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Exterior Cladding Attachment Research

EEBA 2012

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Overview

- Background
- Cladding Support System:
  Direct Attachment Through Insulation
- Discrete Load Components
- Full Scale Assembly Testing
- Full Scale Environmental Exposure Testing
- Industry Impacts
- Recommendations

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Building America Innovations

1. Advanced Technologies & Practices
2. House-as-a-System Business Case
3. Effective Guidance and Tools
4. Infrastructure Development

This research is paving the way for key innovations:

- Construction technology to promote the use of exterior insulation
- Wide adoption for a range of cladding systems
- Code development and integration

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BSC Builder Resources

- Prescriptive Cladding Attachment Requirements
  - 2012 IRC – Table R703.4 Weather Resistant Siding Attachment and Minimum Thickness
- Link to BSC website: www.buildingscience.com
  - IRC FAQ: Cladding Attachment Over Insulating Sheathing
    - Guidance of the application of IRC - Table R703.4:
  - RR-1204: External Insulation of Masonry Walls and Wood Framed Walls
    - Overview of BSC research conducted in 2011 regarding the use of furring strips installed over exterior insulation as the cladding attachment point
    - Report includes detail drawings for retrofitting wood framed and masonry buildings with exterior insulation
- Link to DOE resources: www.buildingamerica.gov

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Background

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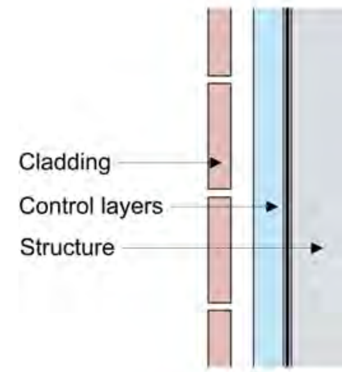
Exterior Rigid Insulation

- The "Perfect" Wall

- Increase overall thermal performance
- Minimize thermal bridges
- Minimize potential for air leakage condensation
- Improve air tightness?
- Improve rainwater management?



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Problem Context

- Current Building Code does provide prescriptive means to attach cladding over exterior insulation
  - Table R704.3 – Note v: *Minimum nail length must accommodate sheathing and penetrate framing a minimum 1 ½ inches.*
- Current pneumatic nailers have maximum fastener lengths of 3" to 3.5" which limits insulation thicknesses to 1.5" max
  - 3.5" fastener, ¼" to ½" siding, 1 ½" embedment (3.5-0.5-1.5 = 1.5" max insulation)
- Therefore, for insulation 1.5" or less – direct attachment of cladding though insulation back to the structure is often practical

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Problem Context

- For insulation greater than 1.5" – a secondary cladding support system is often needed.
- Current Building Codes do not provide any prescriptive means to use a secondary support structure for cladding attachment
- Without prescriptive code provisions, cladding support systems need to be designed (historically done with poor thermal performance and high cost) or pre-engineered solutions need to be used (generally higher cost)

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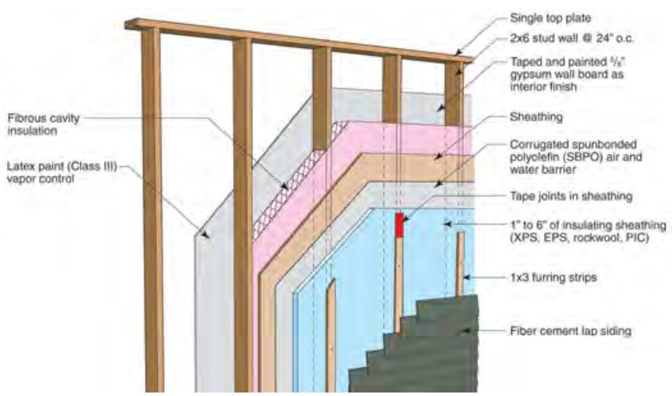
Cladding Support System: Direct Attachment Through Insulation

Technical Approach

- 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)

Technical Approach



Technical Approach

"Myths"

- "Does the insulation crush under load?"
- YES!
- Loading a system until failure (500lbs to 1000lbs or more per screw fastener) will crush most rigid insulations

…..Unfortunately that is the wrong question

"Myths"

- "Does the insulation crush under a load similar to what will be imposed on it in a cladding support application?"
- The answer is no!...

