FUTURE OF FRAMING

Value of SBCRI & SBCRI Testing: What We've Learned & Where We're Going

Kendall Hoyd, Trussway Holdings, Inc.
Kirk Grundahl, SBCA

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FUTURE OF FRAMING

"If we continue to be passive participants in the intellectual property part of our business…"

"…we're going to continue to get what we've always gotten"

SBC RESEARCH™ INSTITUTE

Value Engineering and Innovation Through Testing

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Structural Building Components Industry Truss and Component Raw Material and Construction Products Design Properties Policy

Raw Material and Construction Product Purchasers, Resellers and Users Depend on Design Properties in the Raw Materials and Construction Products to be Accurate and Reliable.

- Key Points
  - Accurate properties create value for SBC Industry and Engineering
  - Prescriptive properties that are overstated devalue the SBC Industry and Engineering
  - Accuracy fosters innovation

Cutting Edge Possibilities

SBCRI Testing Facility + Engineering Experience

=

State-of-the-Art Approach

SBCRI Testing Capabilities

Full Scale Building Testing

- Maximum Full Scale Testing Area: 30 feet wide x 32 feet high x 90 feet long
- Maximum Single Element Component Test Length: 48 to 50 feet.

Small Scale Single Element Testing

- Single Element Compression/Tension Testing Station: 20 feet long, 5 feet wide
- Single Element Lateral Load Station: 4 feet to 20 feet long

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Testing Program

A joint TPI/SBCA product testing and intellectual property development effort.

- **Goals are to:**
  - Improve metal plate connected wood component market share
  - Make contributions to the ANSI/TPI and ANSI/SBCA standards development process that benefit the component industry
  - Improve BCSI and bracing related publications
  - Advance code compliance through testing and Technical Evaluation Reports (TERs)
  - Carry out other agreed upon activities.
- **Focus is on how SBCA/SBCRI helps our small CM Members**
- **All work is to be conducted by SBCRI**

SBCA/TPI Guiding Principles

From Original Signed Agreement -- December 3, 2009

1. Metal Plate Connected Wood Truss (MPCWT) components perform in unique ways as installed in assemblies.
2. Further studying of MPCWT components, through testing of as-built assemblies and analysis of the results may provide the industry with additional information and knowledge. The goal of this testing is to enable greater understanding and continued advancement of MPCWT design while continuing to maintain truss analysis and design founded on sound engineering principles.
3. Pursuing testing and analysis of MPCWT components in built assemblies will present unique opportunities that may challenge current thinking and practices, which is viewed as healthy and a worthwhile step in advancing the industry.

SBCA/TPI Guiding Principles

From Original Signed Agreement -- December 3, 2009

4. While assembly testing is desirable, integrating this new knowledge with individual MPCWT component testing is also desirable so that future advancements can be made using empirical correlation and modeling.
5. SBCA has a state-of-the-art testing facility (SBCRI) capable of testing individual members in components, individual components as designed today and individual components in actual as-built assemblies, making greater understanding of both testing modes and their interrelationship very robust.

“If we have done it before it’s safe.”

“If we haven’t, it’s dangerous, reckless and scary”

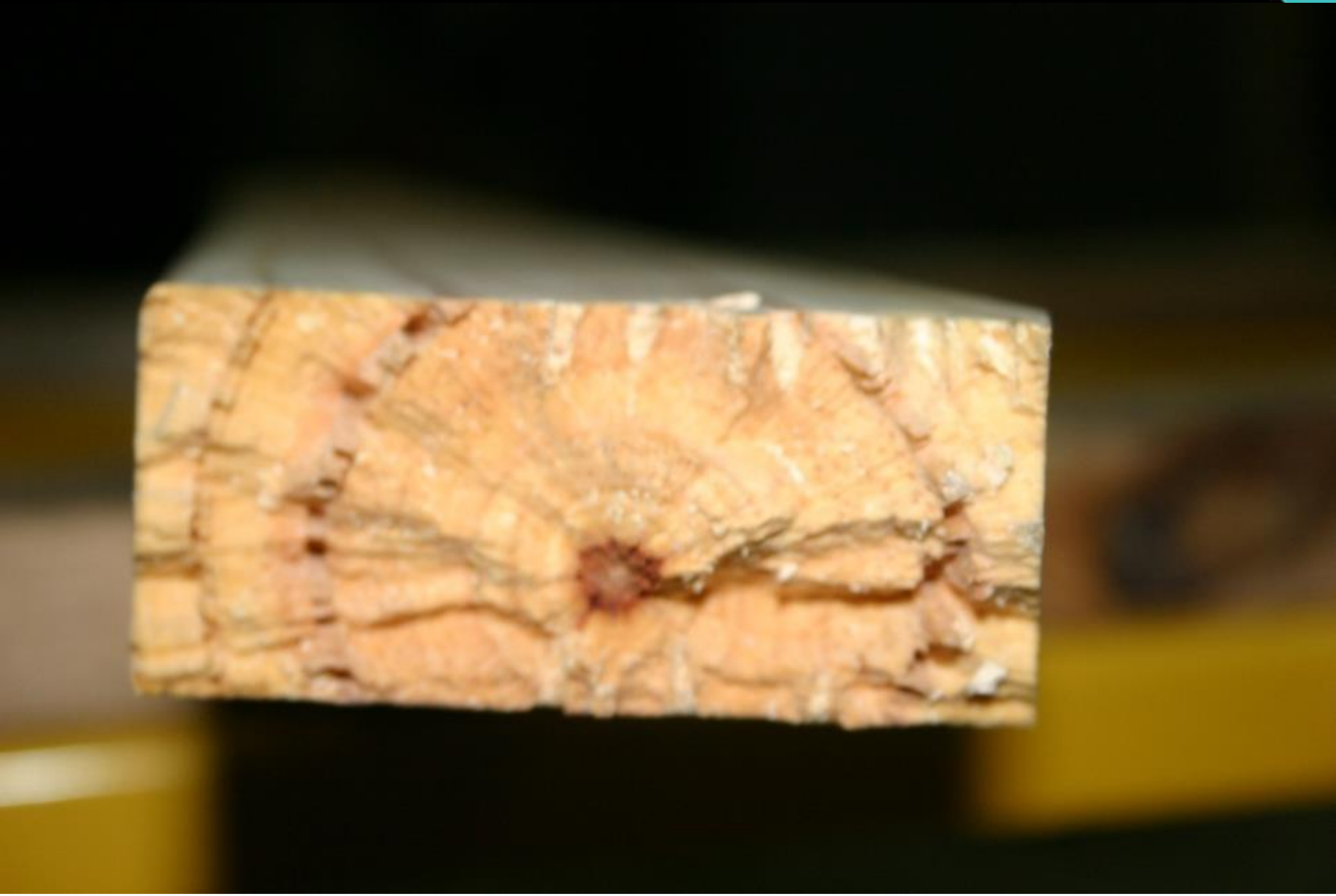
Trusses Used in a Litigation Turns up a Southern Pine Design Value Issue

So why is this important?

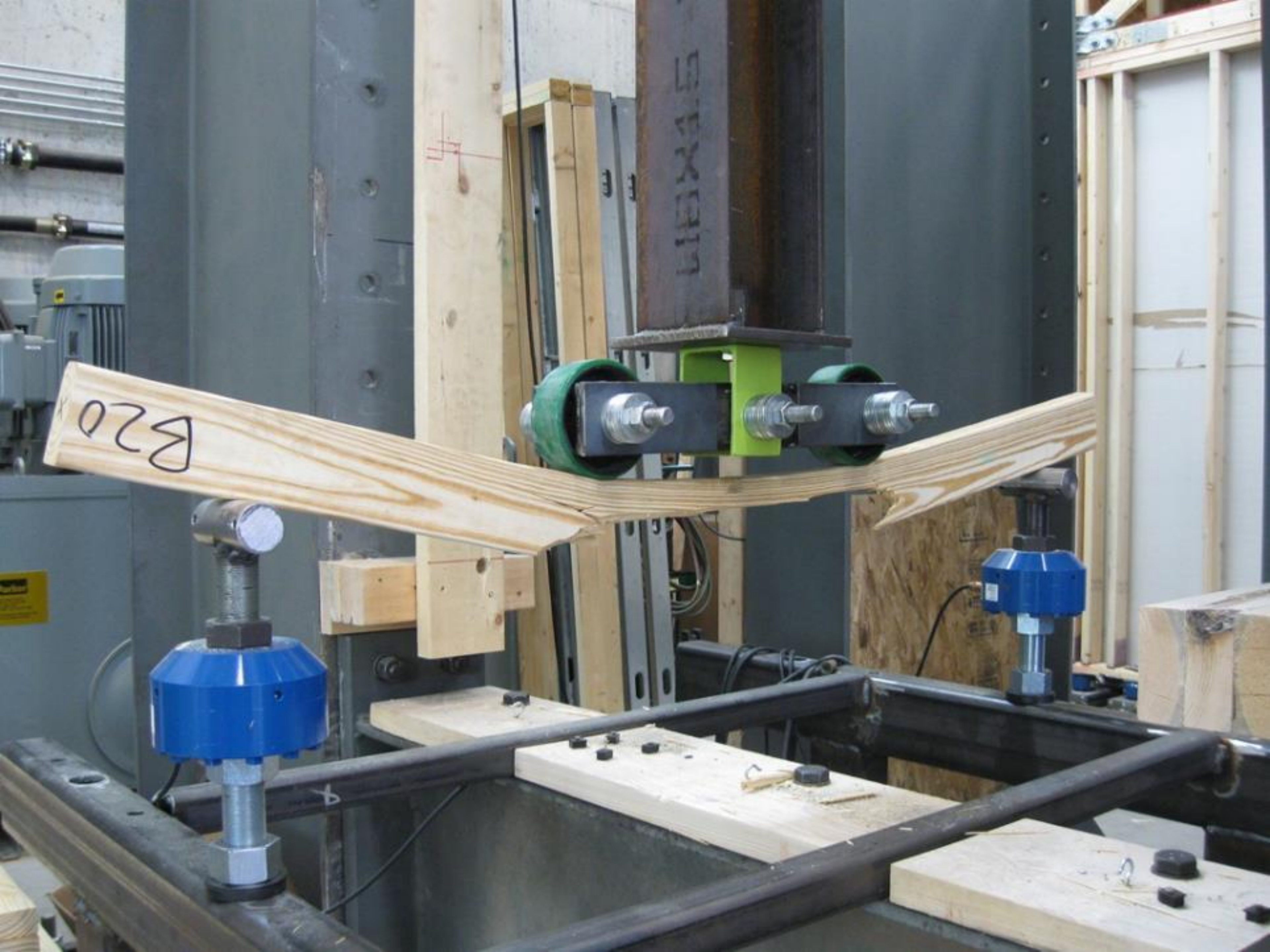
Juvenile wood

Higher density

- Photo from our testing of #2
- Roughly 1/3 of the #2 lumber was pith center.
- Test values shown in histogram next.




SPIB® No.1
KD19 HT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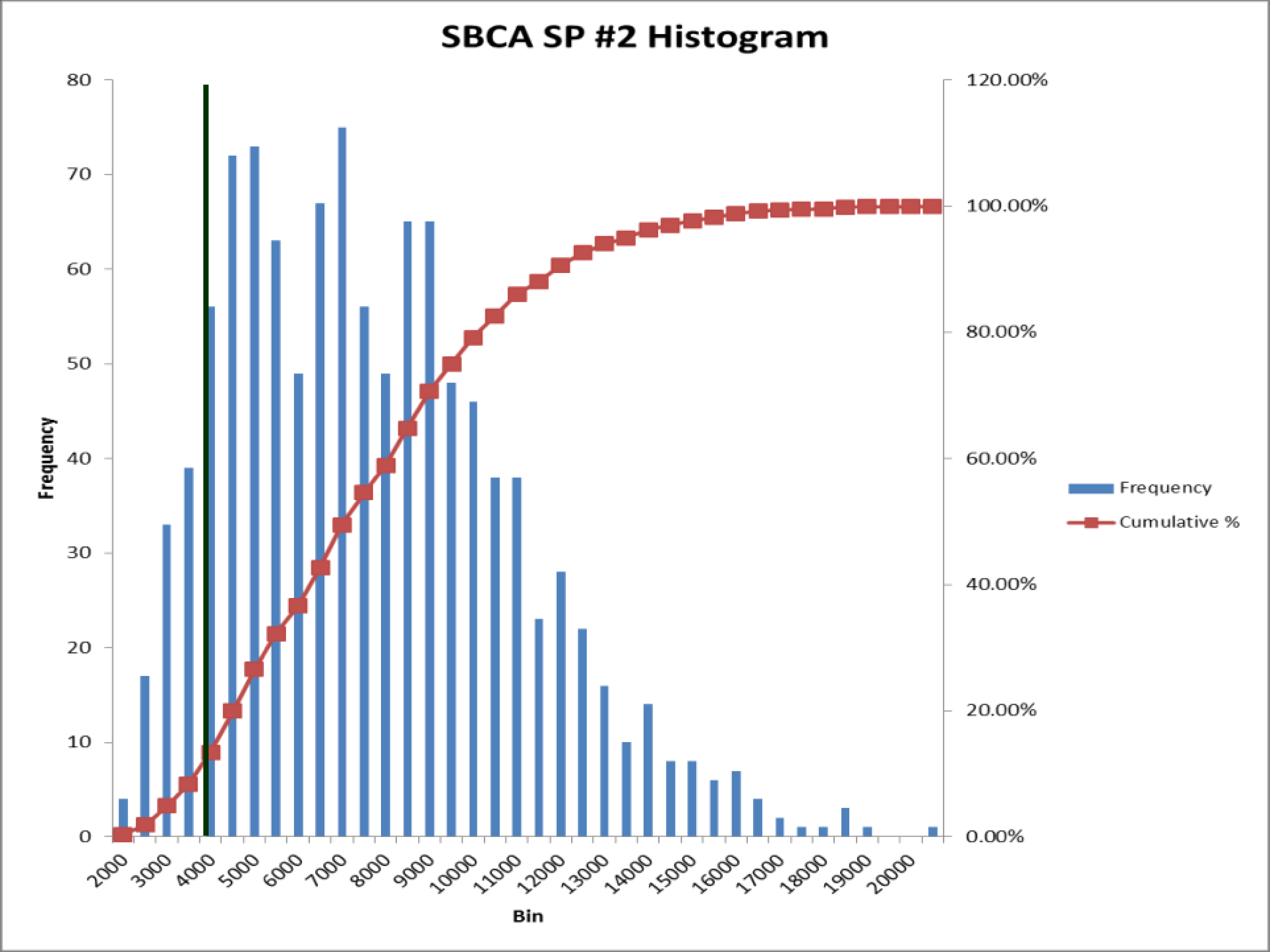

