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Initial and Long Term Movement of Cladding Installed Over Exterior Rigid Insulation

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AIA Best Practice Slide

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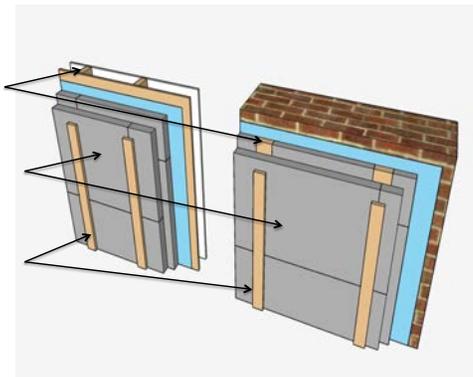
Learning Objectives

- Understand the Mechanisms that affect the vertical movement of cladding attached directly over exterior insulation
- Examine the impacts of environmental exposure on long term movement of cladding
- Review current design recommendations for cladding attachment directly over exterior insulation

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Cladding Attachment System

- Wood structure
- 2" to 4" of exterior rigid insulation
- 1x3 wood furring strips



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Cladding Attachment System

- Need to develop a means to attach cladding over thick layers of exterior insulation that can meet the following requirements:
 - Provides good thermal performance
 - Low cost
 - Easy to construct/install (low cost)

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Background- Cladding Attachment Theory

- European Yield Theory
 - First conceived in the 1940's
 - Looked to predict performance of a wood to wood connection based on yielding of materials (wood or fastener)
 - Validation research completed by US Department of Agriculture Forest Products Laboratory (Aune, Patton-Mallory 1986)
 - First known research to look at wood to wood connection with gaps up to 1"
 - Development of AFPA Technical Report 12 – *General Dowel Equations for Calculating Lateral Connection Values*

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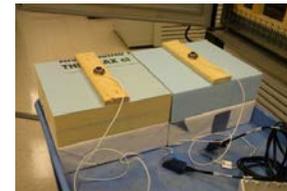
Background- Cladding Attachment Theory

- European Yield Theory (cont.)
 - TR-12 was used as a basis for Additional Research Conducted by Foam Sheathing Coalition (FSC), New York State Energy research and Development Authority (NYSERDA), and Steel Framing Alliance (SFA)
 - Laboratory initial load vs. deflection tests were conducted on small scale samples (2 fasteners per test) for a variety of fastener types and insulation thicknesses
 - Laboratory results at 0.015" deflection were noted to align reasonably well with predicted 5% offset yield results from the TR-12 document

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BSC Cladding Attachment Research

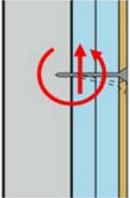
- Began in 2011
- Looking to expand on previous research
- Examined mechanics of the cladding attachment system
- Examined long term environmental exposure



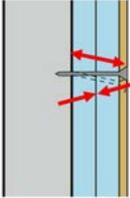
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BSC Cladding Attachment Research

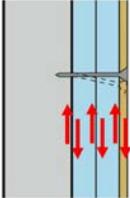
- System Mechanics



Shear and rotational resistance provided by fastener to wood connections



Rotational resistance provided by tension in fastener and compression of the insulation



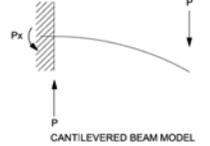
Vertical movement resistance provided by friction between layers

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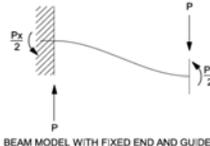
Screw Bending