Context is important

Typical Loads

- Typical cladding weights (psf)

	low	high
Vinyl	0.6	1.0
wood	1.0	1.5
fiber cement	3.0	5.0
stucco	10.0	12.0
adhered stone veneers	17.0	25.0

Typical Loads

- Typical weights per fastener (lbs)

fastener spacing (in)	16" x 16"	16" x 24"	24" x 24"
area/fastener (ft2)	1.78	2.67	4
vinyl	1.8	2.7	4.0
wood	2.7	4.0	6.0
fibercement	8.9	13.3	20.0
stucco	21.3	32.0	48.0
adhered stone veneers	44.4	66.7	100.0

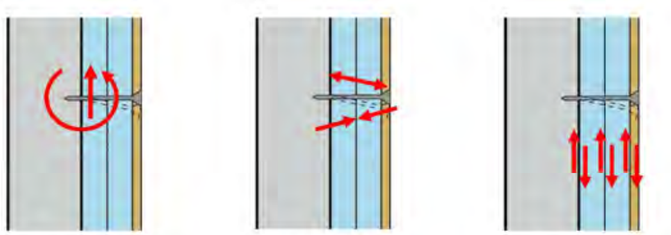
Direct Attachment Through Insulation

- Lots of practical experience with this approach for lightweight cladding systems over thick layers of insulation (several decades).
- Approach has demonstrated very good long term performance
- High resistance from industry

Discrete Load Components

Direct Attachment Through Insulation

- Theorized Load Components



Shear and rotational resistance provided by fastener to wood connections

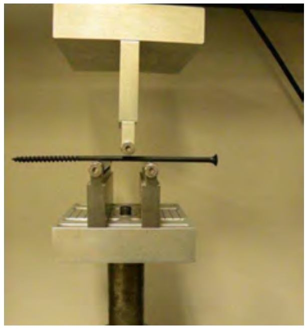
Rotational resistance provided by tension in fastener and compression of the insulation

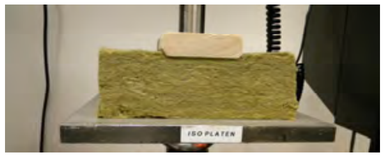
Vertical movement resistance provided by friction between layers

Direct Attachment Through Insulation

- Theorized Load Components
  - Dependent on material properties
    - Strength of fasteners
    - Compressive strength of insulation
    - Coefficient of friction between layers
  - Dependent on boundary conditions
    - Pre-compression of insulation due to tightening of fasteners

Material Properties



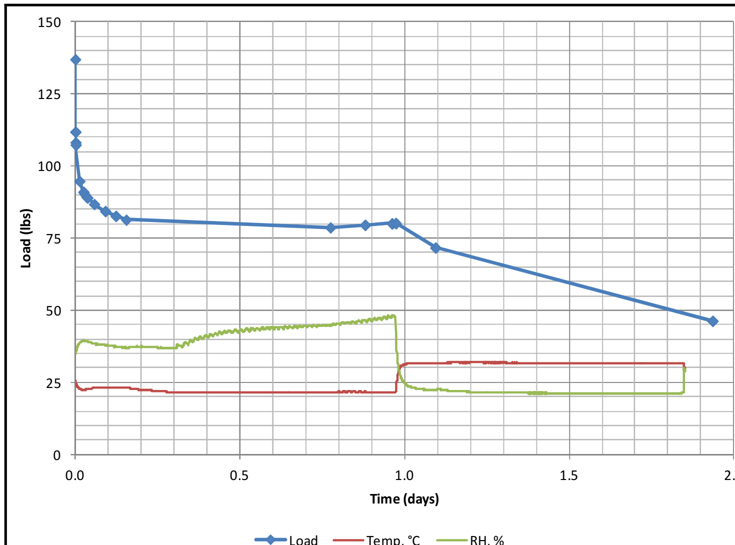


Boundary Conditions

- Pre-compression forces

Boundary Conditions

- Pre-compression forces
  - Failure mechanism – head pull through of fastener through the furring
  - Preliminary results indicate pretty consistent force magnitudes
    - ~ 150 lbs per fastener with screw head flush with furring surface
    - ~ 180 lbs per fastener with screw over driven
  - Forces relax over time
  - Affected by environmental conditions



Discrete Load Component Testing

- Small Scale Discrete System Tests
  - Intent to evaluate individual force resistance components
    - Screw bending/wood bearing
    - Strut and tie model
    - Friction between layers