SBCA SP #2 Histogram
Frequency
Bin
0
10
20
30
40
50
60
70
80
0.00%
20.00%
40.00%
60.00%
80.00%
100.00%
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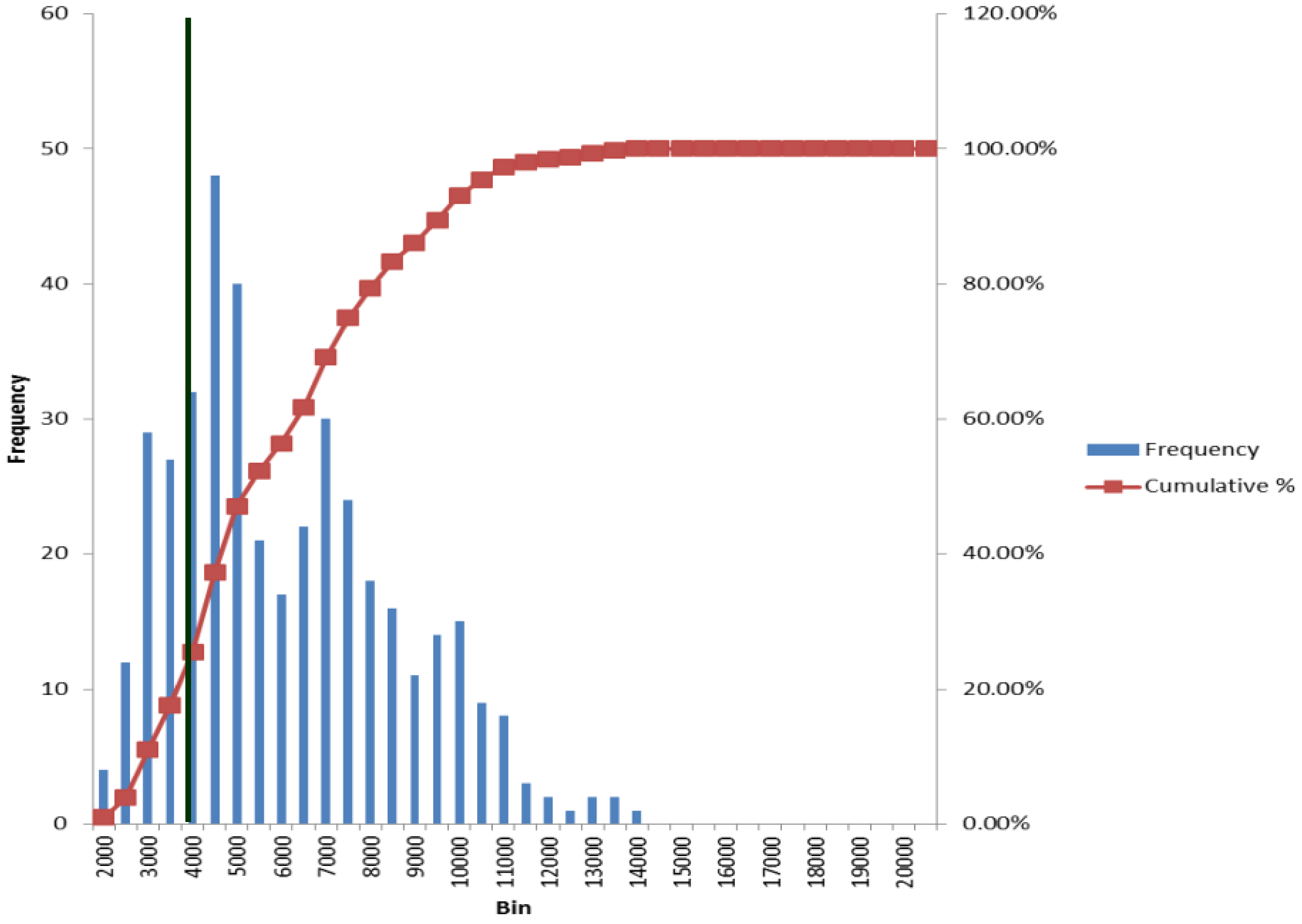
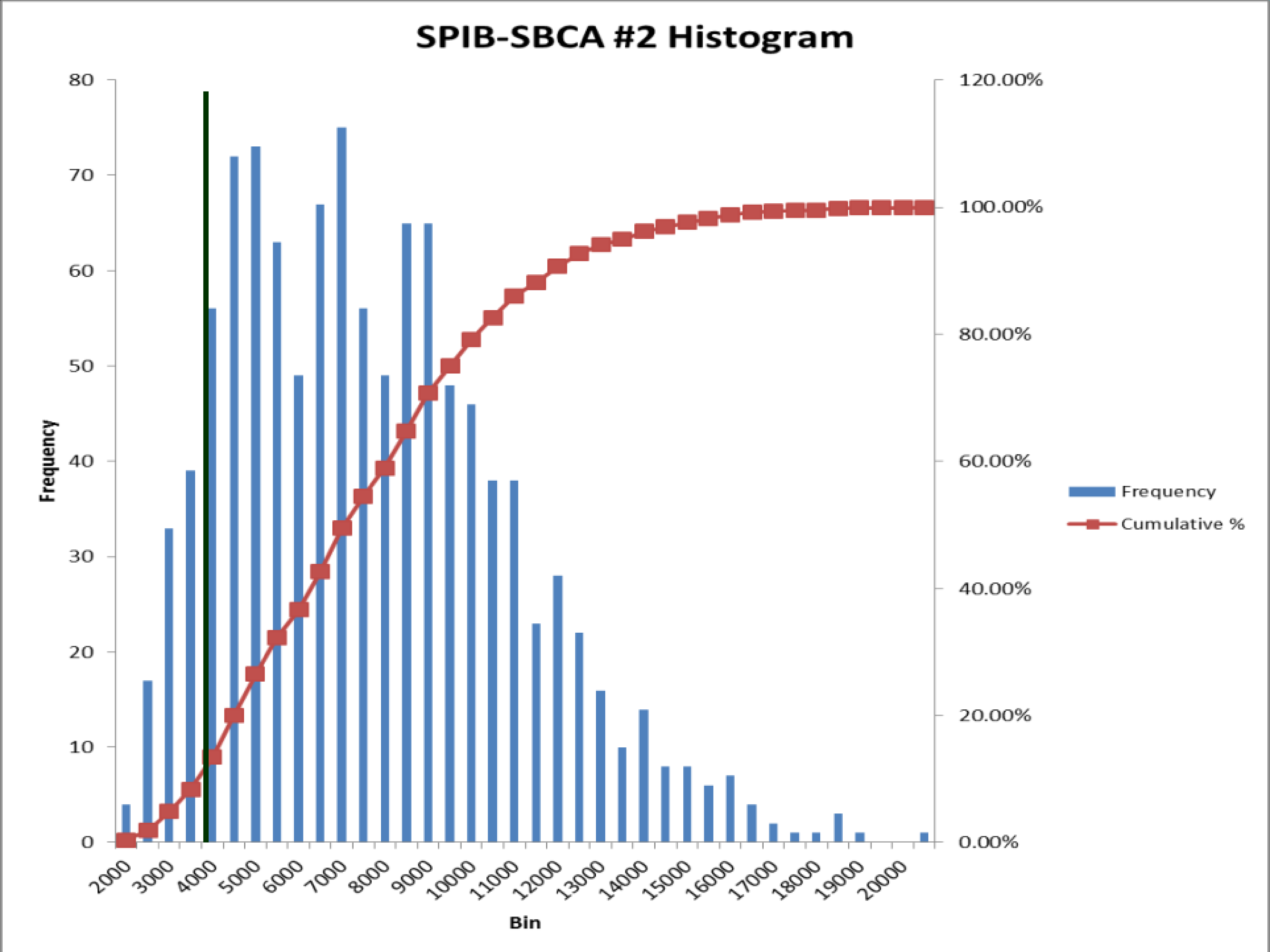
Frequency
Cumulative %

SPIB #2 HIstogram





SPIB-SBCA #2 Histogram
Frequency
Bin
Frequency
Cumulative %
0
10
20
30
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80
0.00%
20.00%
40.00%
60.00%
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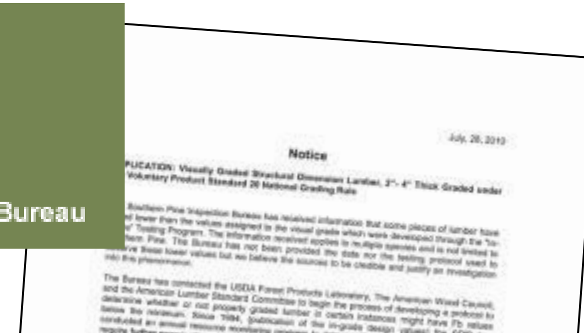
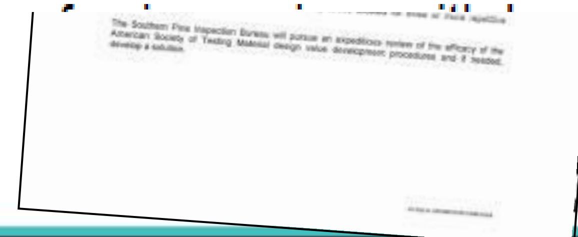
The Issue – July 2010

Southern Pine Inspection Bureau (SPIB) Update

Southern Pine Inspection Bureau



Our investigation will evaluate if there is a need to make some adjustments to either the grading rules or the design values. If consumers of visually graded lumber have



The Optimal Solution to Serve the Lumber & Lumber Using Industry’s Best Interests

- **End result of SPIB Testing Appendix A January 30, 2013**

APPENDIX A
DESIGN VALUES FOR WOOD

Wood is a natural product subject to variations in geography, climate, specific site characteristics, silvacultural practices, and harvesting decisions. Its’ strength properties are not only anisotropic (vary by principal axis) but also can vary with proximity to the center of the tree. These characteristics complicate the assignment of individual pieces into design value groups based on the visual appearance. American Society for Testing and Materials consensus standards D245, D2555 and D1990 are all used to assign design values for bending, tension and compression parallel to ranked by value (numerical order). This procedure, following the ASTM D2915, produces a tolerance limit that provides 75% confidence that the true population 5th percentile value is higher than this estimate. This value is then used to establish the design value. Designers of wood structures are cautioned to take into consideration the variability of wood within a species and grade grouping. Each piece or lot of visually graded lumber is not mechanically tested to verify strength properties. Since the stress ratings are representative of the entire producing region, lots from a specific location may have physical properties at the extremes of the property range or statistical distribution representing that range of strength values.

The Optimal Solution to Serve the Lumber & Lumber Using Industry's Best Interests

Design values are very important to structural end users. We buy accurate design values

Table 1-a – STRUCTURAL LIGHT FRAMING, STRUCTURAL JOISTS AND PLANKS, AND STUDS -2" TO 4" THICK
(Each width has a separate set of design values)

GRADE	Suggested Extreme Fiber in Bending "Fb"	Suggested Tension Parallel to Grain "Ft"	Suggested Horizontal Shear "Fv"	Suggested Compression Perpendicular to Grain "Fc^"	Suggested Compression Parallel to Grain "F$_{c//}$"	Suggested Modulus of Elasticity (million psi) "E"
Kiln Dried or S-Dry, MC 15, MC 19						
APPLIES TO 2" - 4" THICK – 2" - 4" WIDE ONLY						
Dense Select Structural	2700	1900	175	660	2050	1.9
Select Structural	2350	1650	175	565	1900	1.8
Non Dense Select Structural	2050	1450	175	480	1800	1.6
No. 1 Dense	1650	1100	175	660	1750	1.8
No. 1	1500	1000	175	565	1650	1.6
No. 1 Non Dense	1300	875	175	480	1550	1.4
No. 2 Dense	1200	750	175	660	1500	1.6
No. 2	1100	675	175	565	1450	1.4
No. 2 Non Dense	1050	600	175	480	1450	1.3
No. 3 and Stud	650	400	175	565	850	1.3

Table 1-b – STRUCTURAL LIGHT FRAMING, STRUCTURAL JOISTS AND PLANKS, AND STUDS -2" TO 4" THICK

Braced Wall Panel Design and Stick Framing Advantage

Why does this work? What is the value?

Why Evaluate the Testing?

Page 54
MAT107

AMERICAN FOREST & PAPER ASSOCIATION
American Wood Council
Engineered and Traditional Wood Products

Wall Bracing Materials & Methods

- Relative shear strength of the bracing methods is unknown
  - Lateral force resisting capacity of wall bracing is more a function of the overturning restraint than the shear capacity of the material.
  - Since braced walls don't have explicit overturning restraint, it is difficult to determine shear capacity.
    - Implicit overturning restraint provided by dead loads, overlapped nailing, etc.
    - Shear capacity highly affected by the dead load of the wall and the structure above.

This is a relatively formal way to say that we're not sure exactly what resistance to lateral loads are being provided by prescriptive bracing. We know from experience that it works under the limitations of conventional construction. However, since the wall isn't formally designed and it lacks elements of a shear wall, such as connections to the foundation or floor, it's hard to quantify the resistance to any exact degree.

Why Evaluate the Testing?

Page 54
MAT107

Wall Bracing Materials & Methods

Bracing method	Estimated Allowable Shear
1. Let-in diagonal 1x4	0 – 100 plf?
2. 5/8-in. diagonal boards	300 plf?
3. 3/8-in. WSP	220 plf?
4. 1/2-in. fiberboard	180 plf?
5. 1/2-in. gypsum board	100 plf?
6. 1/2-in. particleboard	140 plf?
7. 7/8-in. PC stucco	180 plf?
8. 7/16-in. hardboard	Unknown?

In a formal shear wall design, we can quantify the shear resistance in bracing material; in fact, the code provides those numbers for everything but let-in bracing. But because the overall resistance to racking in conventional construction isn't completely understood, we don't know exactly what shear resistance is being provided by the bracing material itself. Here are some estimates of the shear strength of the 8 allowed bracing materials applied according to the IRC. The widely varying numbers explain why different materials must be provided in different amounts.

Full Scale Anchor Bolt Testing: What Does APA say?

help evaluate and determine the strength of wood structural pan

rom the APA report (based upon 17 $^{7}/_{16}$" WSP BWP tests of var

ing without gypsum has an average peak value of 351 PLF (among 15
of 383 PLF (among 2 tests)[38]...

ews just the tests that have 4' and 8' of isolated bracing, similar t

Full Scale Anchor Bolt Testing: What Does APA say?

A *REVIEW OF LARGE SCALE WOOD STRUCTURAL PANEL BRACING TESTS* by Zeno Martin, P.E., Tom Skaggs, Ph.D.., P.E., Ed Keith, P.E., Borjen Yeh, P
APA – The Engineered Wood Association (Report to BSSC Bracing Committee May 2007)

Table 3. Summary of test results for isolated wood structural panel wall bracing without gypsum finish.

Row #	Description	Load at 0.5% drift (plf)	Peak Load (plf)	Total Length of Wall (ft)	Total Length of Bracing (ft)	Gyp --	Bracing --	Test Protocol --	Segment Width (ft)	Test # in Ref. --	Reference
25	4-ft wall isolated bracing segment	131	180	4	4	No	Isolated	mono.	4	718&719	Simpson, 2007a
30	20-ft wall isolated bracing segments, "Cabo"	136	204	20	8	No	Isolated	mono.	4	713&714	Simpson, 2007d
19	4-ft wall isolated bracing segment	210	225	4	4	No	Isolated	SPD	4	7	APA, 2006
31	20-ft wall isolated bracing, "Cabo" with 2x10 rim joist	158	238	20	8	No	Isolated	mono.	4	721&722	Simpson, 2007d
43	3D - NW: Cabo, NE: Cabo, SW: Cabo, SE: Cabo (+45)	177	256	20	32	No	Isolated	mono.	4	2006744	Simpson, 2007o
47	3D - NW: Cabo, NE: Cabo, SW: Cabo, SE: Cabo (-45)	168	265	20	32	No	Isolated	mono.	4	2006732	Simpson, 2007s
28	20-ft wall isolated bracing, "IRC Center"	115	294	20	4	No	Isolated	mono.	4	702&709	Simpson, 2007c
40	3D - W: Cabo, E: Cabo, N: Cabo, S: Cabo (90)	222	363	20	16	No	Isolated	mono.	4	2006715	Simpson, 2007l
39	3D - W: IRC Center, E: IRC Center, N: IRC Center, S: IRC Center (90)	181	394	20	8	No	Isolated	mono.	4	2006700	Simpson, 2007k
32	20-ft isolated bracing segment "IRC Side"	147	401	20	4	No	Isolated	mono.	4	710&711	Simpson, 2007e
46	3D - NW: IRC Center, NE: IRC Center, SW: IRC Center, SE: IRC Center (+45)	177	420	20	16	No	Isolated	mono.	4	2007001	Simpson, 2007r
29	20-ft wall isolated bracing, "IRC Center" with 2x10 rim joist	172	467	20	4	No	Isolated	mono.	4	723&724	Simpson, 2007c
34	3D - W: Cabo, E: Cabo, N: Cabo, S: Cabo (0)	281	469	20	16	No	Isolated	mono.	4	2006716	Simpson, 2007f
38	3D - W: IRC Center, E: IRC Center, N: IRC Center, S: IRC Center (0)	219	513	20	8	No	Isolated	mono.	4	2006703	Simpson, 2007j
33	20-ft isolated bracing "IRC Side" with 2x10 rim joist	307	582	20	4	No	Isolated	mono.	4	726&727	Simpson, 2007e
	Average =	**187**	**351**								
	Minimum =	**115**	**180**								
	Maximum =	**307**	**582**								

Table 6. Summary of test results for isolated wood structural panel wall bracing with gypsum finish.

Row #	Description	Load at 0.5% drift (plf)	Peak Load (plf)	Total Length of Wall (ft)	Total Length of Bracing (ft)	Gyp --	Bracing --	Test Protocol --	Segment Width (ft)	Test # in Ref. --	Reference
3	40-ft wall with isolated bracing	237	366	40	12	Yes	Isolated	mono.	4	E	Dolan and Heine, 1997a
6	40-ft wall with isolated bracing	273	400	40	12	Yes	Isolated	SPD	4	E	Dolan and Heine, 1997b
	Average =	**255**	**383**								

IRC Wall Bracing Design Values

IRC NUSC Values for the Primary Wood Structural Panel (WSP) Products Used in the Market Based on Work of the ICC Ad Hoc Committee – Wall Bracing (AHC-WB)	Fastener	Fastener Spacing	NUSC (plf) SPF Studs at 16" o.c.	ICC AHC-WB Net Adjustment Factor	*IRC* Effective NUSC (plf)
$^3/_8$" (& $^7/_{16}$" $^{15}/_{32}$", etc.) WSP (sheathing)	2" x 0.113" (6d) nail	6:12	500 (515 plf in *SDPWS*)	1.20	600
$^1/_2$" GWB (gypsum wallboard)	5d cooler nail Type W or S screw 1" long (gypsum)	8:8 Nail or 16:16 Screw	200 (200 plf in *SDPWS*)	1.20	240
Combined WSP & $^1/_2$" GWB	As above	As above	700	1.20	840

[1]Seismic Design Categories A, B and Detached dwellings in C only.

Application of sheathing is as follows – Minimum length of bracing on a braced wall line: 48"; Minimum braced wall panel length: 48"; Thickness: $^3/_8$"; Minimum span rating: Wall-16 for studs 16" o.c.; Minimum span rating: Wall-24 for studs 24" o.c.; Minimum fastener: 6d common (2" x 0.113"); Minimum fastener nailing: 6" at panel edges and 12" on intermediate studs; Minimum edge distance from *SDPWS*: $^3/_8$".

Table 1: *IRC* NUSC Values Created by the ICC AHC-WB

FUTURE OF FRAMING

“To get ahead, we need to see what's possible and go there and try some things…”

“…rather than sit tight and protect my little egg.”

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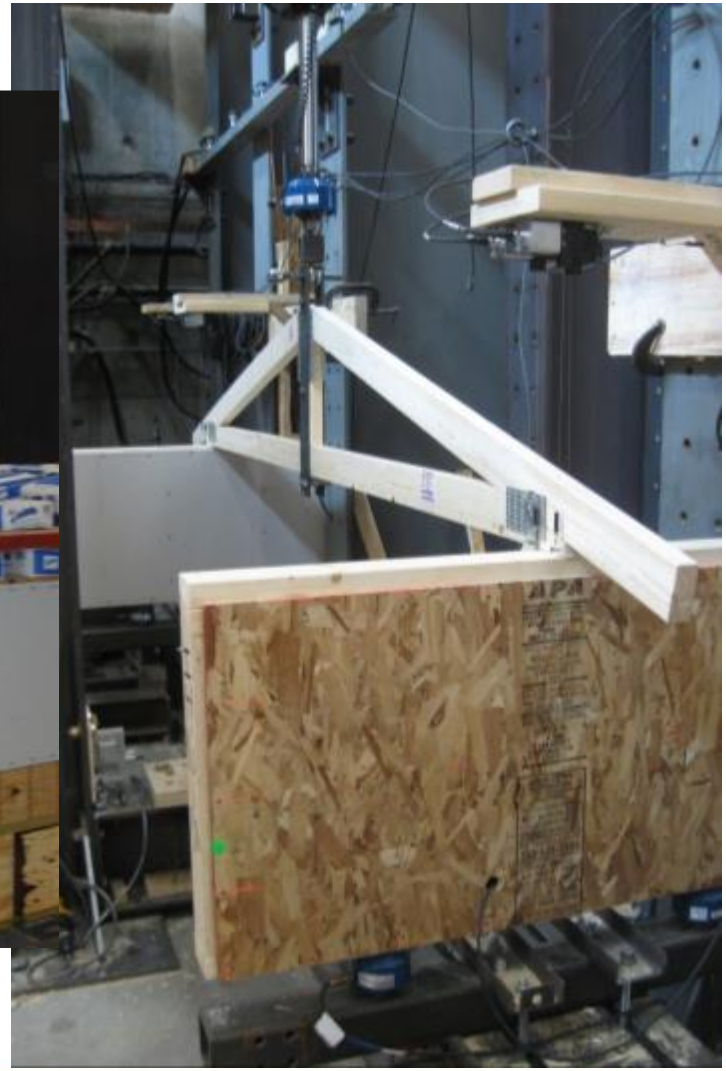

SBCA/TPI Industry “Testing Program” Exhibit A

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Load Path

Maintaining a continuous load path is a key building code requirement as adopted into law.

