTO WALL FRAMING (inches)	FASTENER SPACING IN FURRING (inches)	MAXIMUM THICKNESS OF FOAM SHEATHING[d] (inches)							
					16″ o.c. Furring[e]				24″ o.c. Furring[e]			
					Siding Weight:				Siding Weight:			
					3 psf	11 psf	18 psf	25 psf	3 psf	11 psf	18 psf	25 psf
Minimum 1× Wood Furring[c]	Minimum 2× Wood Stud	0.131″ diameter nail	1-1/4	8	4.00	2.45	1.45	0.95	4.00	1.60	0.85	DR
				12	4.00	1.60	0.85	DR	4.00	0.95	DR	DR
				16	4.00	1.10	DR	DR	3.05	0.60	DR	DR
		0.162″ diameter nail	1-1/4	8	4.00	4.00	2.45	1.60	4.00	2.75	1.45	0.85
				12	4.00	2.75	1.45	0.85	4.00	1.65	0.75	DR
				16	4.00	1.90	0.95	DR	4.00	1.05	DR	DR
		No.10 wood screw	1	12	4.00	2.30	1.20	0.70	4.00	1.40	0.60	DR
				16	4.00	1.65	0.75	DR	4.00	0.90	DR	DR
				24	4.00	0.90	DR	DR	2.85	DR	DR	DR
		1/4 ″ lag screw	1-1/2	12	4.00	2.65	1.50	0.90	4.00	1.65	0.80	DR
				16	4.00	1.95	0.95	0.50	4.00	1.10	DR	DR
				24	4.00	1.10	DR	DR	3.25	0.50	DR	DR

For SI: 1 inch = 25.4 mm, 1 pound per square foot = 0.0479 kPa, 1 pound per square inch = 6.895 kPa.
DR = Design required.
o.c. = on center

a. Wood framing shall be Spruce-pine-fir or any wood species with a specific gravity of 0.42 or greater in accordance with AWC NDS.
b. Nail fasteners shall comply with ASTM F 1667, except nail length shall be permitted to exceed ASTM F 1667 standard lengths.
c. Where the required cladding fastener penetration into wood material exceeds 3/4 inch and is not more than 11/2 inches, a minimum 2x wood furring or an approved design shall be used.
d. Foam sheathing shall have a minimum compressive strength of 15 psi in accordance with ASTM C 578 or ASTM C 1289.
e. Furring shall be spaced not more than 24 inches on center, in a vertical or horizontal orientation. In a vertical orientation, furring shall be located over wall studs and attached with the required fastener spacing. In a horizontal orientation, the indicated 8-inch and 12-inch fastener spacing in furring shall be achieved by use of two fasteners into studs at 16 inches and 24 inches on center, respectively.

2018 IBC Section 2603.13 Cladding attachment over foam sheathing to wood framing. Cladding shall be specified and installed in accordance with Chapter 14 and the cladding manufacturer's installation instructions. Where used, furring and furring attachments shall be designed to resist design loads determined in accordance with Chapter 16. In addition, the cladding or furring attachments through foam sheathing to framing shall meet or exceed the minimum fastening requirements of Section 2603.13.1, Section 2603.13.2, or an approved design for support of cladding weight.

Exceptions:

1. Where the cladding manufacturer has provided approved installation instructions for application over foam sheathing, those requirements shall apply.
2. For exterior insulation and finish systems, refer to Section 1408.
3. For anchored masonry or stone veneer installed over foam sheathing, refer to Section 1405.

2603.13.1 Direct attachment. Where cladding is installed directly over foam sheathing without the use of furring, cladding minimum fastening requirements to support the cladding weight shall be as specified in Table 2603.13.1.

2603.13.2 Furred cladding attachment. Where wood furring is used to attach cladding over foam sheathing, furring minimum fastening requirements to support the cladding weight shall be as specified in Table 2603.13.2. Where placed horizontally, wood furring shall be preservative treated wood in accordance with Section 2303.1.9 or naturally durable wood and fasteners shall be corrosion resistant in accordance with Section 2304.10.5.