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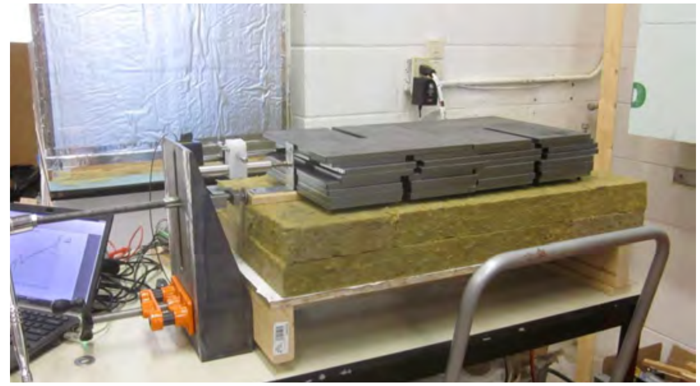
Discrete Load Component Testing



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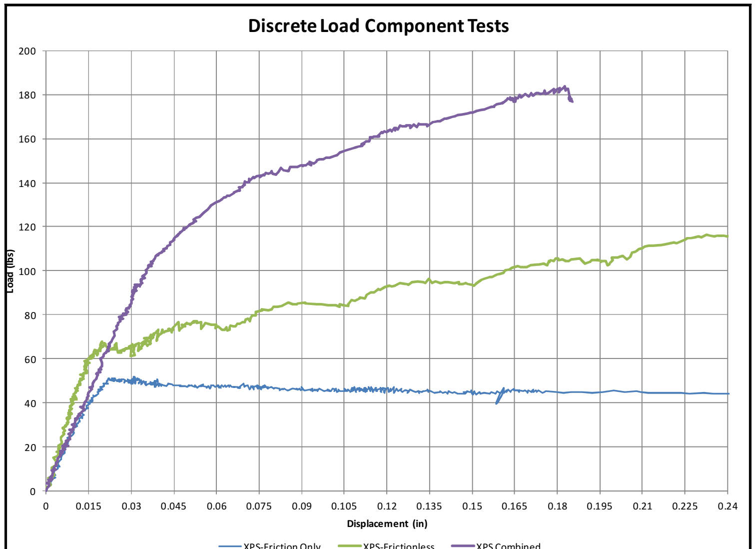
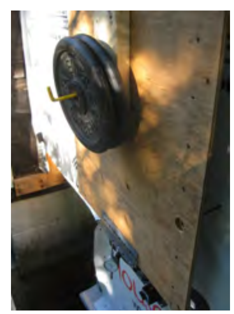


Discrete Load Component Testing

- System loaded with air gap between furring and wall



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Discrete Load Component Testing

- System loaded with 4” of rigid mineral fiber insulation between furring and wall

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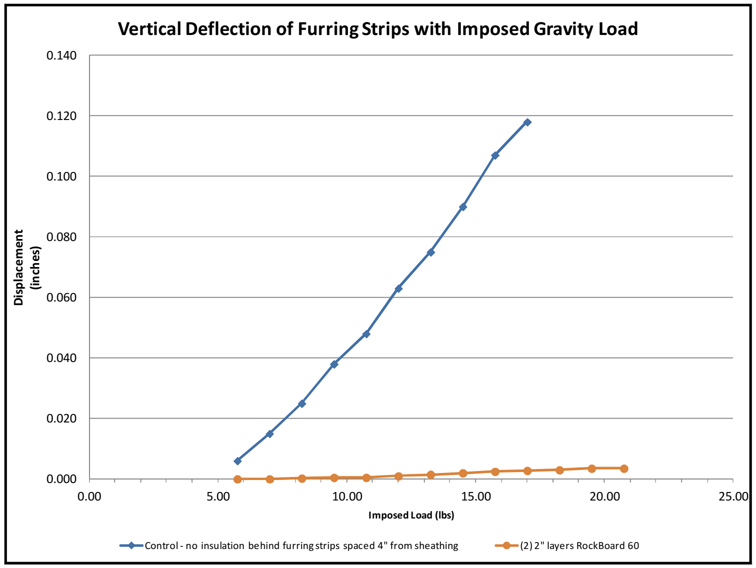

Results

- Friction loads can be a large component of the total load depending on pre-compression forces and normal forces imposed by the strut and tie model
- Strut and tie provides additional capacity but requires rotation of the fastener to engage the compression of the insulation
- Screw bending and bearing capacity is low compared to other mechanisms