SECTION R301
DESIGN CRITERIA

R301.1 Application. Buildings and structures, and all parts thereof, shall be constructed to safely support all loads, including dead loads, live loads, roof loads, flood loads, snow loads, wind loads and seismic loads as prescribed by this code. The construction of buildings and structures in accordance with the provisions of this code shall result in a system that provides a complete load path that meets all requirements for the transfer of all loads from their point of origin through the load-resisting elements to the foundation. Buildings and structures constructed as prescribed by this code are deemed to comply with the requirements of this section.

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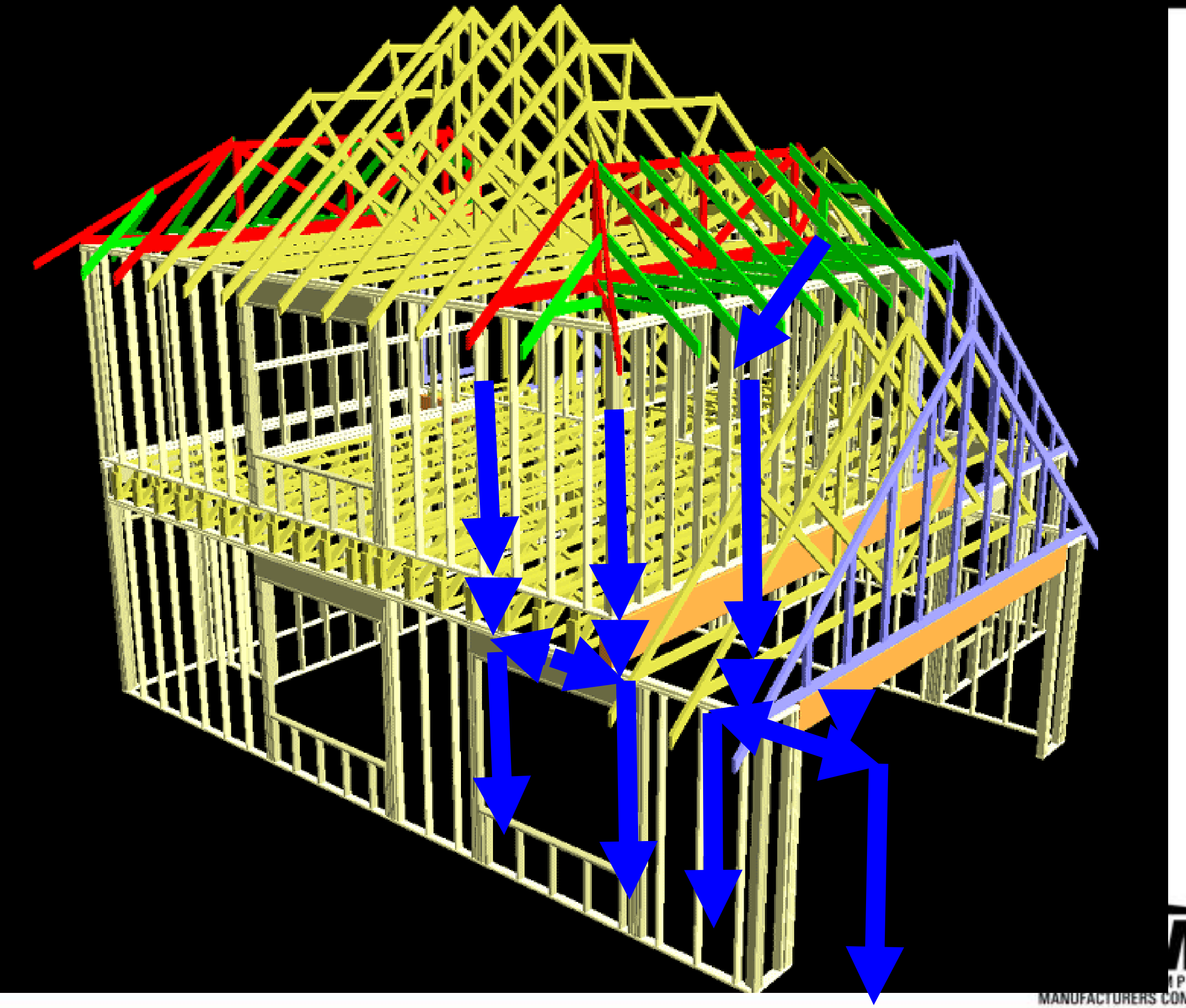
Load Path



Test Program Creation & Implementation Task Group

- SBCRI Test Program Creation and Implementation Task Group for CMs
  - Dave Motter, P.E. (co-chair)
  - Paul Johnson, P.E. (co-chair)
  - Steve Kennedy, P.E.
  - Bob Dayhoff
  - SBCA Staff Support
    - Dan Hawk, E.I.T. (SBCRI-Qualtim)
    - Keith Hershey (SBCRI-Qualtim)
    - SBCA (Qualtim) Professional Engineers for vetting

Current Project:
Top-Chord Bearing Limits

- Issue:
  - Section 7.4.2 of TPI 1-2007 limits bearing capacity of top chord bearing parallel chord trusses
  - Design limits have been questioned and can be exceeded with sufficient test data
- Testing Pertinent to:
  - Plate/Software Suppliers
  - Component Manufacturers
  - ANSI/TPI with TPI member vetting
  - Generally Accepted Engineering Practice

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Current Project:
Top-Chord Bearing Limits

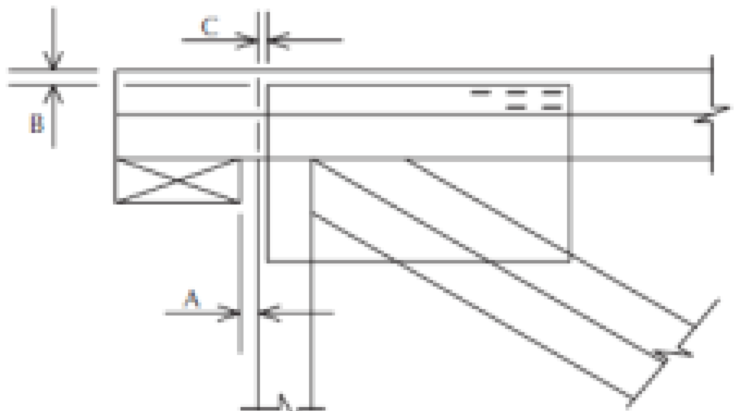

Figure 7.4-1(b)

Trusses Tested	Data Points	End Type	Top-Chord Lumber	Species	Gap
2	4	7.4.1(b)	#2	SPF	1/2"
2	4	7.4.1(b)	#2	SYP	1/2"
2	4	7.4.1(b)	#2	DF	1/2"
2	4	7.4.1(b)	2400 MSR	SPF	1/2"
2	4	7.4.1(b)	2400 MSR	SYP	1/2"

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Current Project: Top-Chord Bearing Limits

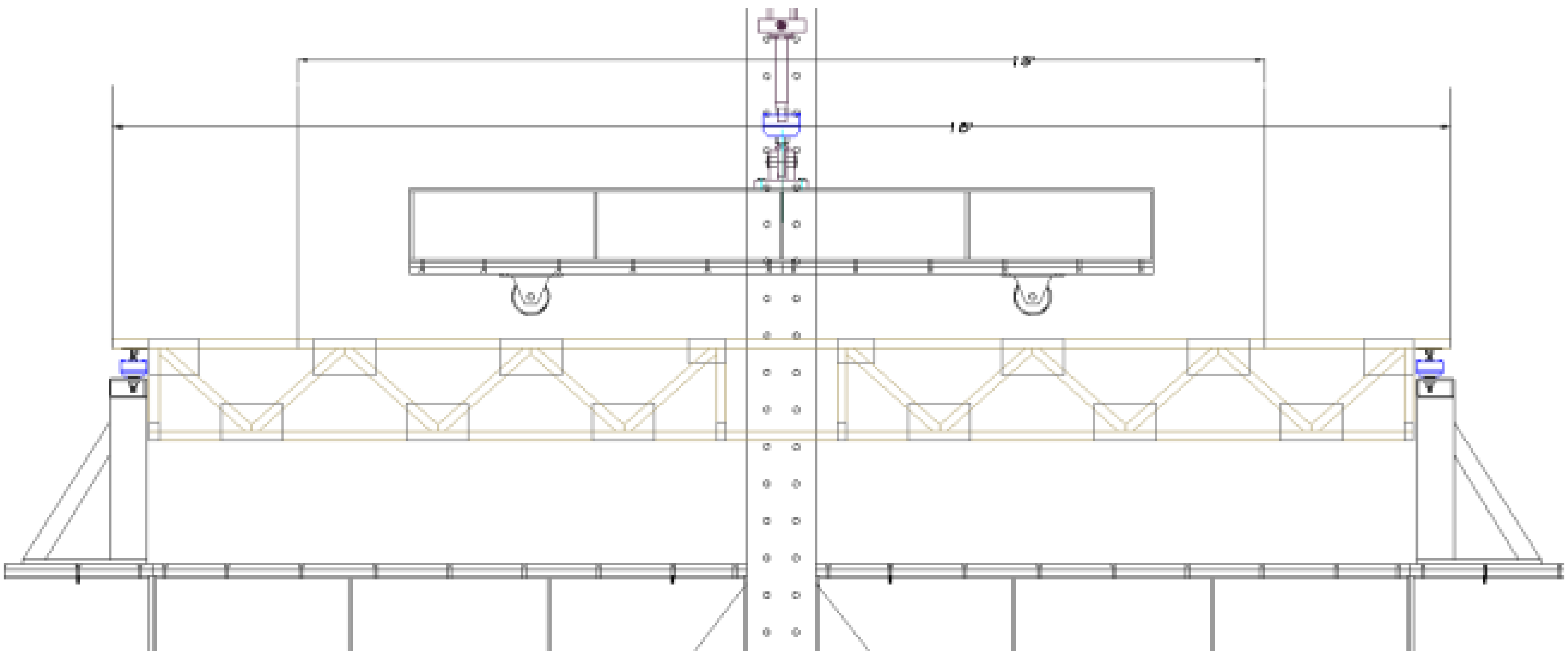

Figure 2: Representation of the Test Fixturing

Proprietary Project with Industry Data Value: Resilient Channel

- Proprietary Project set up in SBCRI
- Completion of project resulted in non-destruction of assembly
- Utilized the assembly for quick, low-cost testing
- Determine the effect resilient channel has on lateral resistance which would or would not act as bottom chord bracing for a floor or roof assembly

Proprietary Project with Industry Data Value: Resilient Channel

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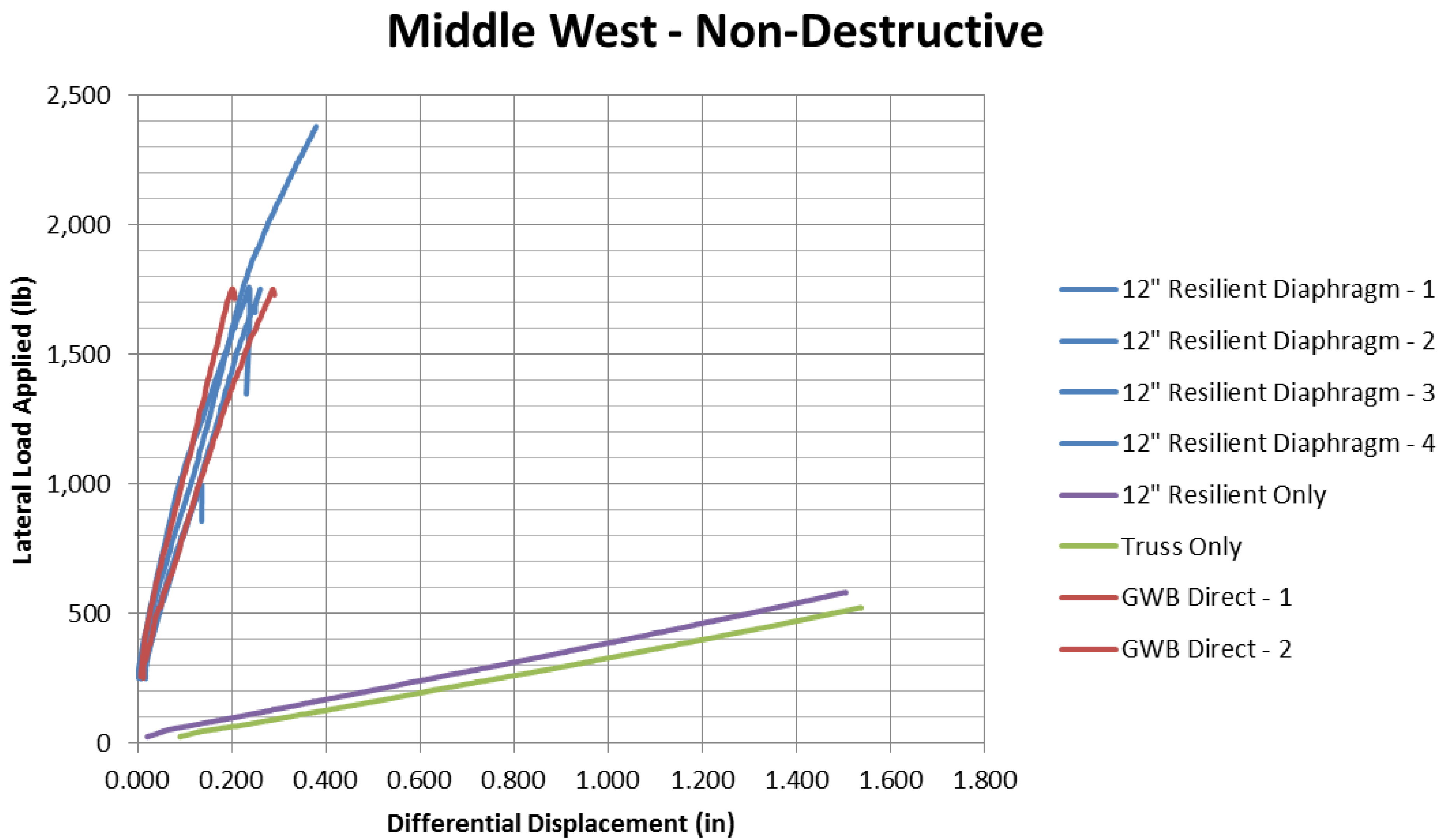
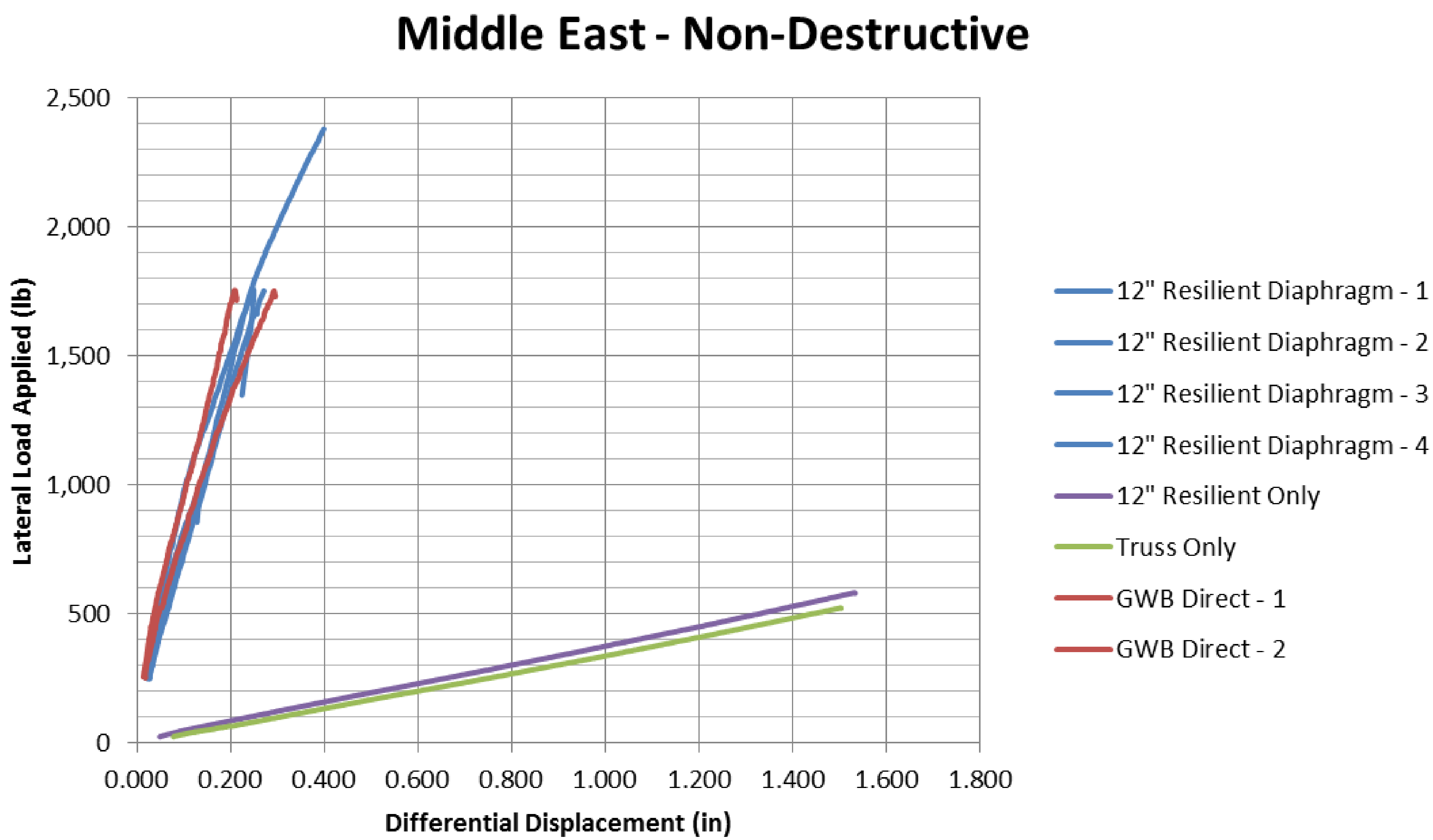
Proprietary Project with Industry Data Value: Resilient Channel



Proprietary Project with Industry Data Value: Resilient Channel



Proprietary Project with Industry Data Value: Resilient Channel

- Proprietary Project set up in SBCRI
- Completion of project resulted in non-destruction of assembly
- Utilized the assembly for quick, low-cost testing
- Evaluating long term creep performance.
  - 4 assemblies overloaded by up to 45%, yet still compliant with code based deflection limits.
  - First two assemblies had load applied for greater than 10 days.
  - Last two assembly have had applied load for greater than 10 days and are still loaded.

