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Cladding Attachment Over Thick Exterior Rigid Insulation

BA Webinar: High Performance Enclosure Strategies: Part II, New Construction

Building Science Corporation

Background

- Industry trend to using exterior rigid insulation
  - Increased thermal value
  - Condensation resistance
  - Increased air tightness (possibly)
  - Increased rainwater management (possibly)
- 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)

Background

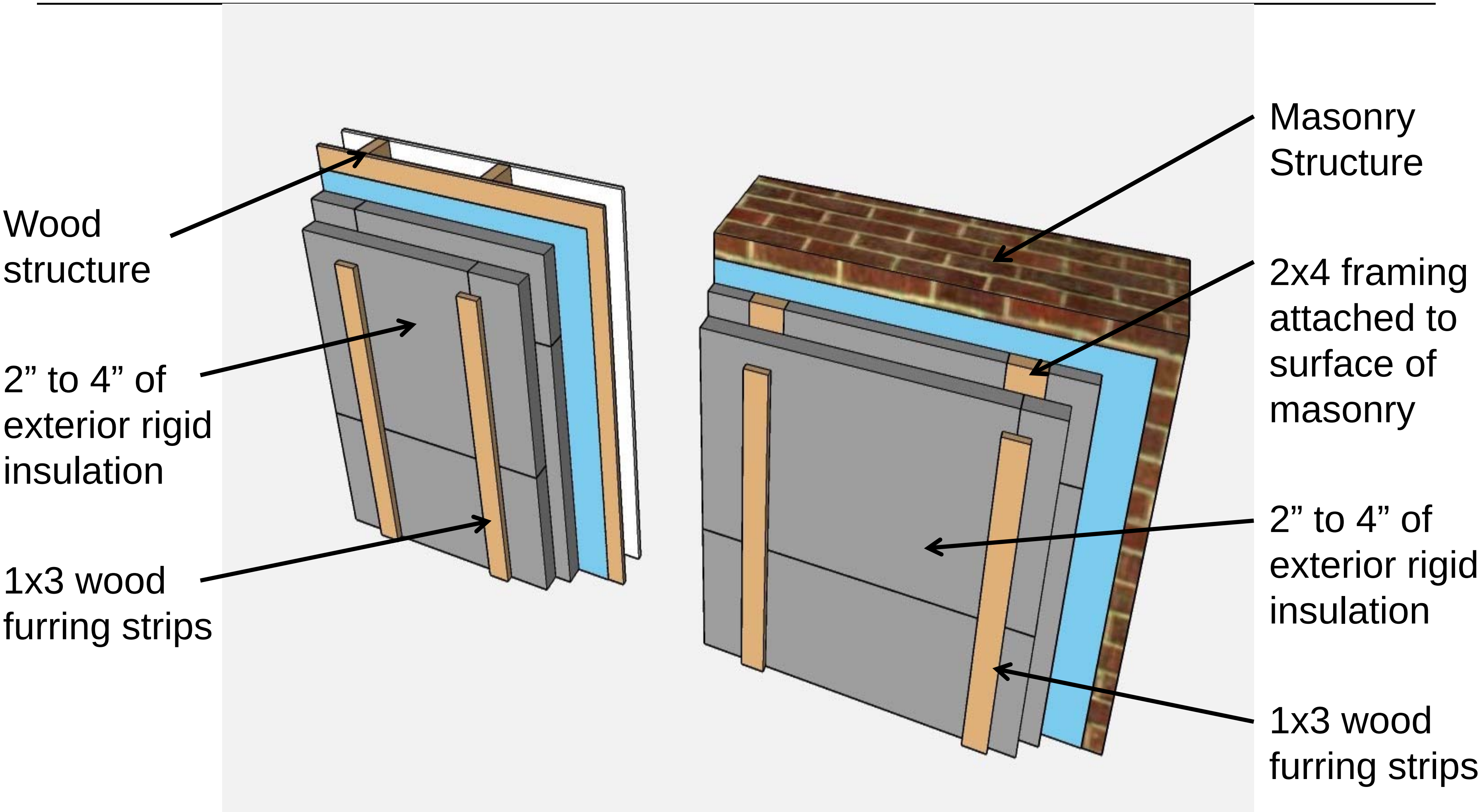
- Current Building Code does provide prescriptive means to attach cladding over exterior insulation
  - Table R704.3 – Note v: *Minimum nail length must accommodate sheathing and penetrate framing a minimum 1 ½ inches.*
- Current pneumatic nailers have maximum fastener lengths of 3” to 3.5” which limits 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 greater than 1.5” direct attachment of cladding though the insulation back to the structure is often not practical