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Full Scale Assembly Testing

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Full Scale Testing

- Short Term and Long Term Deflection Testing
- Multiple insulation types
  - EPS
  - XPS
  - Foil faced polyisocyanurate
  - Rigid mineral fiber

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Full Scale Testing

- Short term testing
- Test panels
  - 4'x8'
  - 1x3 furring spaced 24" oc
  - 16" vertical spacing of fasteners
- Multiple thicknesses
  - 4" and 8" tests

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Full Scale Testing

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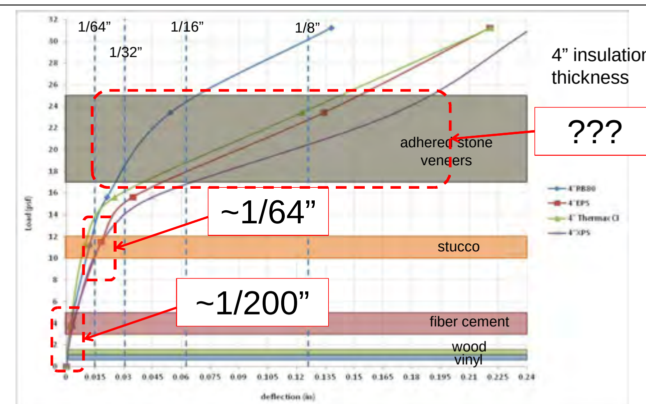
Full Scale Testing



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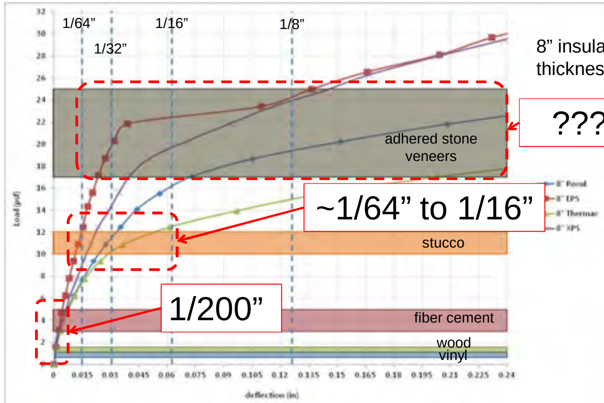
Full Scale Testing



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Long-term Gravity Load Response

- Long term testing
- Test panels
  - 2'x8'
  - 1x3 furring
  - 16" vertical spacing of fasteners
- Load
  - 13 psf if 24" oc
  - 20 psf if 16" oc
  - 30 lb/fastener

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Long-term Gravity Load Response

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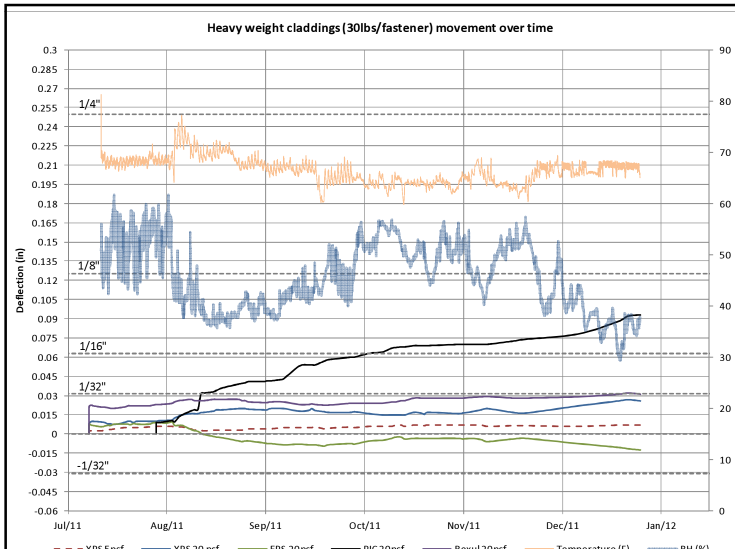

Full Scale Climate Exposure Testing

Climate Exposure Testing

- Creep is still not well understood or quantified
- Affected by multiple factors
  - Expansion and contraction of wood
  - Expansion and contraction of insulation
  - Relaxation of wood fibers
  - Plastic deformation of insulation
- Many of these are affected by temperature and relative humidity
- Need to examine the performance of these systems in exposed environments