Other Proposed Projects in No Particular Order

- Heel Blocking
- Ply-to-Ply Girder Connections
- Web Reinforcement Bracing
- Repair Types & Methods
- Full System Assembly Testing

Heel Blocking

- Issue
  - Need method to transfer lateral load from the roof diaphragm to the shear wall
  - What is the capacity of heel blocks?
  - What is the capacity of partial height blocking?
  - When is blocking unnecessary?
- Testing Pertinent to:
  - Building Code
  - Generally Accepted Engineering Practice
  - Plate/Software Suppliers
  - Component Manufacturers
  - ANSI/TPI with TPI member vetting
  - BCSI

Ply-to-Ply Girder Connections

- Issue
  - What load transfer is there between plies?
  - Is there no, partial or full composite action?
  - What are minimum:
    - Nails required?
    - Screws required?
    - Bolts required?
- Testing Pertinent to:
  - Building Code/NDS
  - Generally Accepted Engineering Practice
  - Plate/Software Suppliers
  - Component Manufacturers
  - ANSI/TPI with TPI member vetting
  - BCSI

Web Reinforcement Bracing

- Issue
  - What is the design capacity of permanent “T”, “L” or “I” web bracing?
  - What are the minimum fastening requirements to achieve an acceptable capacity?
- Testing Pertinent to:
  - Generally Accepted Engineering Practice
  - Plate/Software Suppliers
  - Component Manufacturers
  - ANSI/TPI with TPI member vetting
  - BCSI

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Repair Methods

- Issue
  - What are the true capacities or effects of:
    - Holes in Truss Members
    - Scabs
      - Nails
      - Screws
      - Nails or Screws with Glue
    - Gussets (Single and Double Shear)
      - Nails (Clinched and Non-Clinched)
      - Screws
      - Nails or Screws with Glue

Repair Methods

- Testing Pertinent to:
  - Building Code
  - Generally Accepted Engineering Practice
  - Plate/Software Suppliers
  - Component Manufacturers
  - ANSI/TPI with TPI member vetting
  - BCSI

Full System Assembly Testing

- Test a truss assembly to quantify & benchmark
  - System Strength Effects
  - System Stiffness Effects
  - External Load Path
  - Internal Load Distribution

Full System Assembly Testing

- Test each component for comprehensive data
  - Lumber
    - As Tested Strength Properties
    - As Tested MOE
    - NDS Allowable Strength Design Values
    - NDS Allowable MOE
  - Individual Truss Performance
    - Stiffness
    - Strength
    - Internal Load Distribution
  - Assembly Performance
    - Stiffness
    - Strength
    - External Load Path
    - Internal Load Distribution

Full System Assembly Testing

- Testing Pertinent to:
  - Building Code
  - Generally Accepted Engineering Practice
  - Plate/Software Suppliers
  - Component Manufacturers
  - ANSI/TPI with TPI member vetting
  - BCSI

SBCRI Testing Examples Innovation Advantage

Knowledge Is Power?

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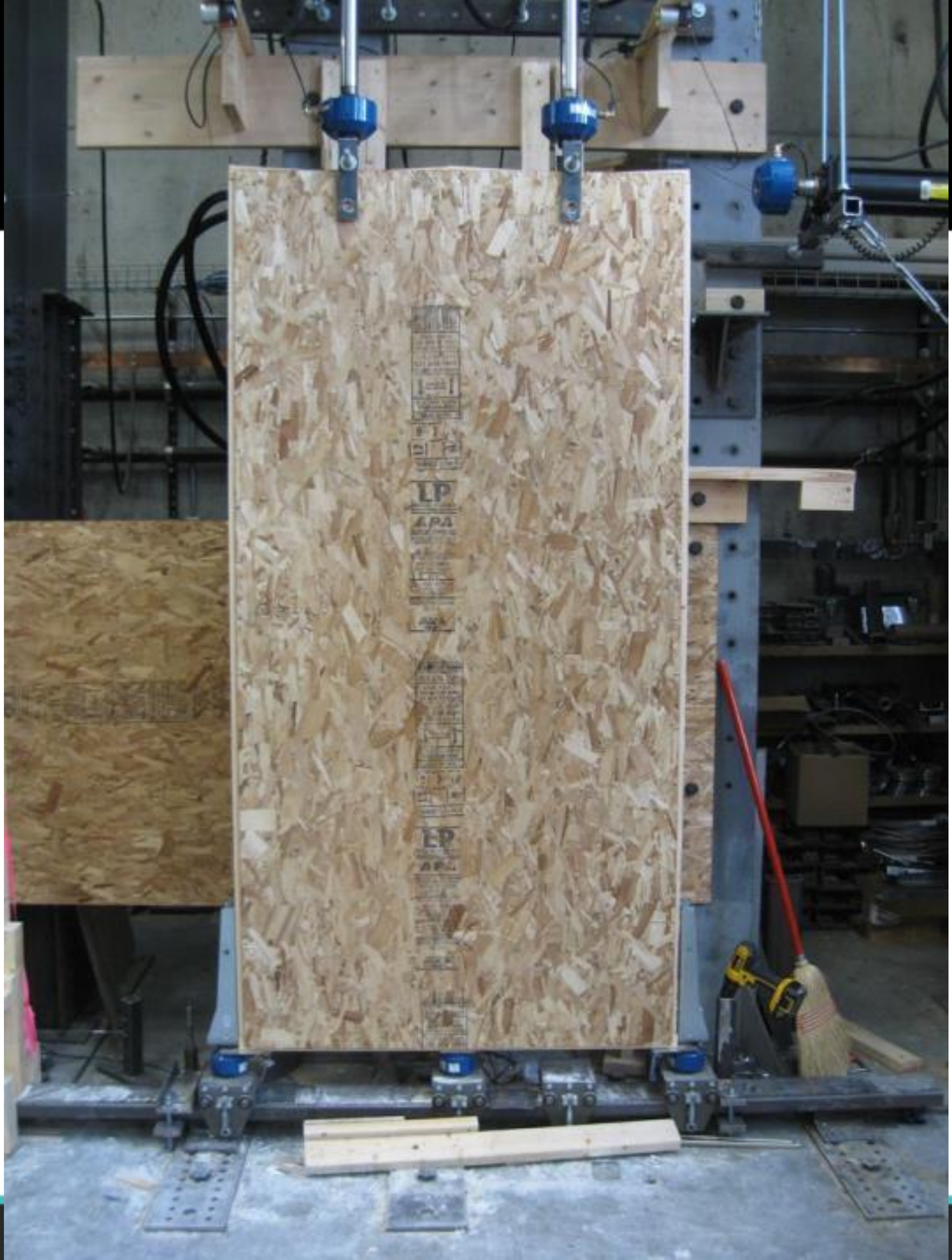
G1



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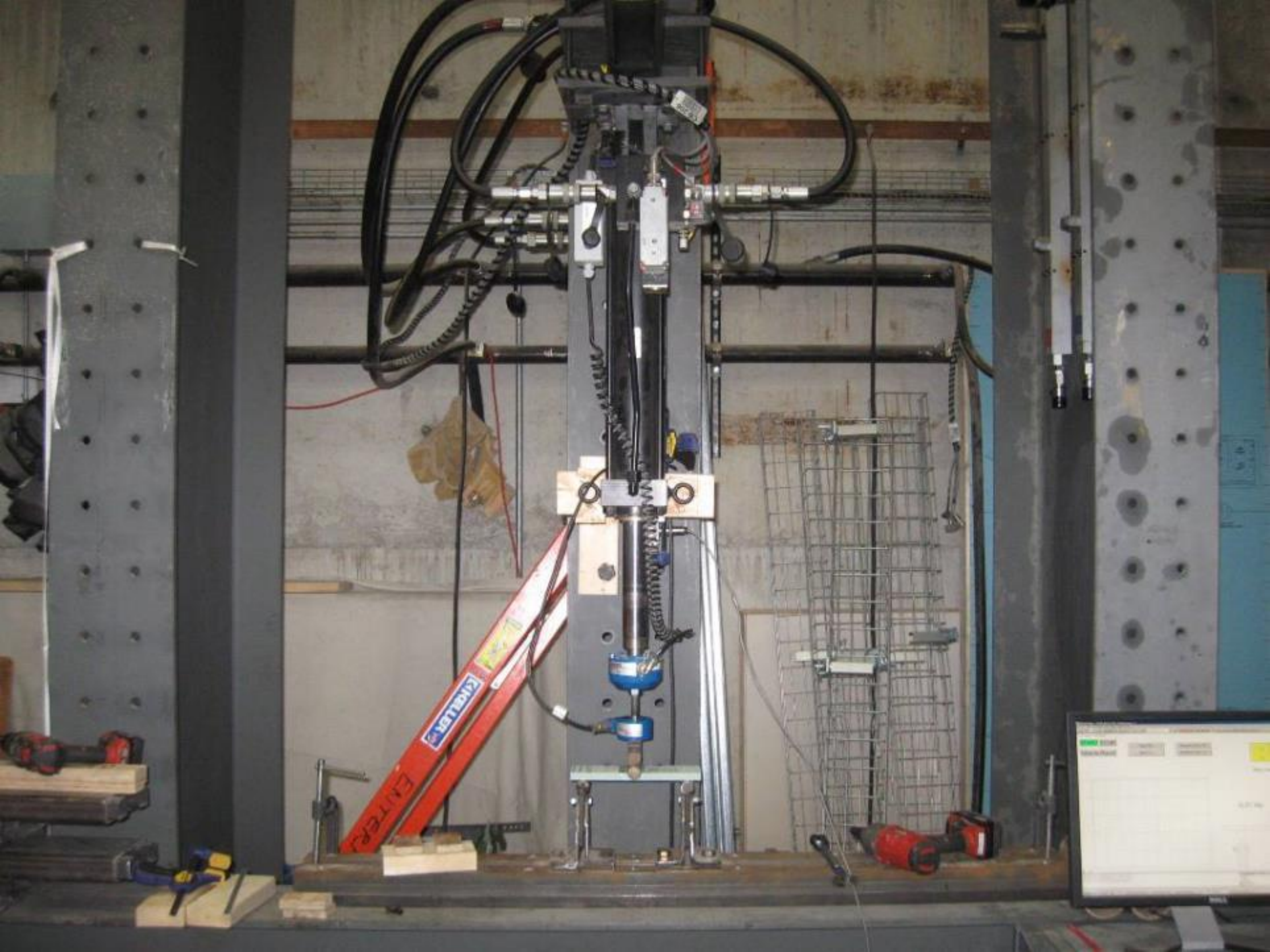
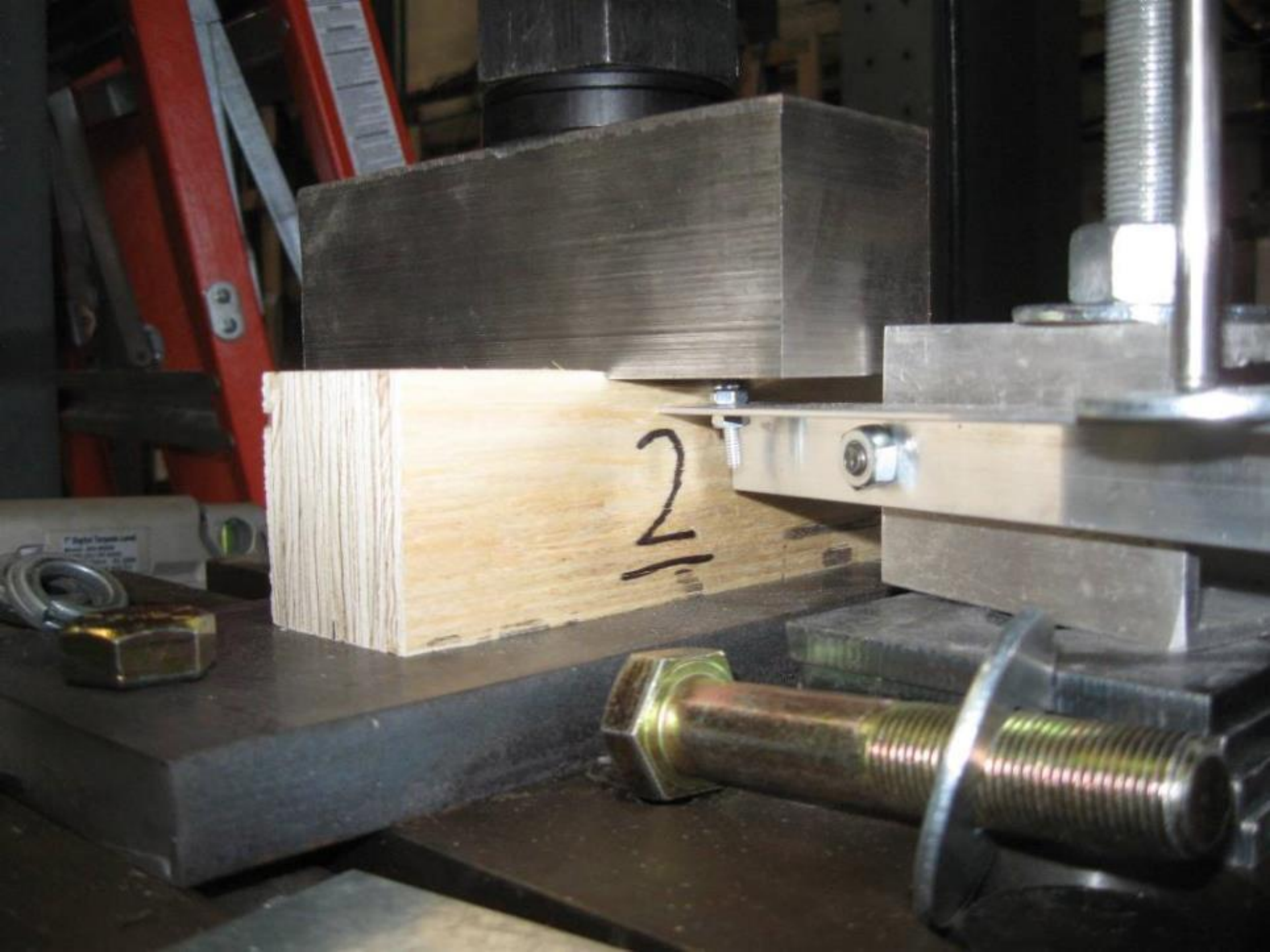

KELLER


B2-1


B1-1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B4-3


F1-6


6
G1-7

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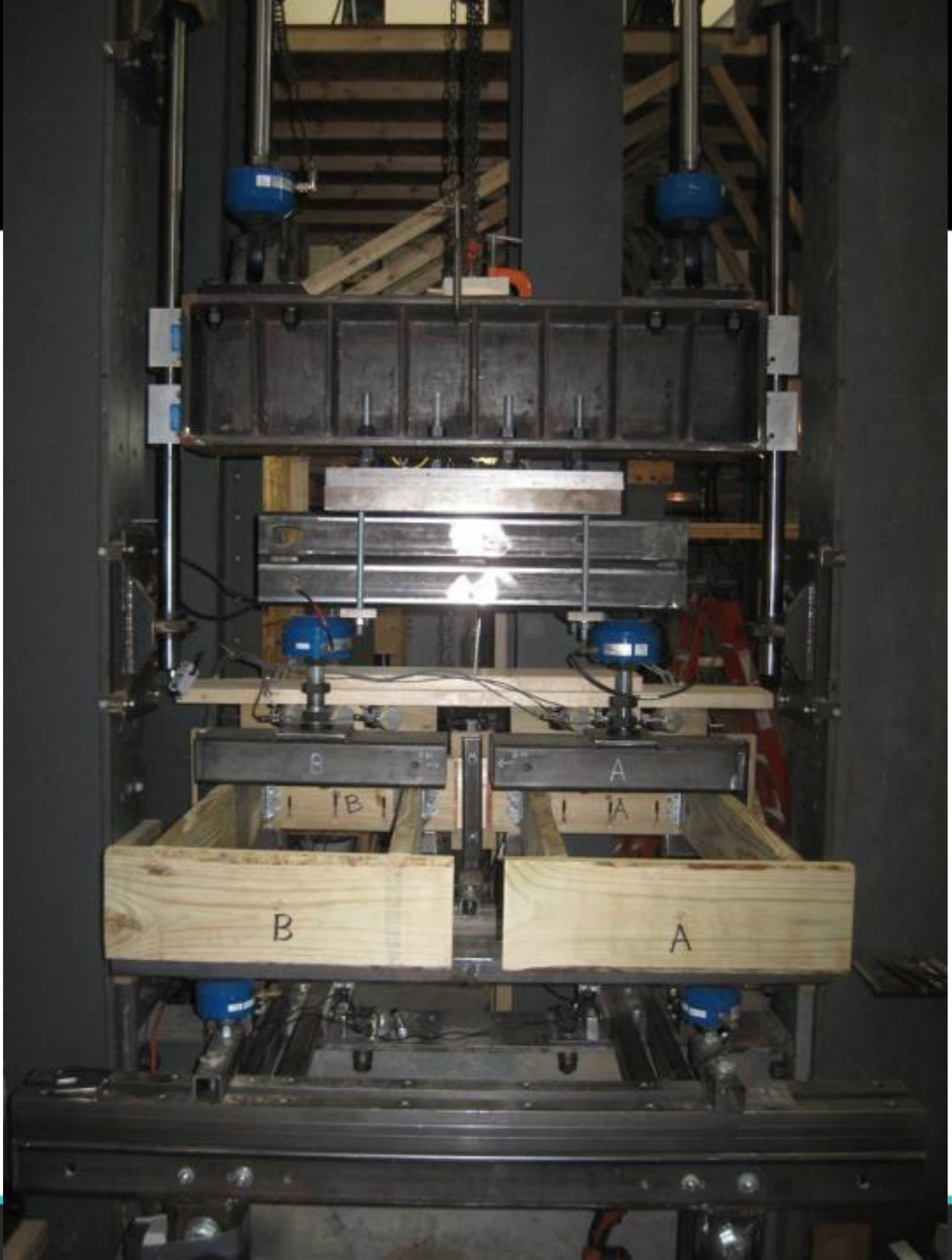