TABLE 2603.13.1
CLADDING MINIMUM FASTENING REQUIREMENTS FOR DIRECT ATTACHMENT OVER FOAM PLASTIC SHEATHING TO SUPPORT CLADDING WEIGHT[a]

CLADDING FASTENER THROUGH FOAM SHEATHING	CLADDING FASTENER TYPE AND MINIMUM SIZE[b]	CLADDING FASTENER VERTICAL SPACING (inches)	MAXIMUM THICKNESS OF FOAM SHEATHING[c] (inches)							
			16″ o.c. Fastener Horizontal Spacing				24″ o.c. Fastener Horizontal Spacing			
			Cladding Weight:				Cladding Weight:			
			3 psf	11 psf	18 psf	25 psf	3 psf	11 psf	18 psf	25 psf
Wood Framing (minimum 1-1/4 -inch penetration)	0.113″ diameter nail	6	2.00	1.45	0.75	DR	2.00	0.85	DR	DR
		8	2.00	1.00	DR	DR	2.00	0.55	DR	DR
		12	2.00	0.55	DR	DR	1.85	DR	DR	DR
	0.120″ diameter nail	6	3.00	1.70	0.90	0.55	3.00	1.05	0.50	DR
		8	3.00	1.20	0.60	DR	3.00	0.70	DR	DR
		12	3.00	0.70	DR	DR	2.15	DR	DR	DR
	0.131″ diameter nail	6	4.00	2.15	1.20	0.75	4.00	1.35	0.70	DR
		8	4.00	1.55	0.80	DR	4.00	0.90	DR	DR
		12	4.00	0.90	DR	DR	2.70	0.50	DR	DR
	0.162″ diameter nail	6	4.00	3.55	2.05	1.40	4.00	2.25	1.25	0.80
		8	4.00	2.55	1.45	0.95	4.00	1.60	0.85	0.50
		12	4.00	1.60	0.85	0.50	4.00	0.95	DR	DR

For SI: 1 inch = 25.4 mm, 1 pound per square foot = 0.0479 kPa, 1 pound per square inch = 6.895 kPa.
DR = Design required.
o.c. = on center
a. Wood framing shall be Spruce-pine-fir or any wood species with a specific gravity of 0.42 or greater in accordance with AWC NDS.
b. Nail fasteners shall comply with ASTM F 1667, except nail length shall be permitted to exceed ASTM F 1667 standard lengths.
c. Foam sheathing shall have a minimum compressive strength of 15 psi in accordance with ASTM C 578 or ASTM C 1289.

TABLE 2603.13.2

FURRING MINIMUM FASTENING REQUIREMENTS FOR APPLICATION OVER FOAM PLASTIC SHEATHING TO SUPPORT CLADDING WEIGHT[a,b]

FURRING MATERIAL	FRAMING MEMBER	FASTENER TYPE AND MINIMUM SIZE	MINIMUM PENETRATION INTO WALL FRAMING (inches)	FASTENER SPACING IN FURRING (inches)	MAXIMUM THICKNESS OF FOAM SHEATHING[d] (inches)							
					16″ o.c. Furring[e]				24″ o.c. Furring[e]			
					Siding Weight:				Siding Weight:			
					3 psf	11 psf	18 psf	25 psf	3 psf	11 psf	18 psf	25 psf
Minimum 1× Wood Furring[c]	Minimum 2× Wood Stud	0.131″ diameter nail	1-1/4	8	4.00	2.45	1.45	0.95	4.00	1.60	0.85	DR
				12	4.00	1.60	0.85	DR	4.00	0.95	DR	DR
				16	4.00	1.10	DR	DR	3.05	0.60	DR	DR
		0.162″ diameter nail	1-1/4	8	4.00	4.00	2.45	1.60	4.00	2.75	1.45	0.85
				12	4.00	2.75	1.45	0.85	4.00	1.65	0.75	DR
				16	4.00	1.90	0.95	DR	4.00	1.05	DR	DR
		No.10 wood screw	1	12	4.00	2.30	1.20	0.70	4.00	1.40	0.60	DR
				16	4.00	1.65	0.75	DR	4.00	0.90	DR	DR
				24	4.00	0.90	DR	DR	2.85	DR	DR	DR
		1/4 ″ lag screw	1-1/2	12	4.00	2.65	1.50	0.90	4.00	1.65	0.80	DR
				16	4.00	1.95	0.95	0.50	4.00	1.10	DR	DR
				24	4.00	1.10	DR	DR	3.25	0.50	DR	DR