Climate Exposure Testing

- Full Scale Wall Assemblies
- Loaded to three representative cladding weights
  - Fiber cement
  - Stucco
  - Cultured stone
- Deflection to be measured over the course of the year

Climate Exposure

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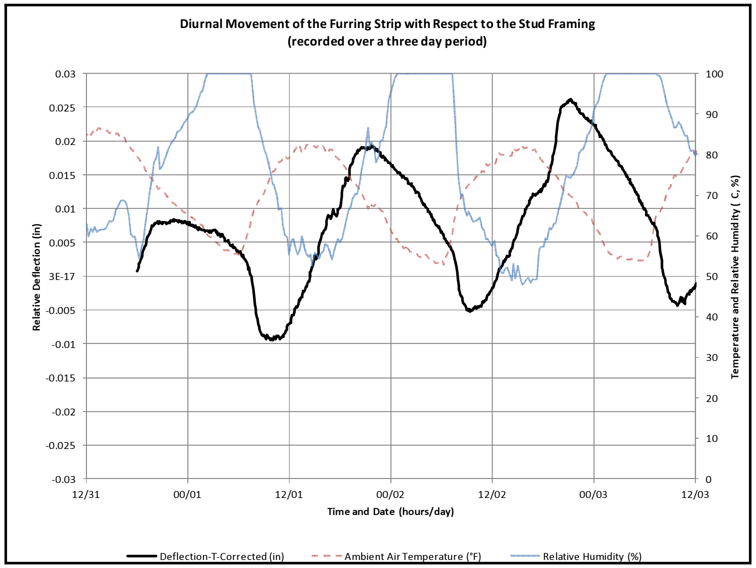