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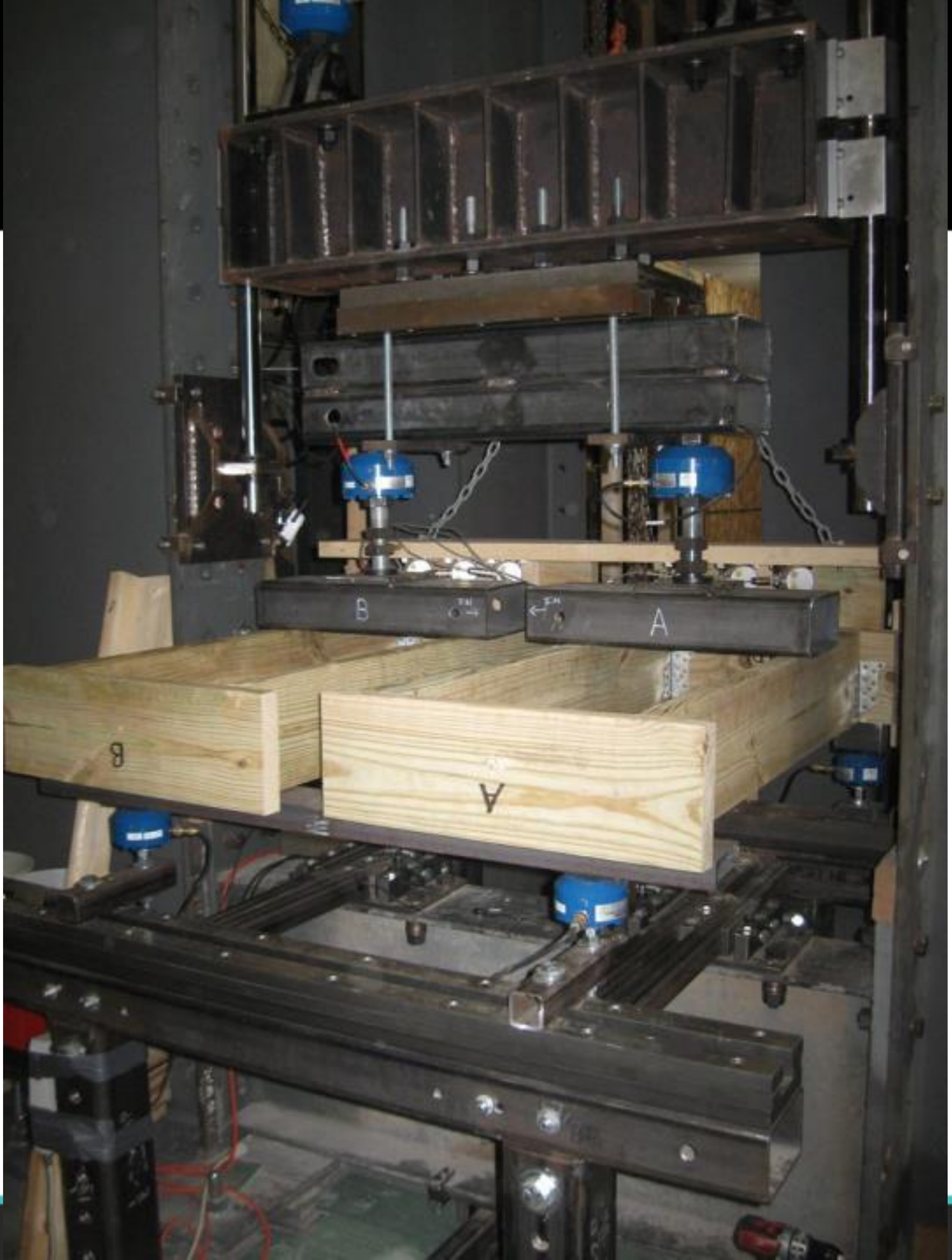

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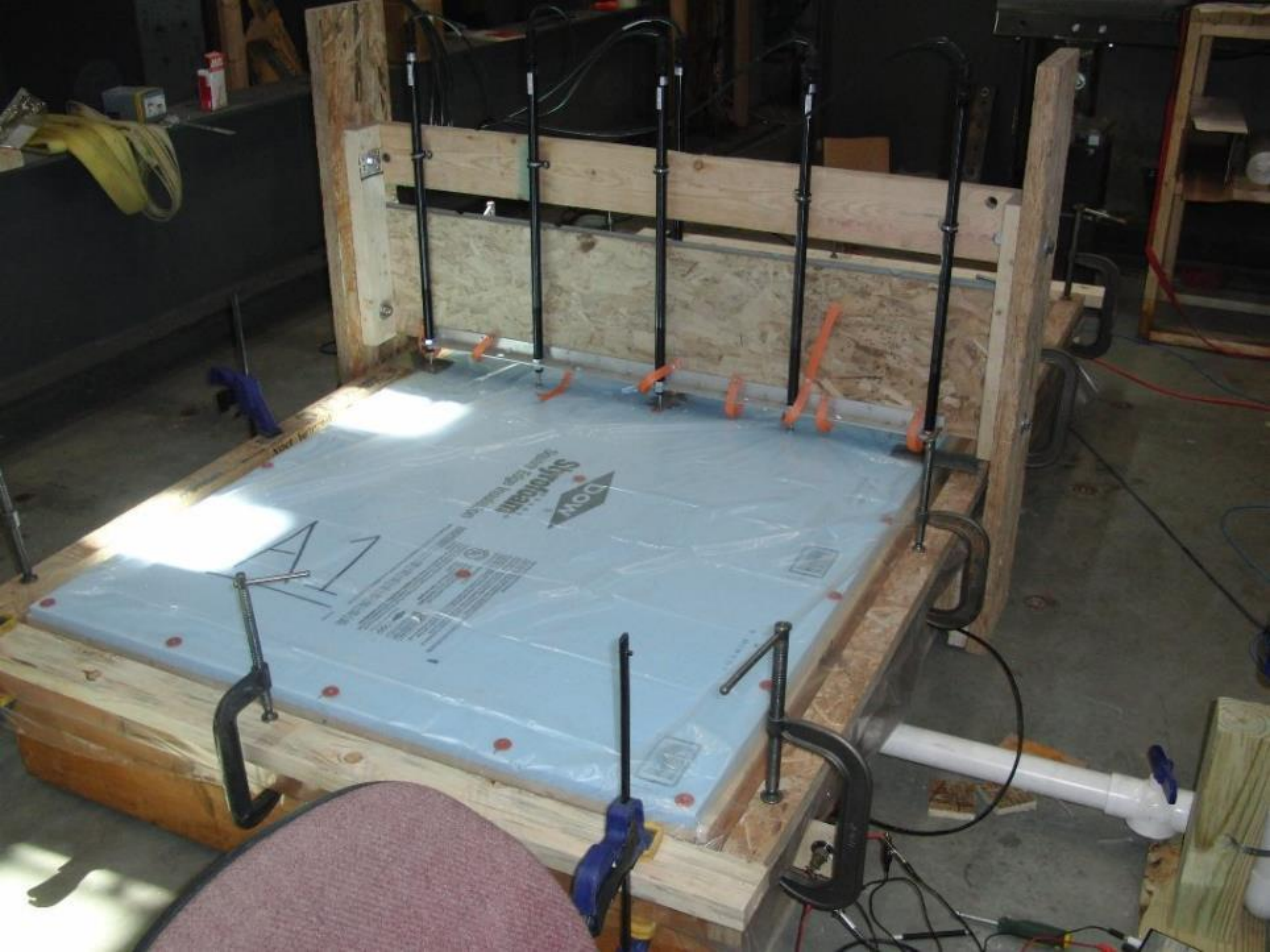
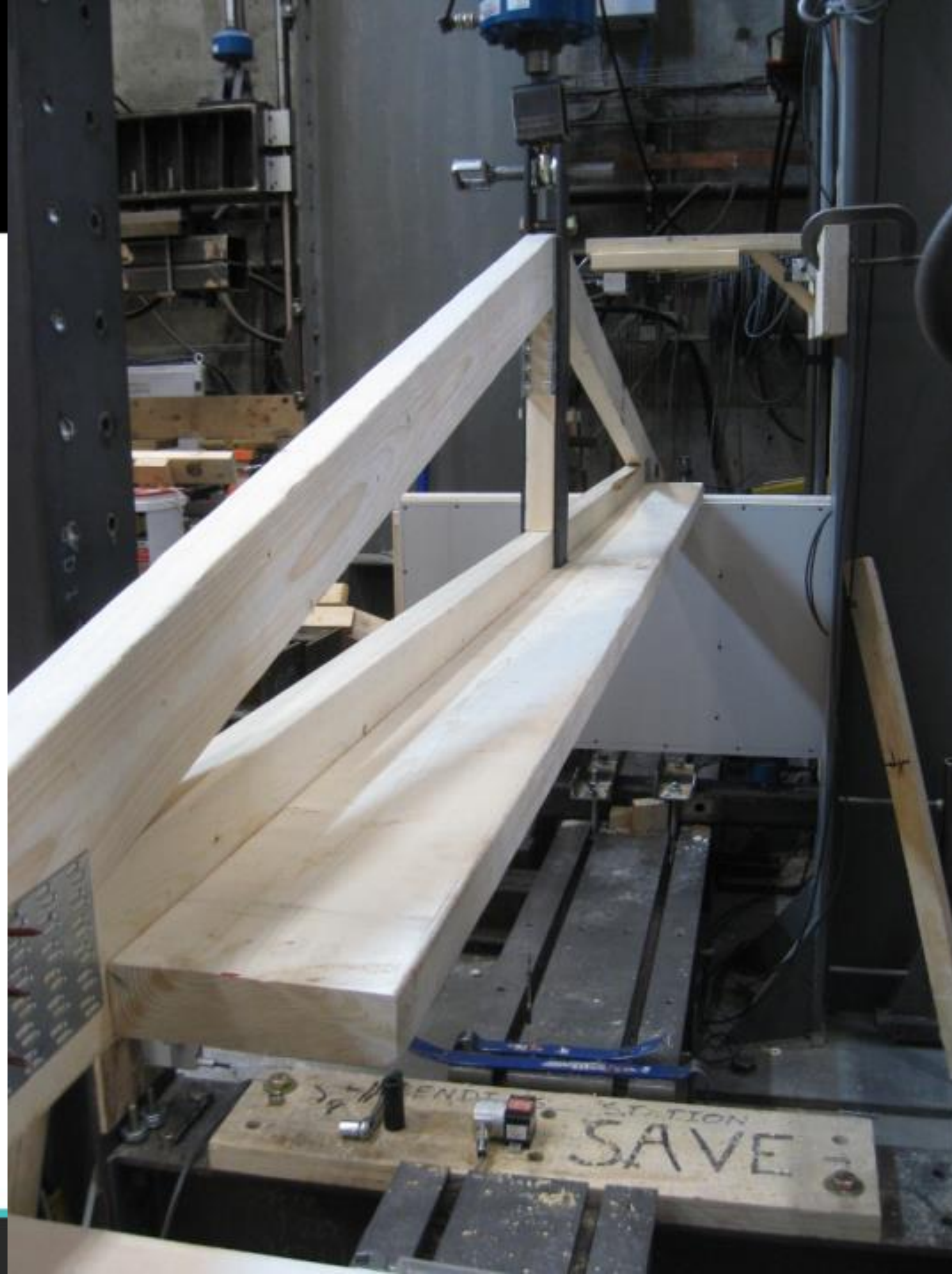

A1


Vacuum Box


B1-2


C1a


SAVE

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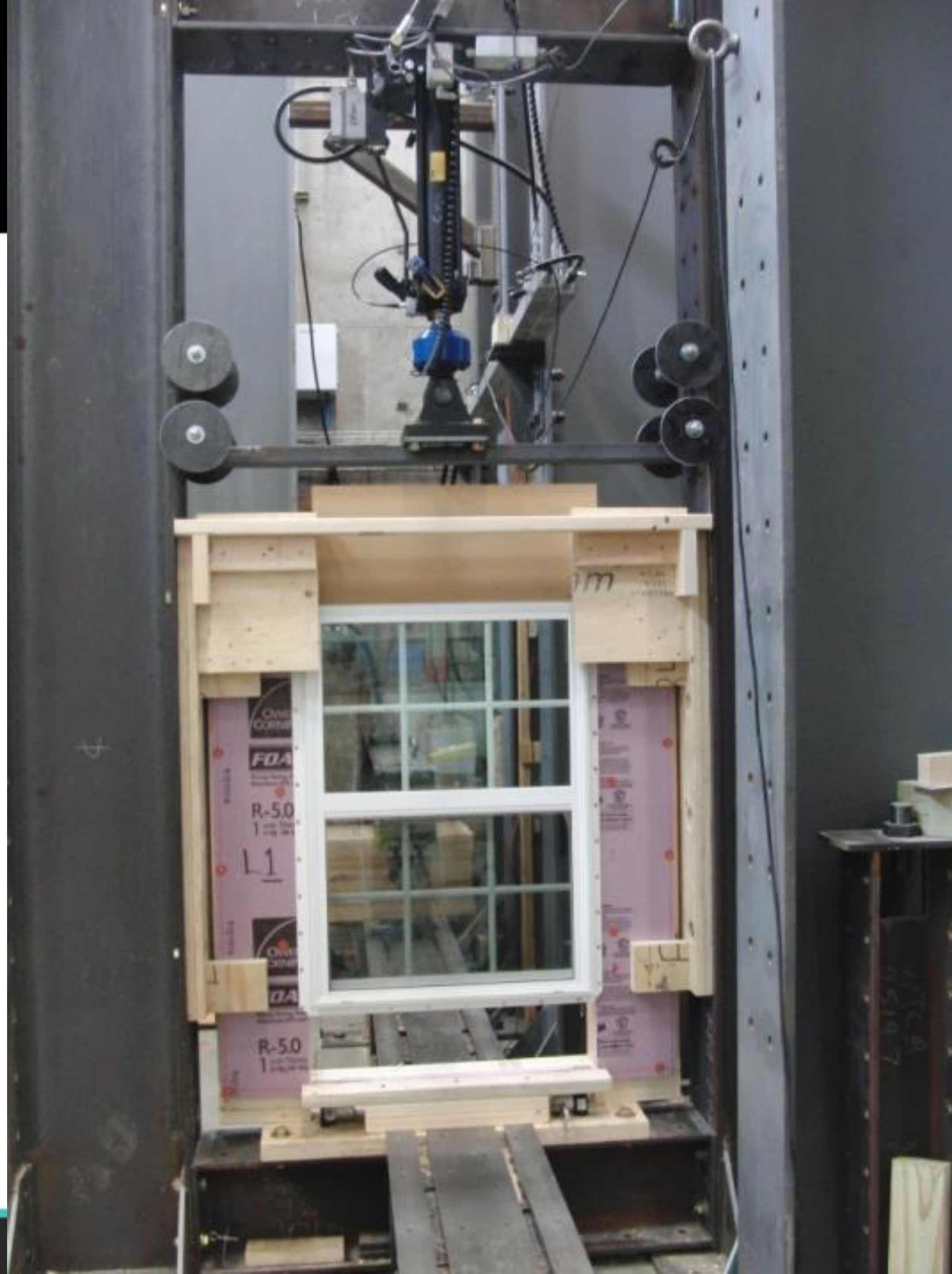
C2
FOAMULAR 150