- Cantilever
- Double Bending
- Screw Shaft Bearing



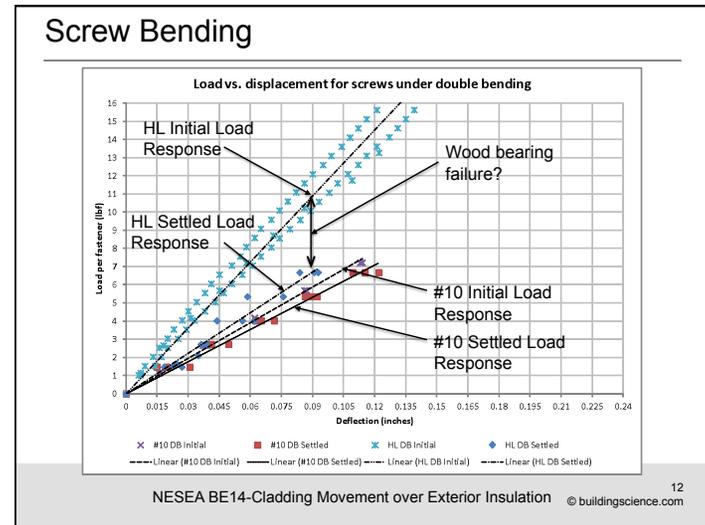
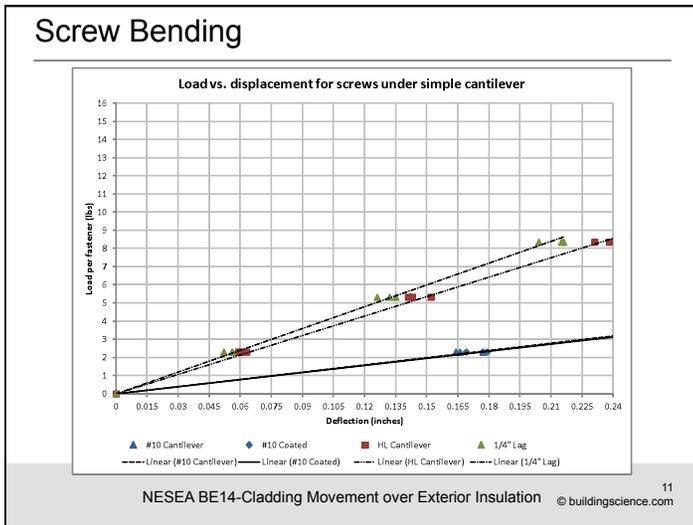


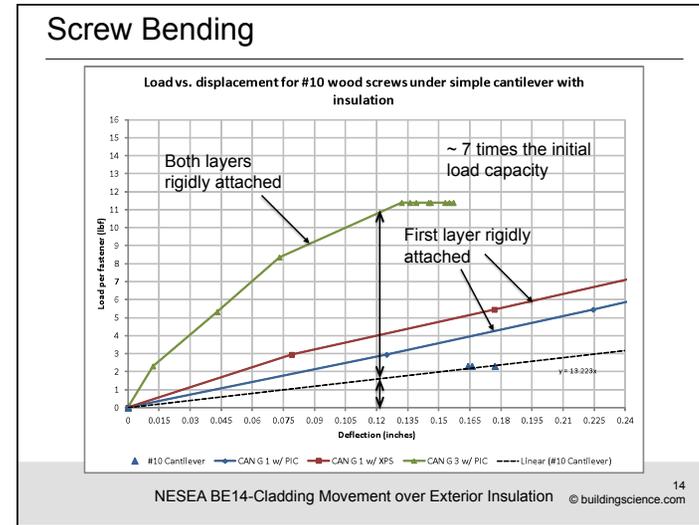
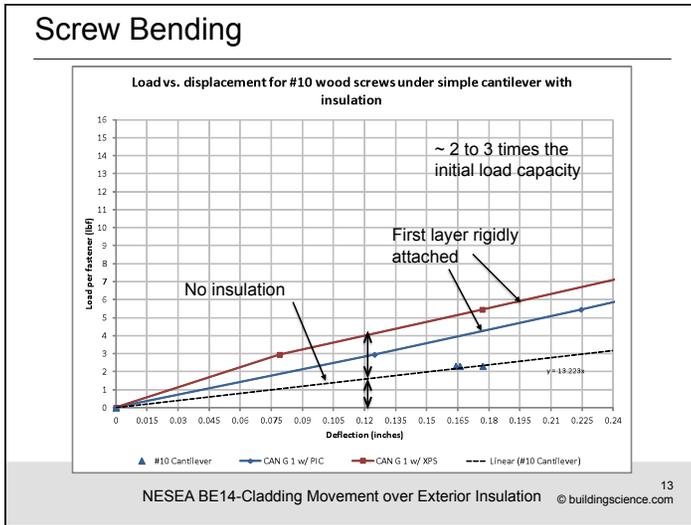
CANTILEVERED BEAM MODEL



BEAM MODEL WITH FIXED END AND GUIDED END

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System Friction

- Compression Forces
- Coefficients of Friction

FRICTION MODEL

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System Friction

- Compression Forces
 - Needed to benchmark clamping forces
 - ~150lbs/fastener to drive a #10 wood screw flush with face of furring