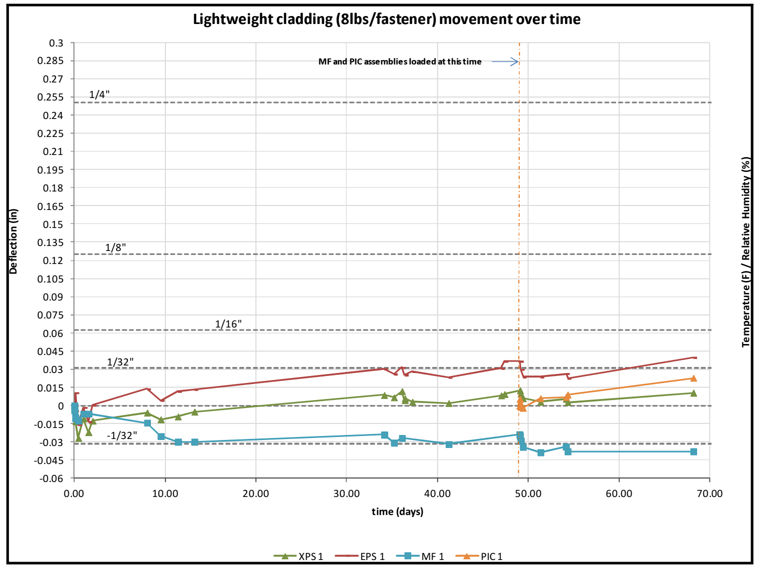

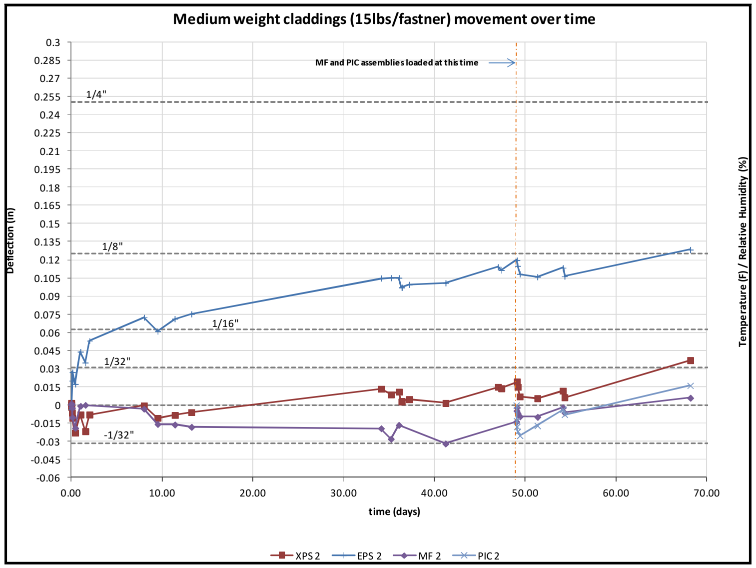

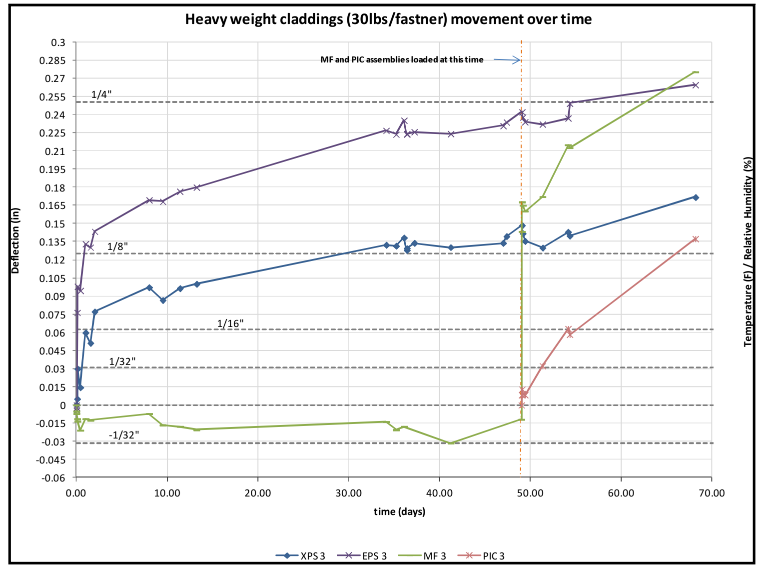

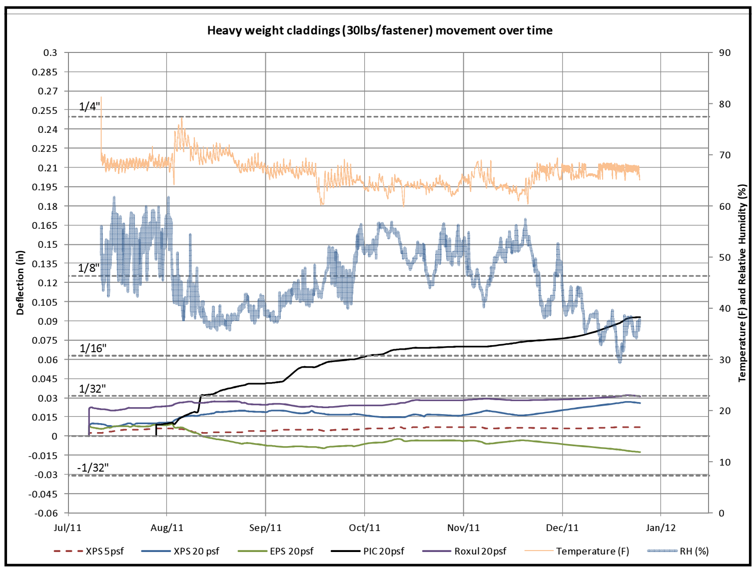

Testing Results

- Movement due to environmental exposure can be significant (measured 1/32" in a single day)
- Lightweight claddings appear to be relatively stable
- Creep is a significant factor in heavier claddings

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Industry Impacts

Industry Impacts

- Acceptable deflection not ultimate capacity governs
- What is acceptable deflection?
  - Movement a cladding system can accommodate without physical damage or exceeding aesthetic tolerances
- Proposed limits
  - Lap sidings and panel cladding ~ 1/16”? 1/8”?
  - Brittle claddings ~1/64”? 1/32”?, more?

Industry Impacts

- Movements due to environmental exposure may exceed proposed limits.
  - More research is needed to understand how much typically cladding systems move under environmental exposure
- Expansion and contraction of materials may impact system forces such as friction and the strut and tie
  - functions may need to be removed for design of the system capacity (ie. designed capacity based on fastener bending only or other structural connection)

Recommendations

Recommendations

- System performs well for lightweight claddings (5psf or less)
- Medium weight (5psf to 10 psf) and heavy weight claddings (10 psf to 25psf or greater) may need more design
  - Increase number of fasteners
  - Add a shear block or other structural attachment
- Code proposal should be developed that is based on acceptable deflection not ultimate capacity

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Questions?

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