For SI: 1 inch = 25.4 mm, 1 pound per square foot = 0.0479 kPa, 1 pound per square inch = 6.895 kPa.

DR = Design required.

o.c. = on center

a. Wood framing and furring shall be Spruce-pine-fir or any wood species with a specific gravity of 0.42 or greater in accordance with AWC NDS.

b. Nail fasteners shall comply with ASTM F 1667, except nail length shall be permitted to exceed ASTM F 1667 standard lengths.

c. Where the required cladding fastener penetration into wood material exceeds 3/4 inch and is not more than 1-1/2 inches, a minimum 2× wood furring or an approved design shall be used.

d. Foam sheathing shall have a minimum compressive strength of 15 psi in accordance with ASTM C 578 or ASTM C 1289.

e. Furring shall be spaced a maximum of 24 inches (610 mm) on center in a vertical or horizontal orientation. In a vertical orientation, furring shall be located over wall studs and attached with the required fastener spacing. In a horizontal orientation, the indicated 8 inch (203 mm) and 12 inch (305 mm) fastener spacing in furring shall be achieved by use of two fasteners into studs at 16 inches (406 mm) and 24 inches (610 mm) on center, respectively.

In addition to the above model code provisions based on engineering methods and data as documented in this research report, the following additional provision for cladding attachments through foam sheathing to wood structural panels is included in the 2015 and 2018 editions of the IRC:

R703.3.2 Fasteners.

Exterior wall coverings shall be securely fastened with aluminum, galvanized, stainless steel or rust-preventative coated nails or staples in accordance with Table R703.3(1) or with other approved corrosion-resistant fasteners in accordance with the wall covering manufacturer's installation instructions. Nails and staples shall comply with ASTM F 1667. Nails shall be T-head, modified round head, or round head with smooth or deformed shanks. Staples shall have a minimum crown width of $^{7}/_{16}$ inch (11.1 mm) outside diameter and be manufactured of minimum 16-gage wire. Where fiber-board, gypsum, or foam plastic sheathing backing is used, nails or staples shall be driven into the studs. Where wood or wood structural panel sheathing is used, fasteners shall be driven into studs unless otherwise permitted to be driven into sheathing in accordance with either the siding manufacturer's installation instructions or Table R703.3.2.

TABLE R703.3.2
OPTIONAL SIDING ATTACHMENT SCHEDULE FOR FASTENERS WHERE NO STUD PENETRATION NECESSARY

APPLICATION	NUMBER AND TYPE OF FASTENER	SPACING OF FASTENERS[b]
Exterior wall covering (weighing 3 psf or less) attachment to wood structural panel sheathing, either direct or over foam sheathing a maximum of 2 inches thick.[a] Note: Does not apply to vertical siding.	Ring shank roofing nail (0.120" min. dia.)	12" o.c.
	Ring shank nail (0.148" min. dia.)	15" o.c.
	No. 6 screw (0.138" min. dia.)	12" o.c.
	No. 8 screw (0.164" min. dia.)	16" o.c.

For SI: 1 inch = 25.4 mm.

a. Fastener length shall be sufficient to penetrate back side of the wood structural panel sheathing by at least $^{1}/_{4}$ inch. The wood structural panel sheathing shall be not less than $^{7}/_{16}$ inch in thickness.

b. Spacing of fasteners is per 12 inches of siding width. For other siding widths, multiply "Spacing of Fasteners" above by a factor of 12/s, where "s" is the siding width in inches. Fastener spacing shall never be greater than the manufacturer's minimum recommendations.