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System Friction

- Coefficients of Friction
 - Tested insulation materials on Buildingwrap

	Static COF
EPS	0.27
XPS	0.23
MF	0.45
PIC	0.26



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System Friction

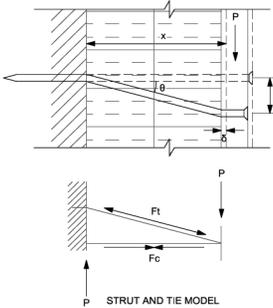
- Measured Friction
 - Tested small scale assemblies with no fasteners using weights to induce the normal load
 - Results were in line with predicted values based on measured COF



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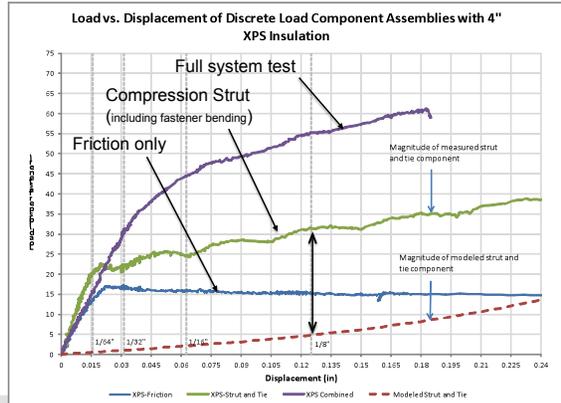
Compression Strut

- Function of fastener tension and insulation compression
- Measured insulation compression properties
- Difficult to measure directly
 - Fastener bending present
 - Hard to create a "frictionless" system



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Compression Strut



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Full System Laboratory Tests

- Looked at initial response full system capacity as well as long term sustained loading
- Used full scale samples to limit variations in fastener installation



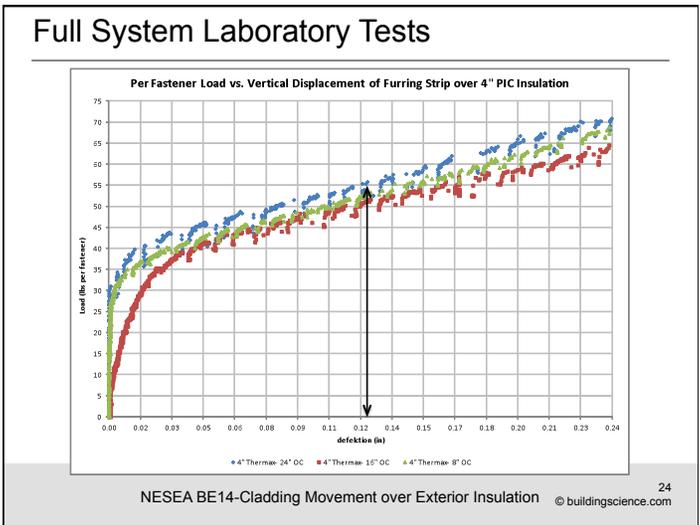
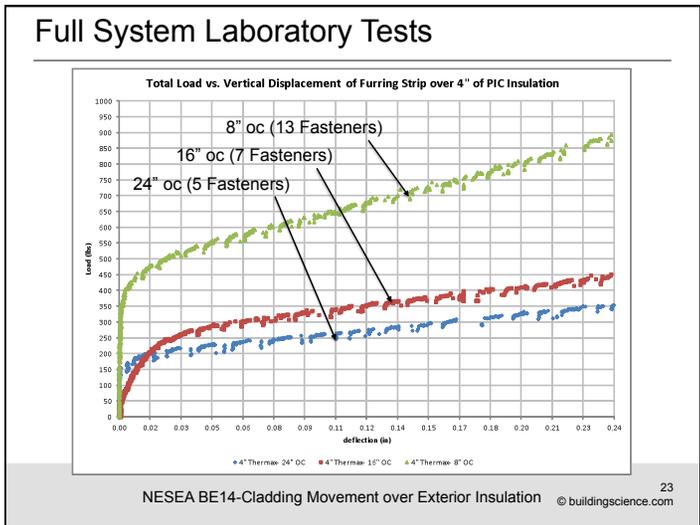
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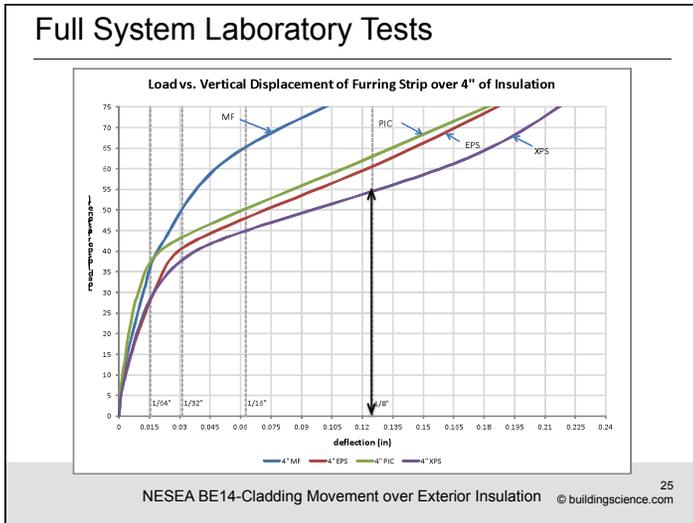
Full System Laboratory Tests