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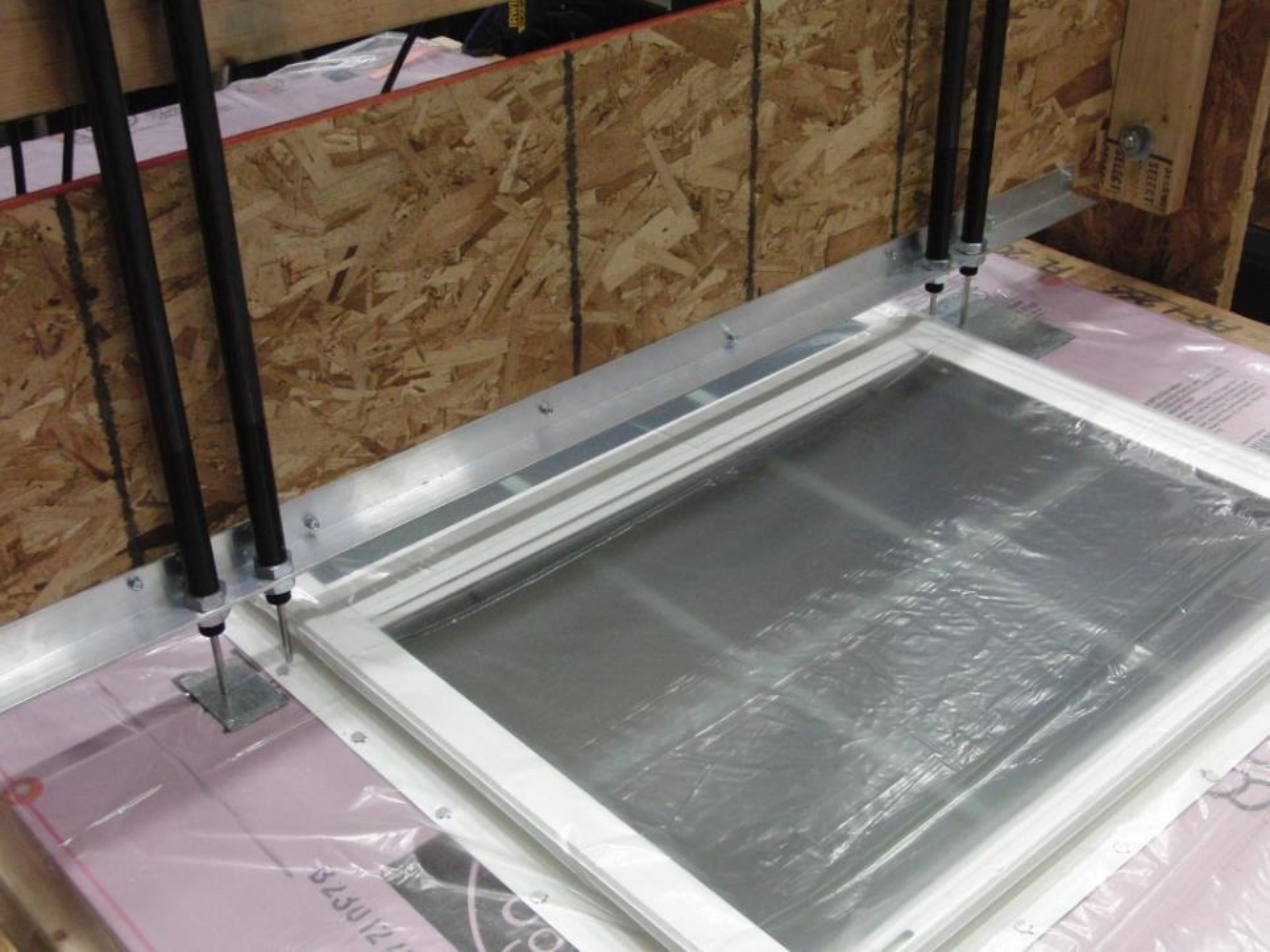
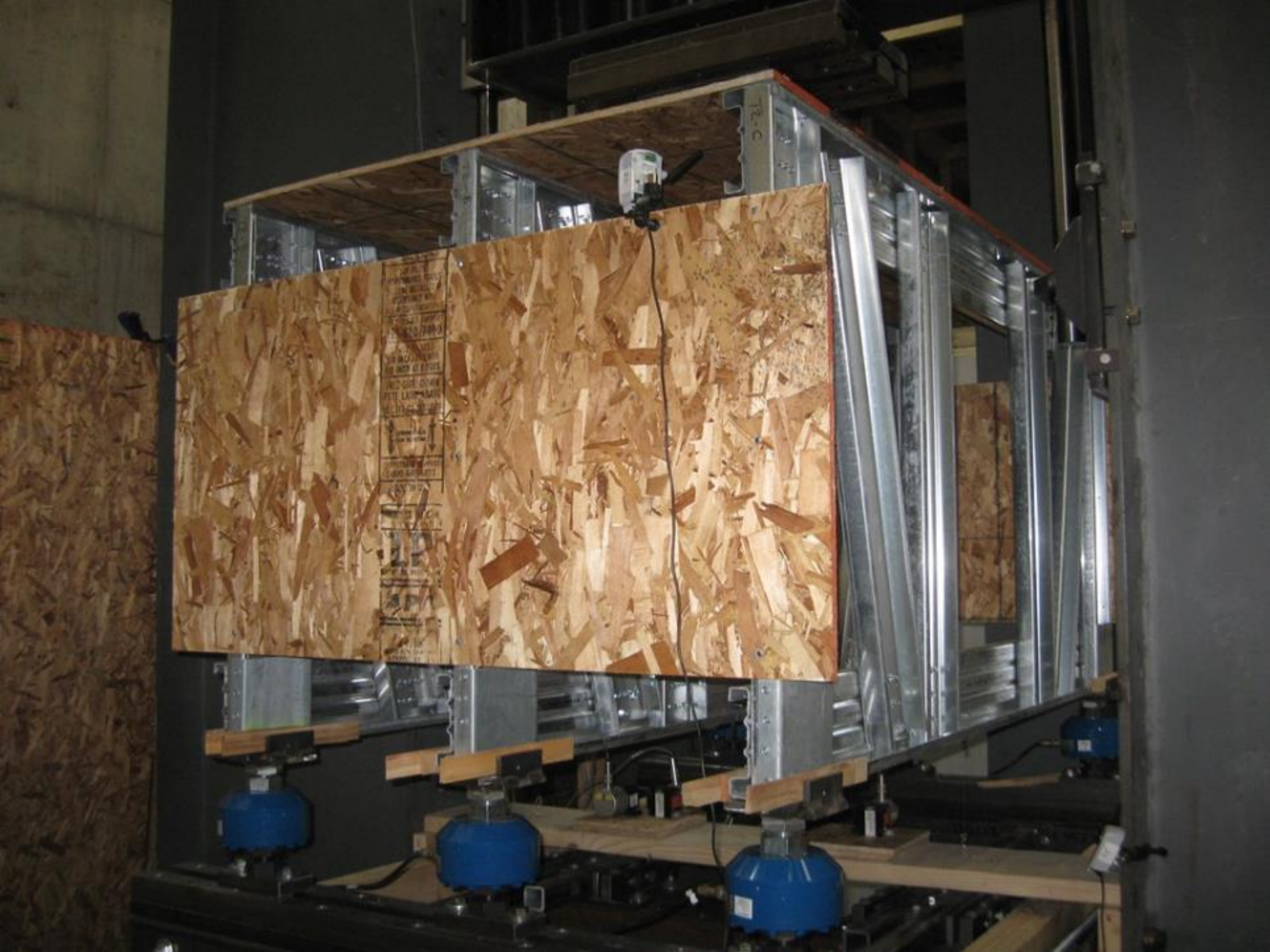
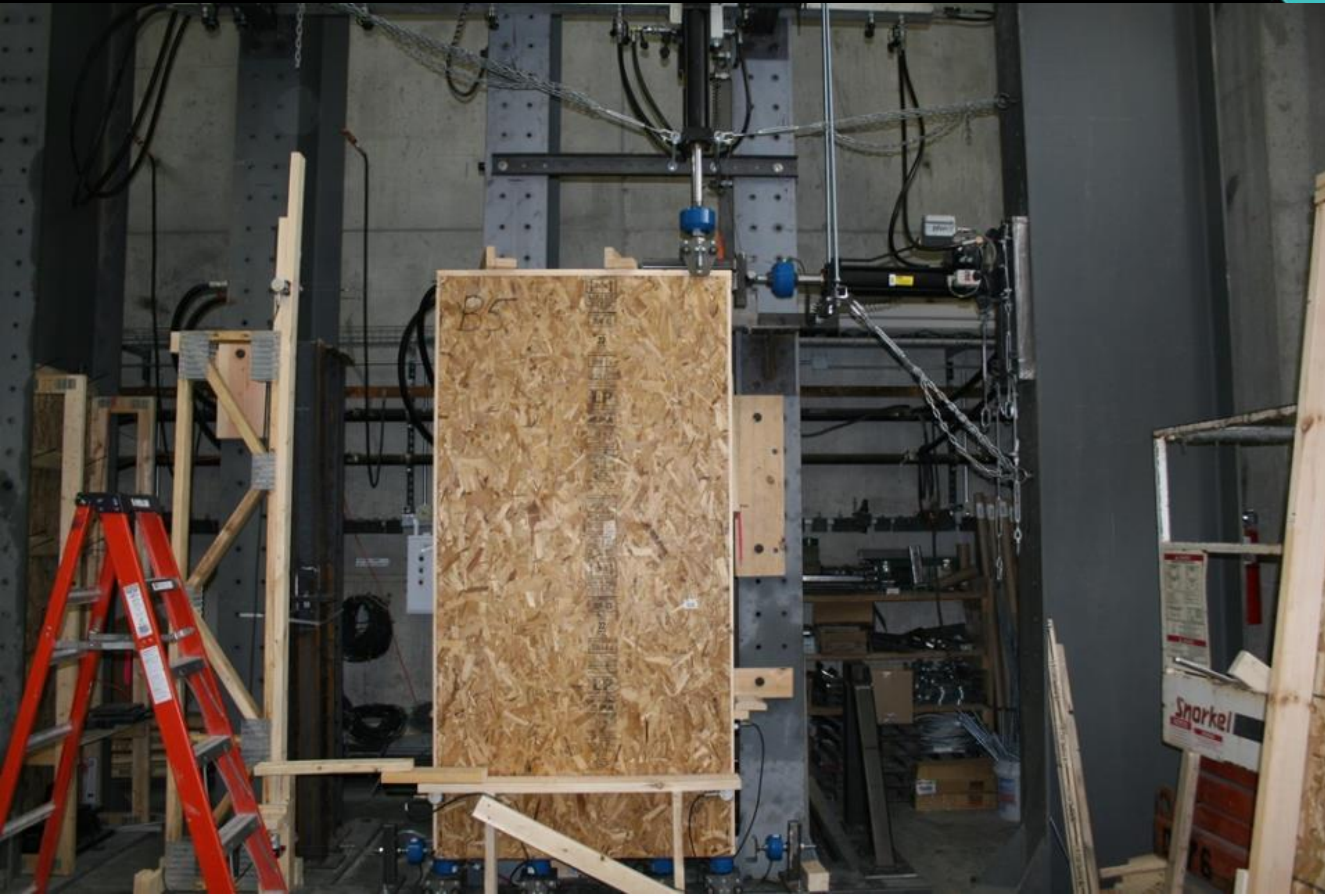
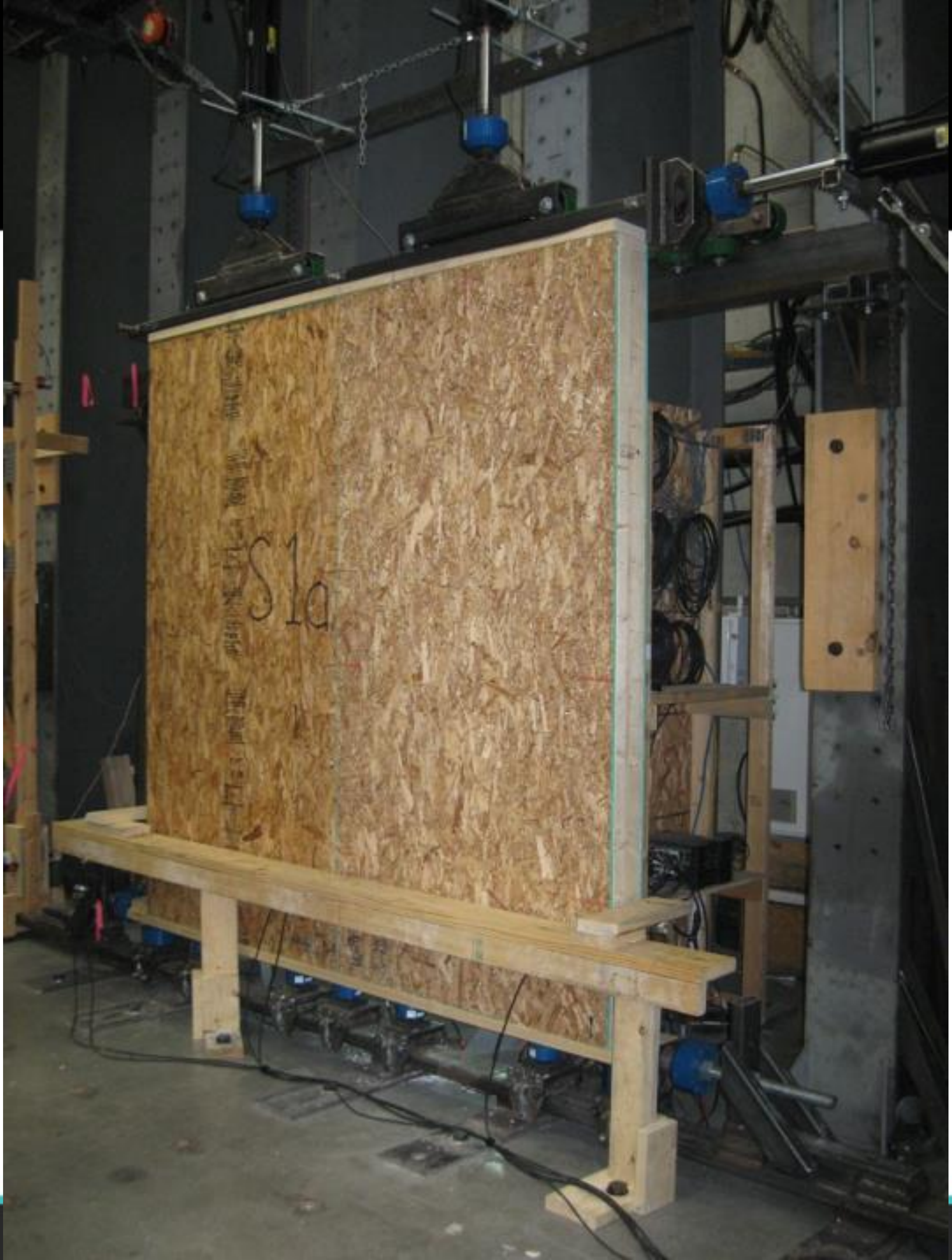
OWENS CORNING
FOAMULAR 150
R-10
R-10
330






B5
LP
Snorkel

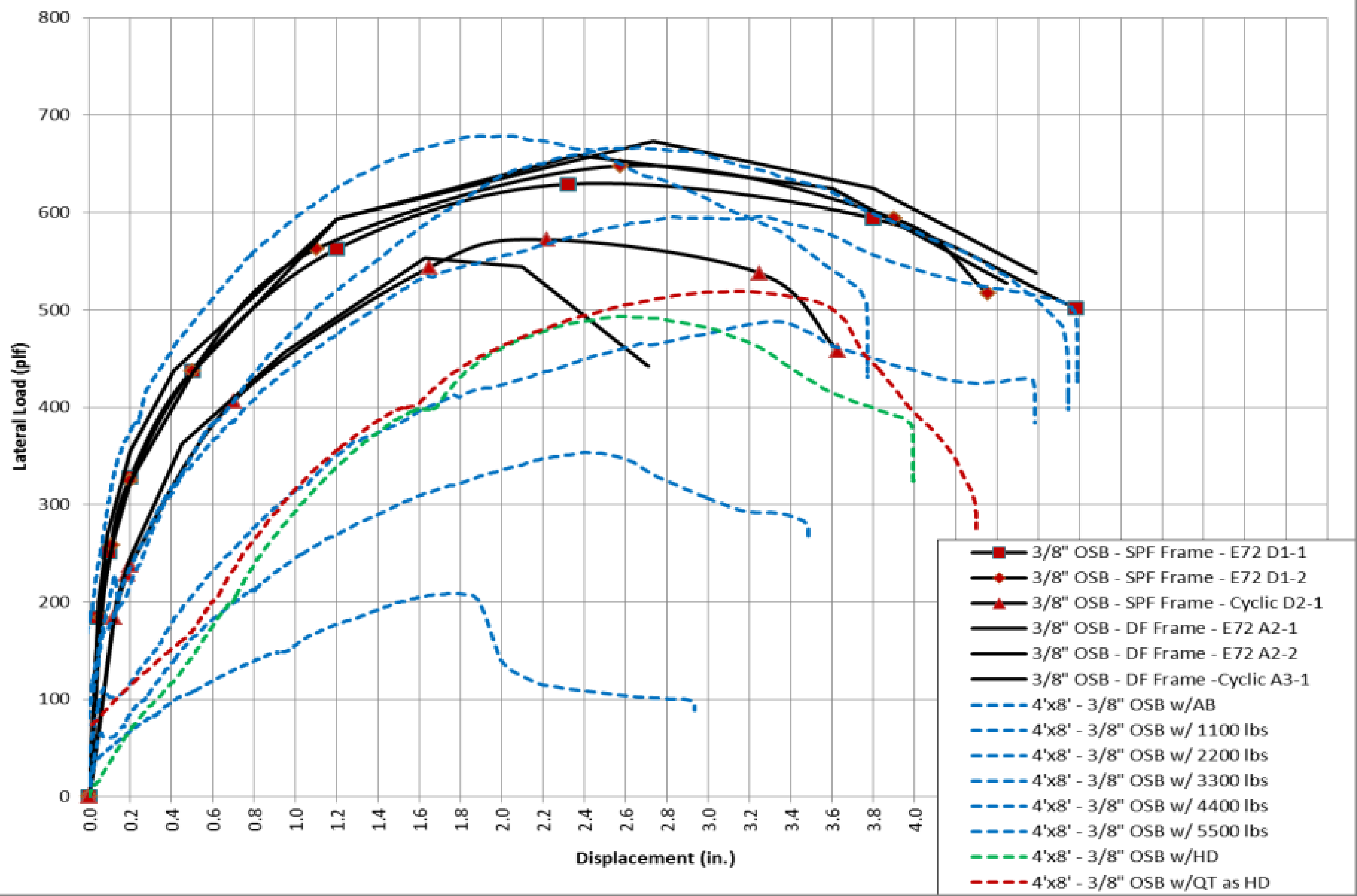

S1a


CONCRETE MIX

9
8
7


1B12
1B10

SBCRI Testing Confirms Effects of Vertical Load & Hold-Down Anchors on the Response of Wood Framed Shear Walls