- Results
 - Insulation type not a significant influence on system capacity
 - System capacity is a function of the number of fasteners used
 - High measured capacities and stable performance under controlled environmental conditions



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System Totals (using Joe math)

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)\$-.'	/0'	12'	32'

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33' 33' 33'

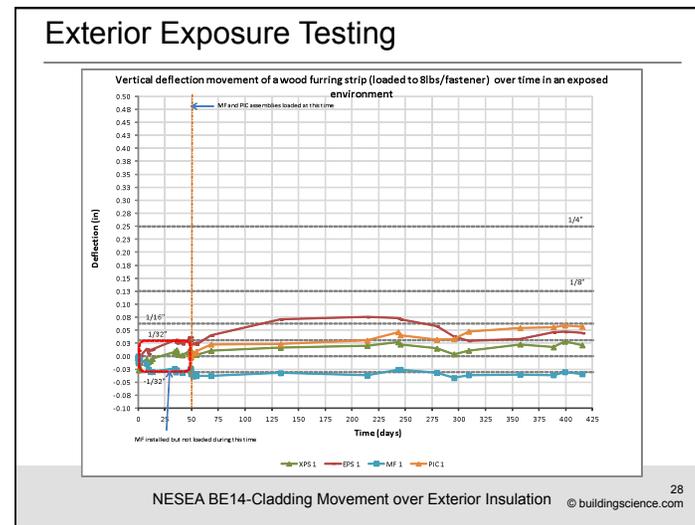
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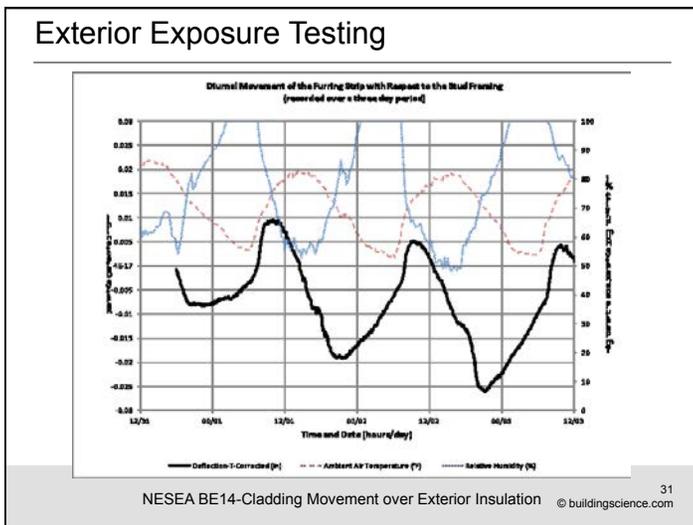
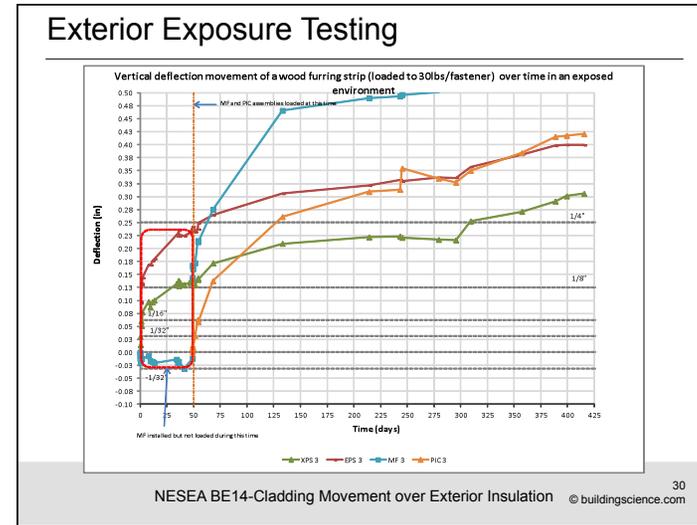
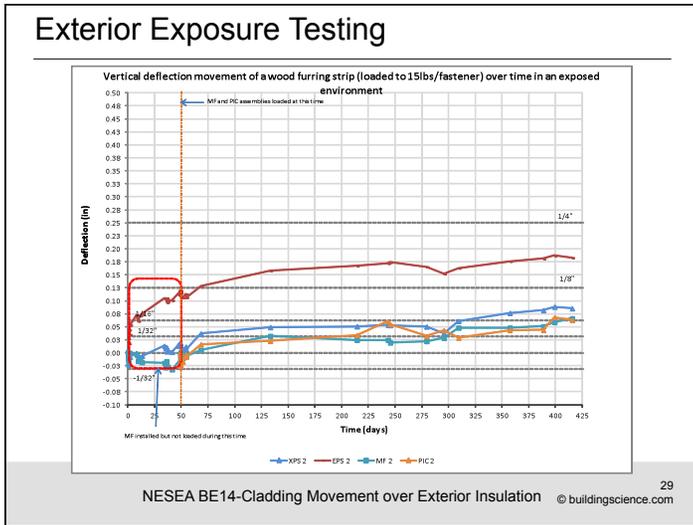
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Exterior Exposure Testing

- Looked at long term movement of systems under sustained loads in an exposed environment

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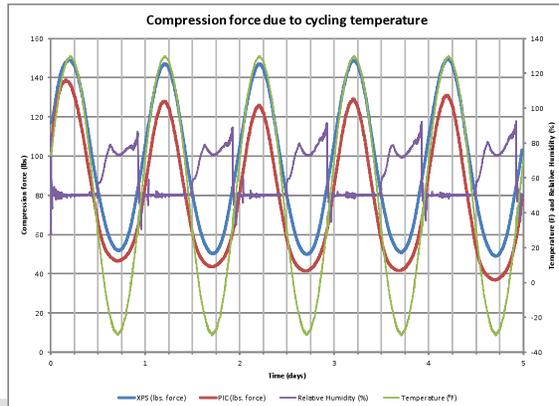


Exterior Exposure Testing

- Daily movements measured on the order of 1/32"
- Theorized that it was related to thermal expansion and contraction of materials
- Conducted climate chamber tests to examine compression force change due to temperature

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Exterior Exposure Testing



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Conclusions (System Mechanics)

- Initial load response measurements are on the order of 50lbs/fastener to 60lbs/fastener at 1/8" deflection and 4" of insulation
- Insulation type does not appear to be overly significant
- Capacity is a function of the number of fasteners used.
- Capacity would be expected to increase for less insulation due to higher fastener component at a smaller cantilever

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Conclusions (System Mechanics)

- Friction component is significant, but highly variable due to initial clamping magnitudes and thermal expansion and contraction of materials
- Compression strut component is present, however the magnitude of the impact is difficult to quantify.

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Conclusions (Long Term Exposure)

- System creep was apparent at high per fastener sustained loading (30lbs/fastener)
- At low per fastener loads (8lbs/fastener) the system demonstrated stable performance
- At moderate per fastener load (15lbs/fastener) the system demonstrated relatively stable performance, though there is some possible slight indication of system creep

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Recommendations

- Based on the results of the testing it is currently recommended to use a maximum load per fastener of no more than 10lbs for up to 4" of insulation

Cladding weight (psf)	16" oc Furring	24" oc Furring
5	18	12
10	9	6
15	6	4
20	4	3
25	3	2

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Questions?

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Questions?

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Questions?

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