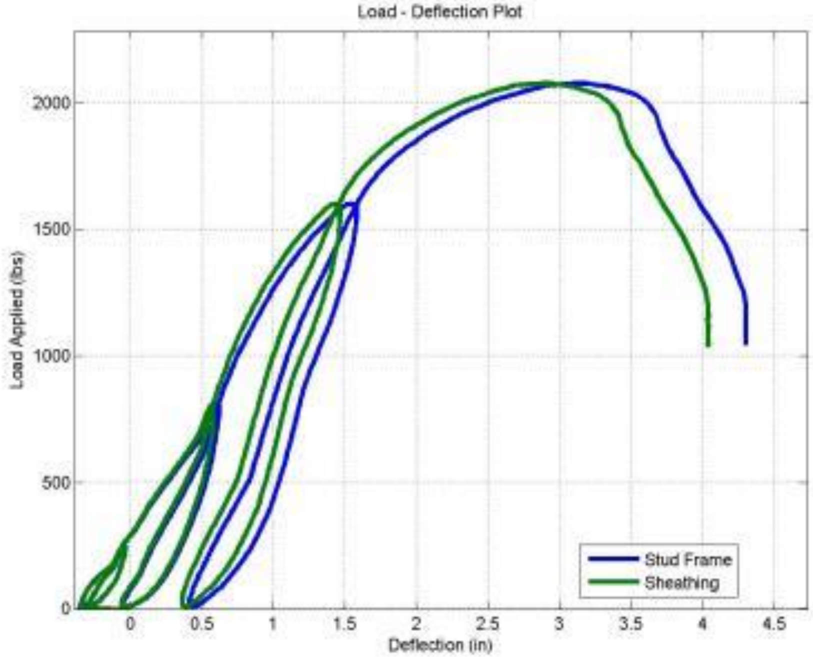



1
25ft
in
ft

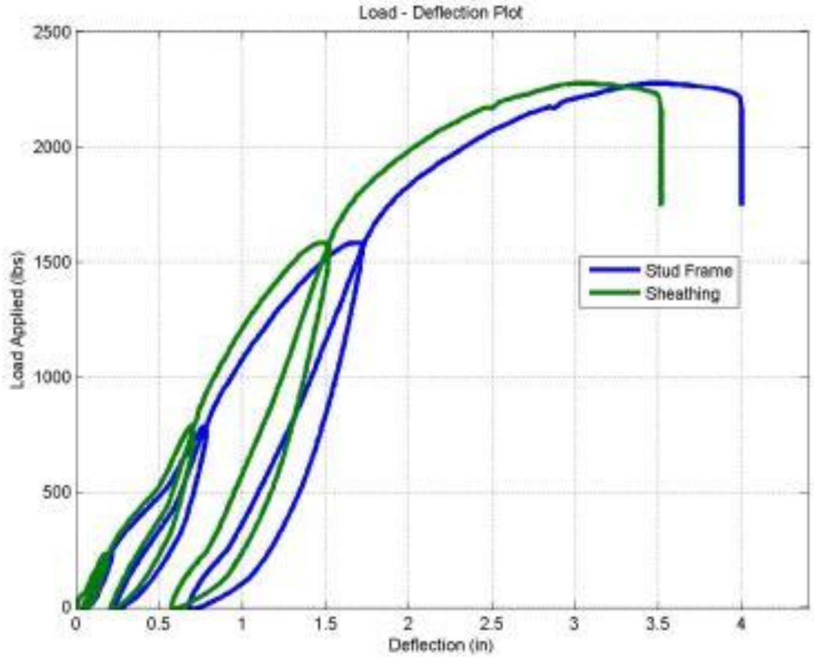
STANLEY
3
2
25ft
ft
in
1

Quick Tie & HDU8 Comparison

¼” Quick Tie (QTG) Load Deformation Graph



HDU8 Load Deformation Graph



The only difference is QTG has residual capacity and is a soft failure as opposed to the HDU8 break.

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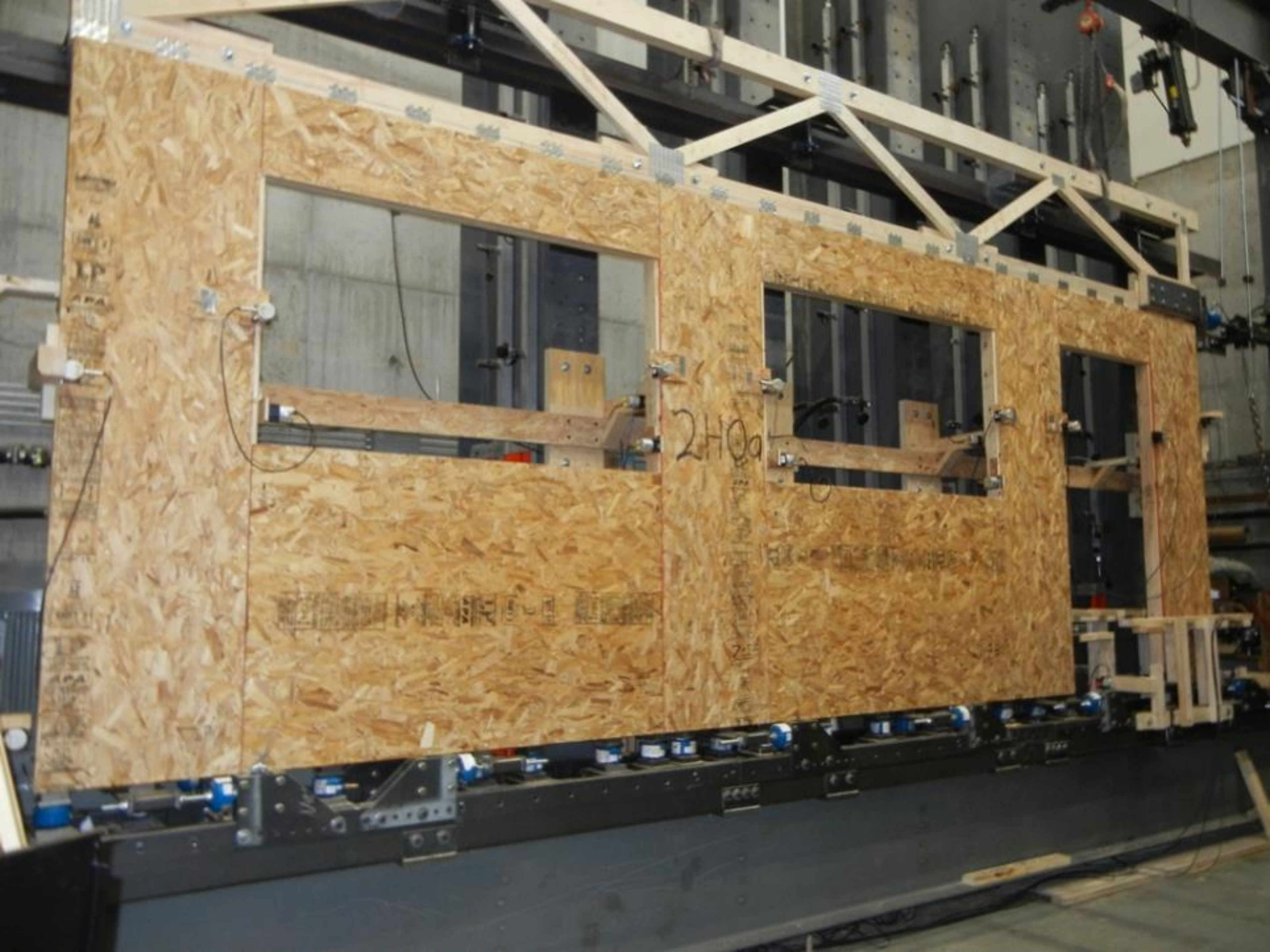
L1a
33
18A


LP
APA


4H2a


2HOa


3H0a

AWES
JONNESWAY

FULL SCALE TESTING STATION
12’ X 30’ BUILDING

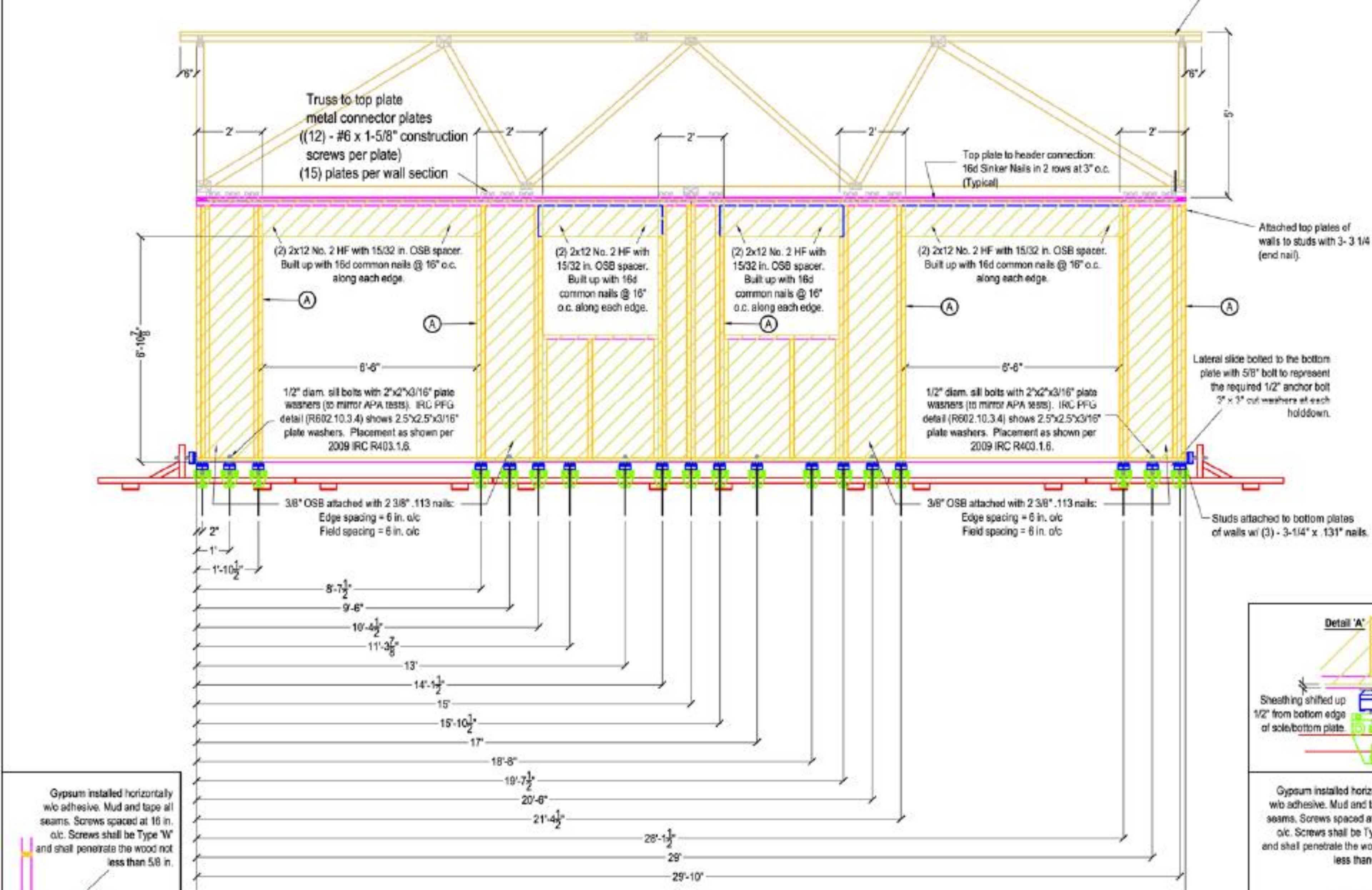
Sample ASTM E2126 CUREE Protocol Seismic Testing Data from our 12x30 Building

09-0104-39a

- 24" On-Center Stud Spacing
- Full 3/8" OSB: 2 3/8"x.113 nails, 6" On-Center (Edges) / 6"On-Center (Field)
- Full 1/2" Gypsum: #6 1-1/4" Type 'W' screws, 16" On-Center

NOTE:

- 2' x 8' strips of OSB to be used at all piers of door and window openings. Cover remaining surfaces with appropriate sizes of OSB sheathing.



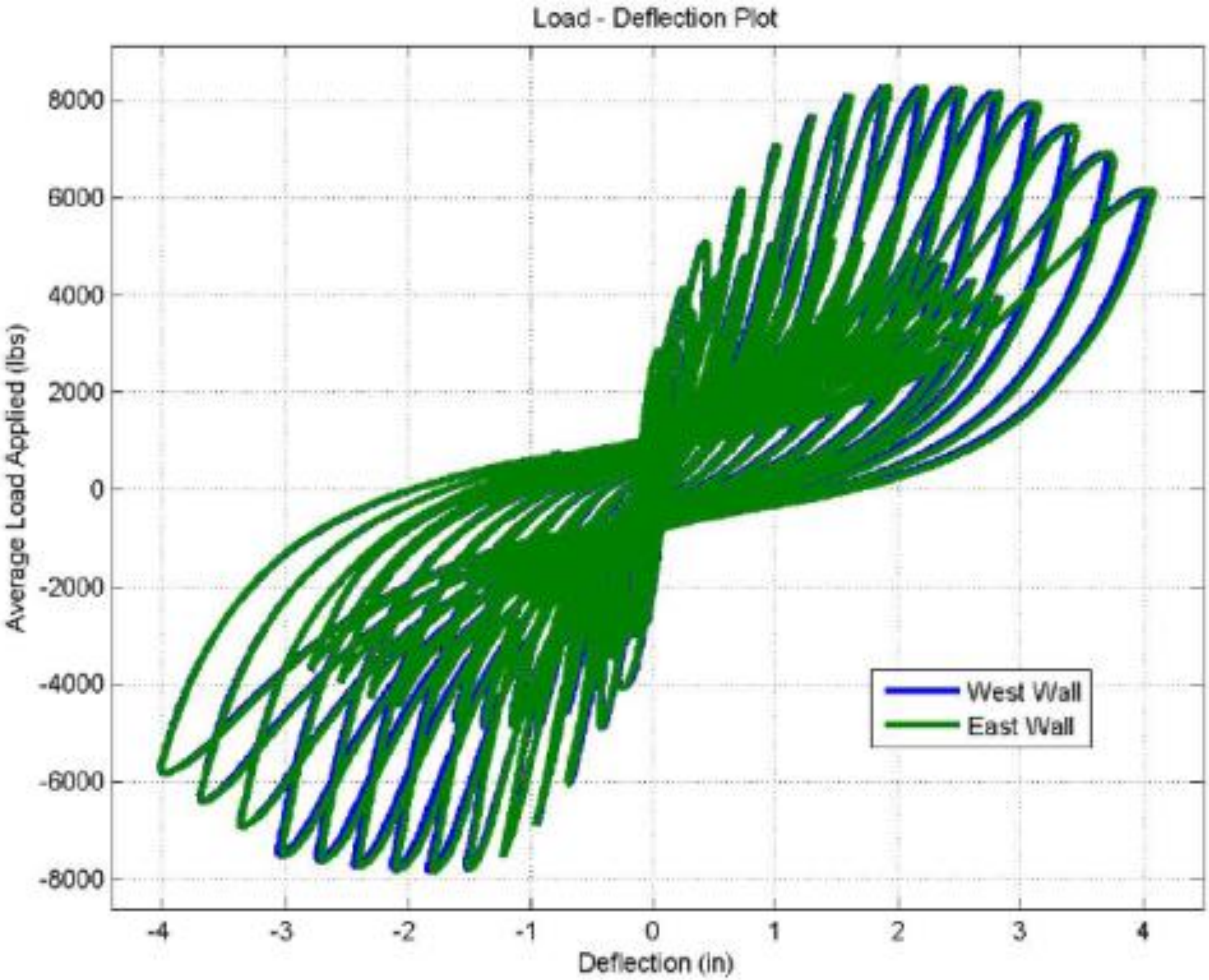


Figure 10: Load-Deflection Plot – Full Data Set – Global Wall Displacement – Both Walls

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LP
BUILDING PRODUCTS
APA
SHEATHING
24 OC
CATEGORY
W24
9.5mm
CSA 0325-07
EXTERIOR TYPE
ADHESIVE
STRENGTH AXIS
THIS DIRECTION

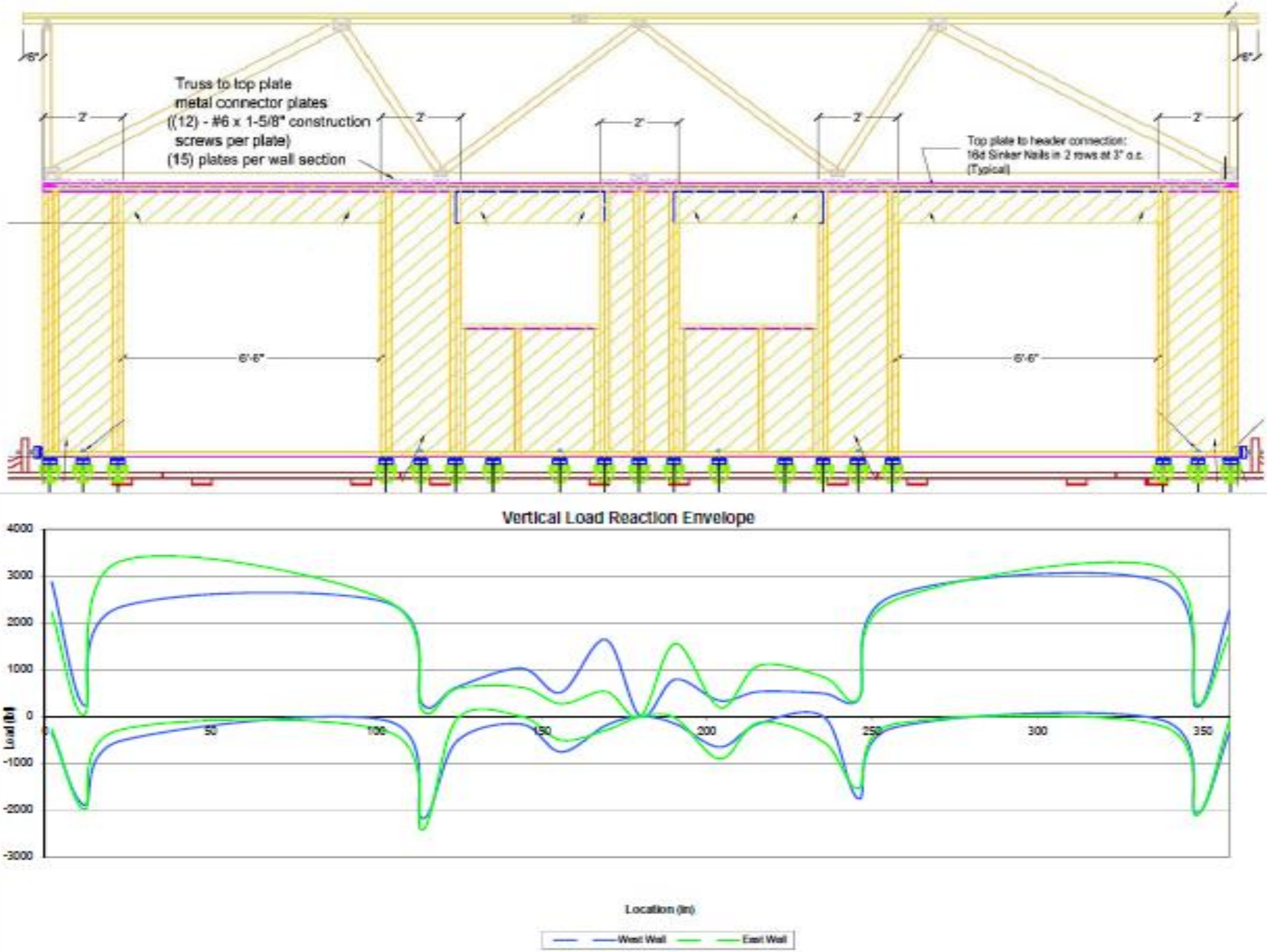

Figure 15: Vertical Distribution of Loads During Cyclic Test

Calibration of Lateral Wall Station to 12′x30′ Building

4/26/2013

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Comparison of 12′x30′ Building to Lateral Wall Station

12′ by 30′ Building **23′ Lateral Wall Station**

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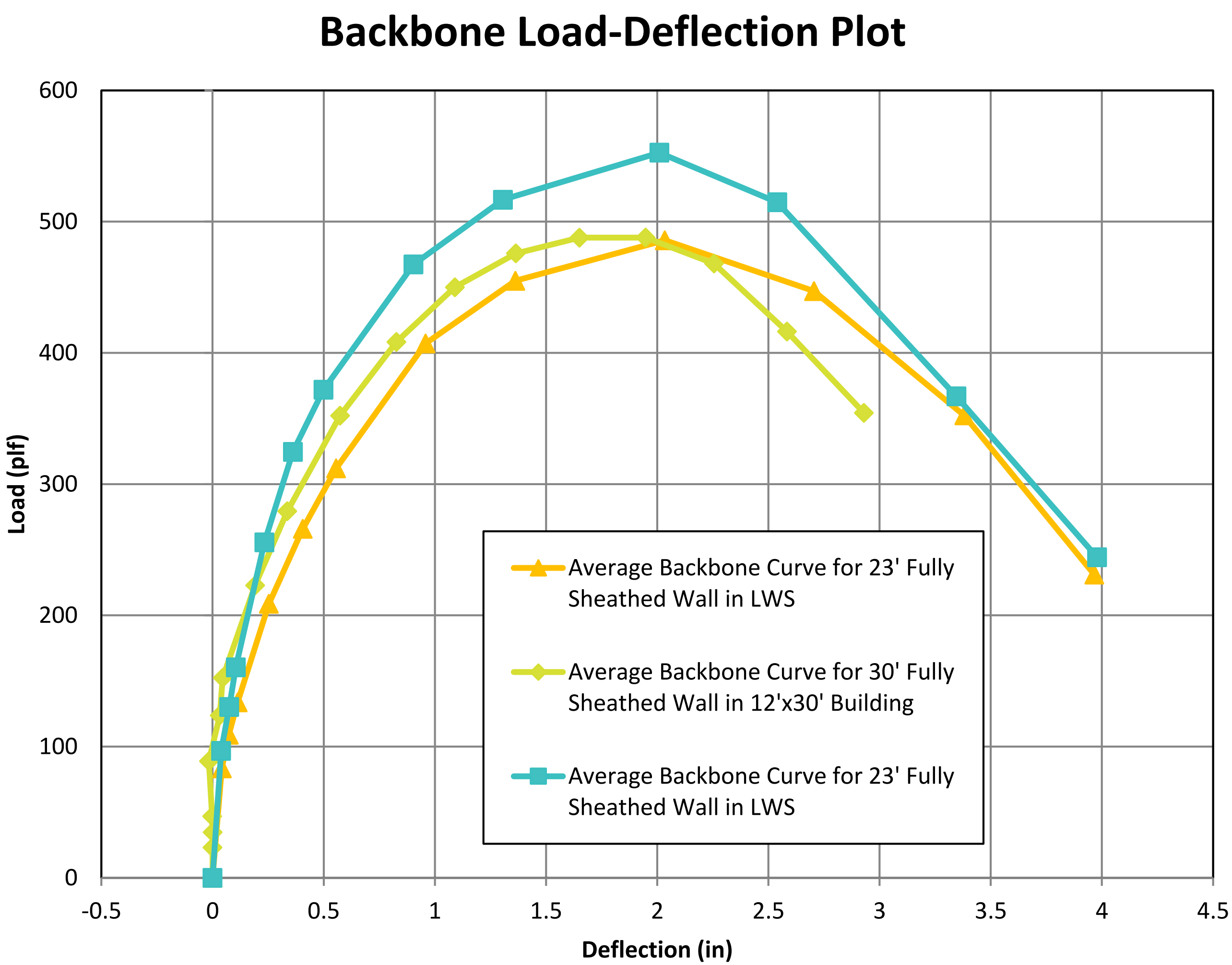
Comparison of Average Backbone Curves



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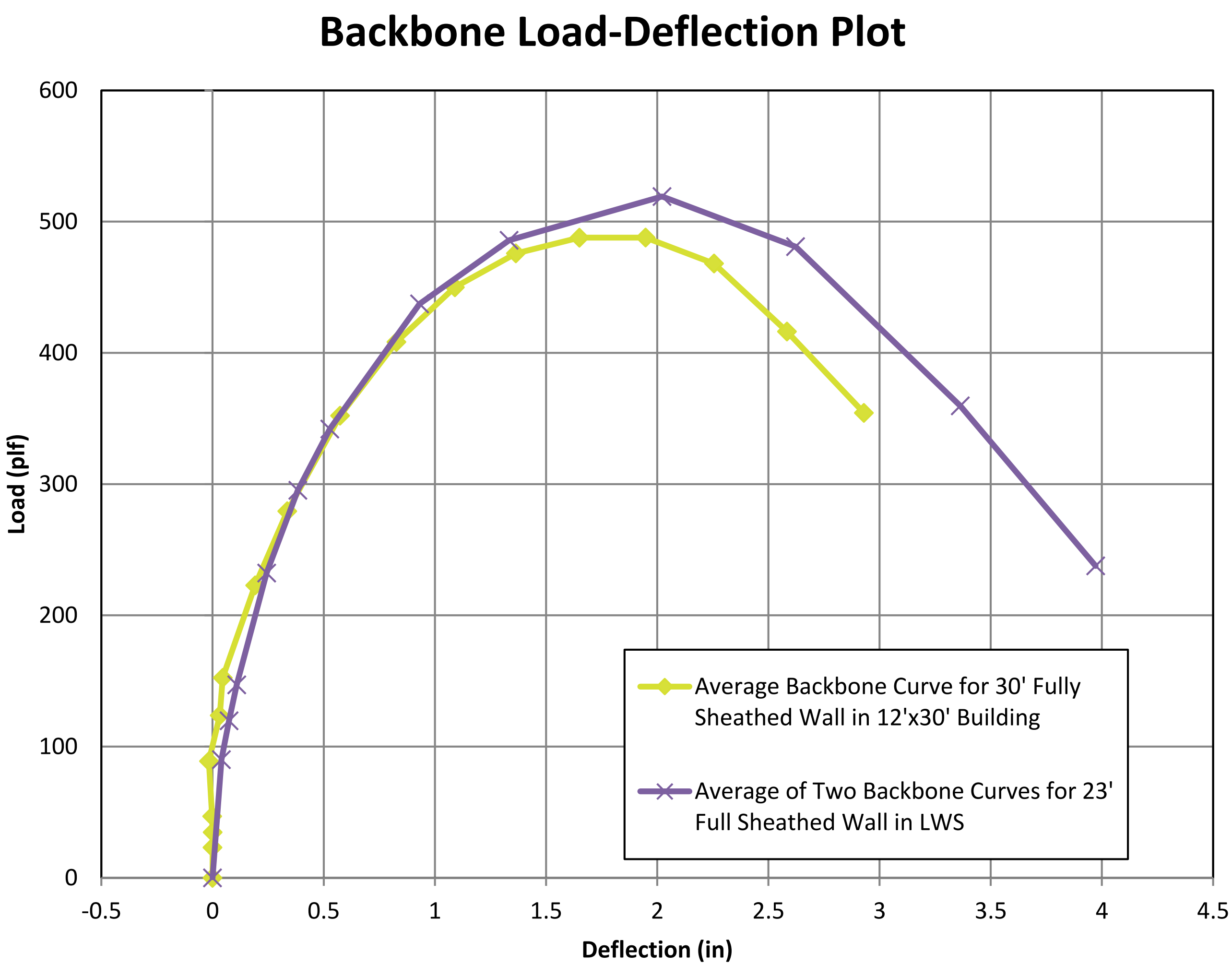
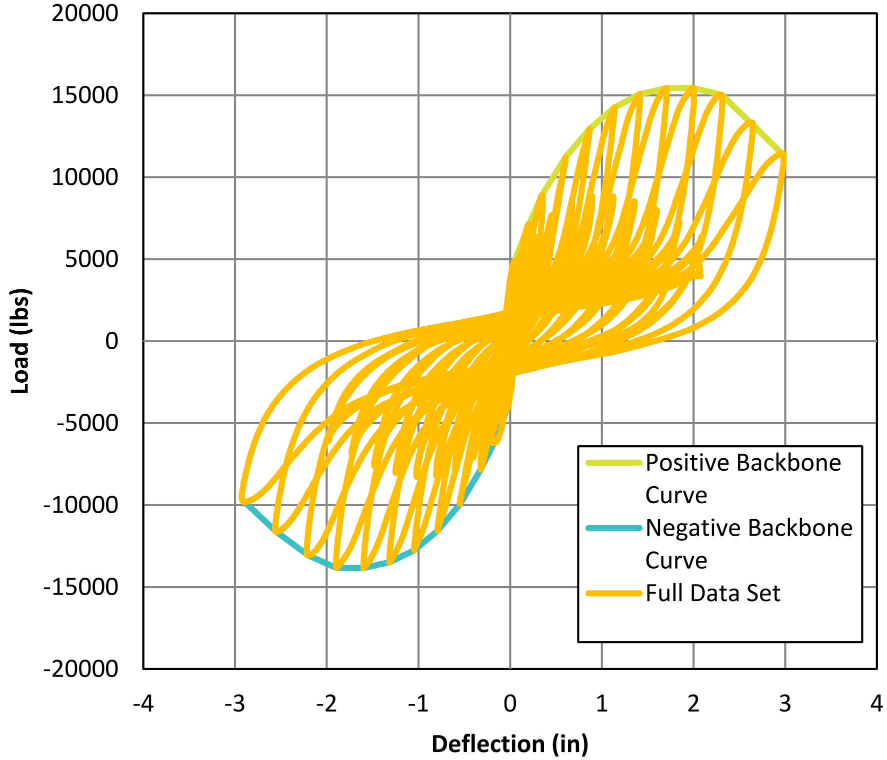
Comparison of Average Backbone Curves

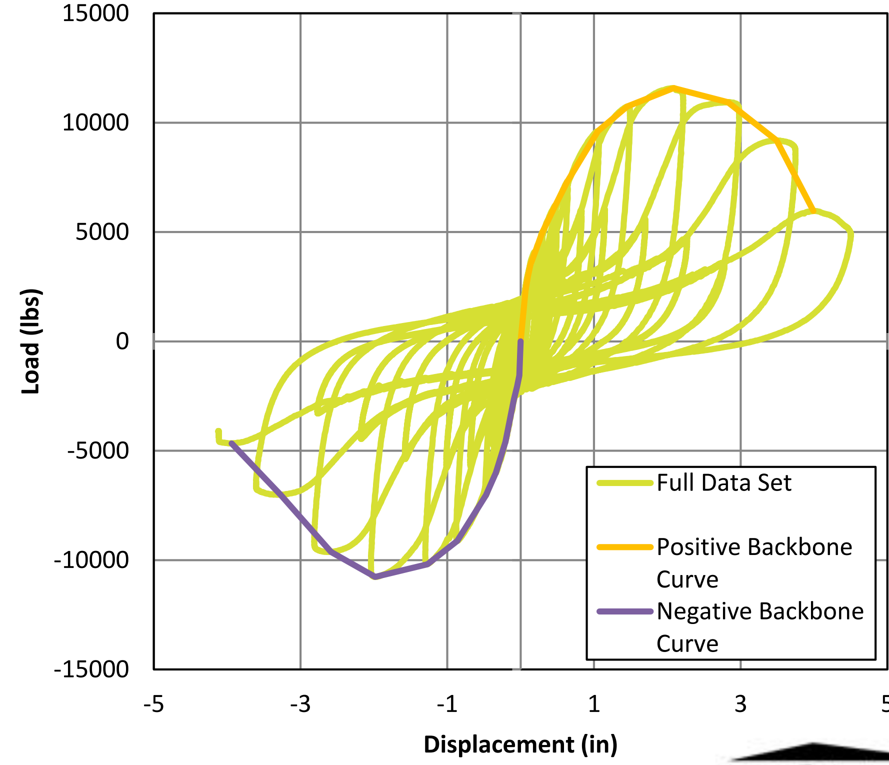


Hysteresis Cycles

Hysteresis Cycles for Fully Sheathed wall in 12'x30' Structure



Hysteresis Cycles for Fully Sheathed 23’ Wall in Lateral Wall Station



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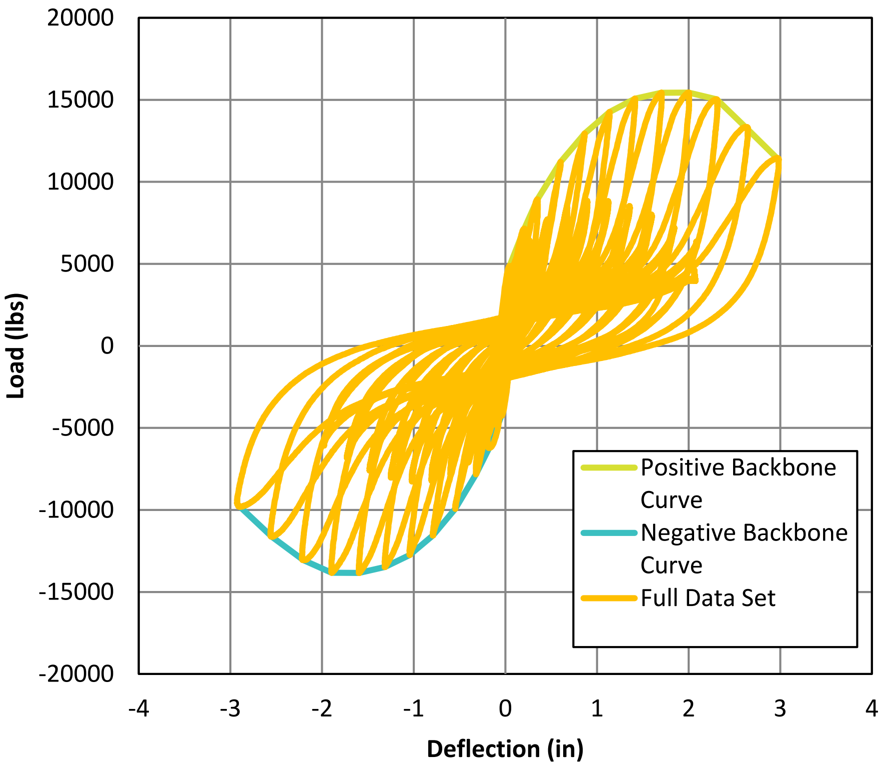
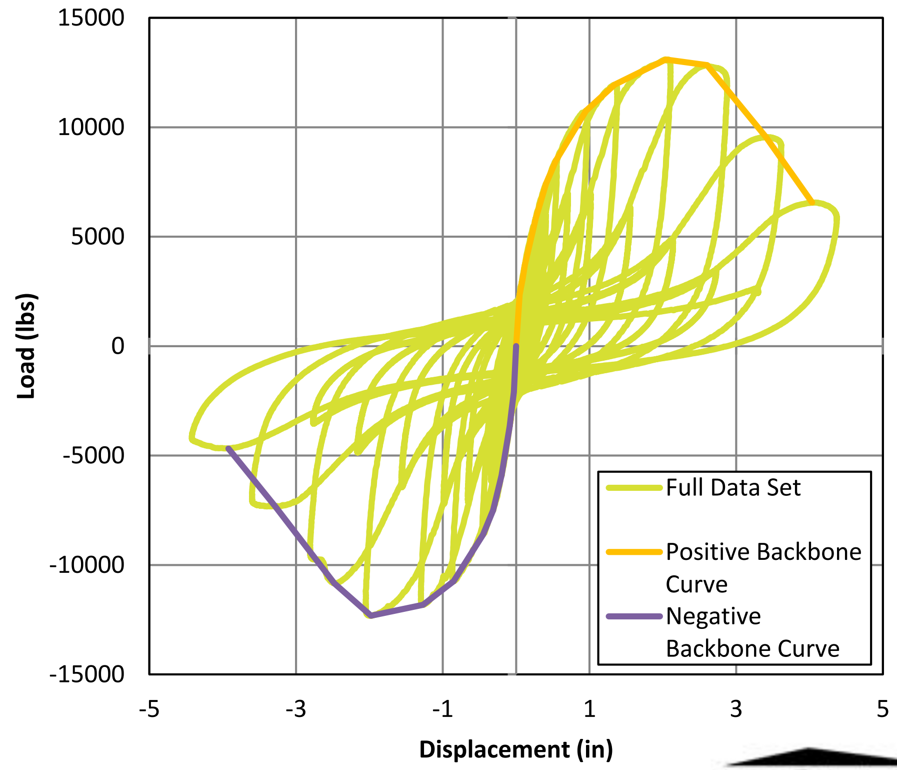
Hysteresis Cycles

Hysteresis Cycles for Fully Sheathed wall in 12'x30' Structure



Hysteresis Cycles for Fully Sheathed 23’ wall in Lateral Wall Station



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Calibrating Current Engineering Assumptions to Reality

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Questions?

- Questions, Comments and Feedback
  - Please participate by asking questions and offering comments so that everyone can learn from each other.
    - Please remember to complete your session evaluation form – thank you!