Background

- 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)

Cladding Support System:
Direct Attachment Through Insulation

Direct Attachment Through Insulation



Direct Attachment Through Insulation

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
  - Compression resistance of insulation
  - Long term creep

"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

Design Criteria

- Acceptable deflection not ultimate capacity governs
- What is acceptable deflection?
  - Movement a cladding system can accommodate without physical damage or exceeding aesthetic tolerances
- Proposed limit of 1/16” vertical deflection

BSC Cladding Attachment Research

- Began in 2011
- Looking to expand on previous research
- Broken into two sections:
  - mechanics of the cladding attachment system
  - long term environmental exposure

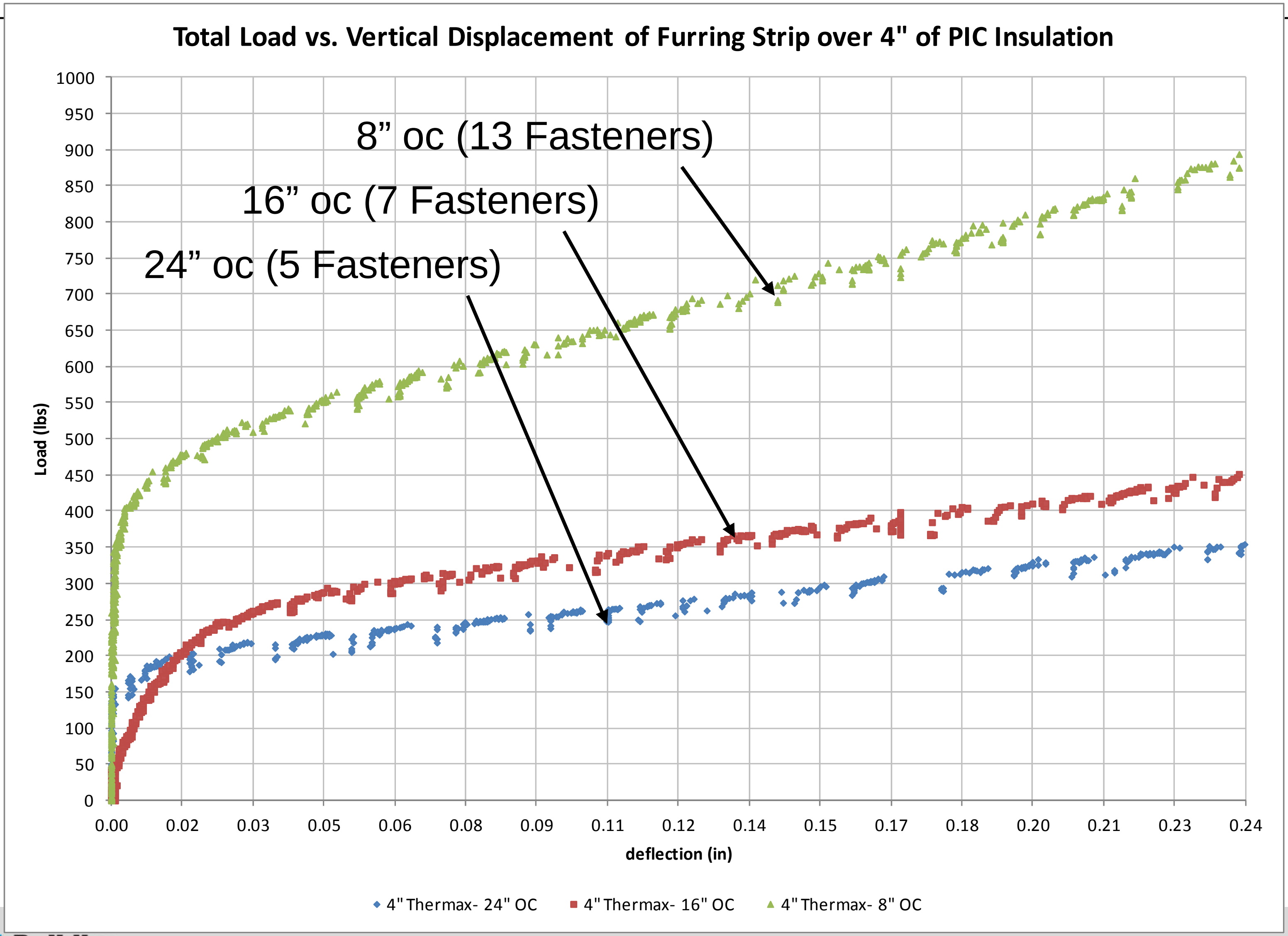
Full System Laboratory Tests

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

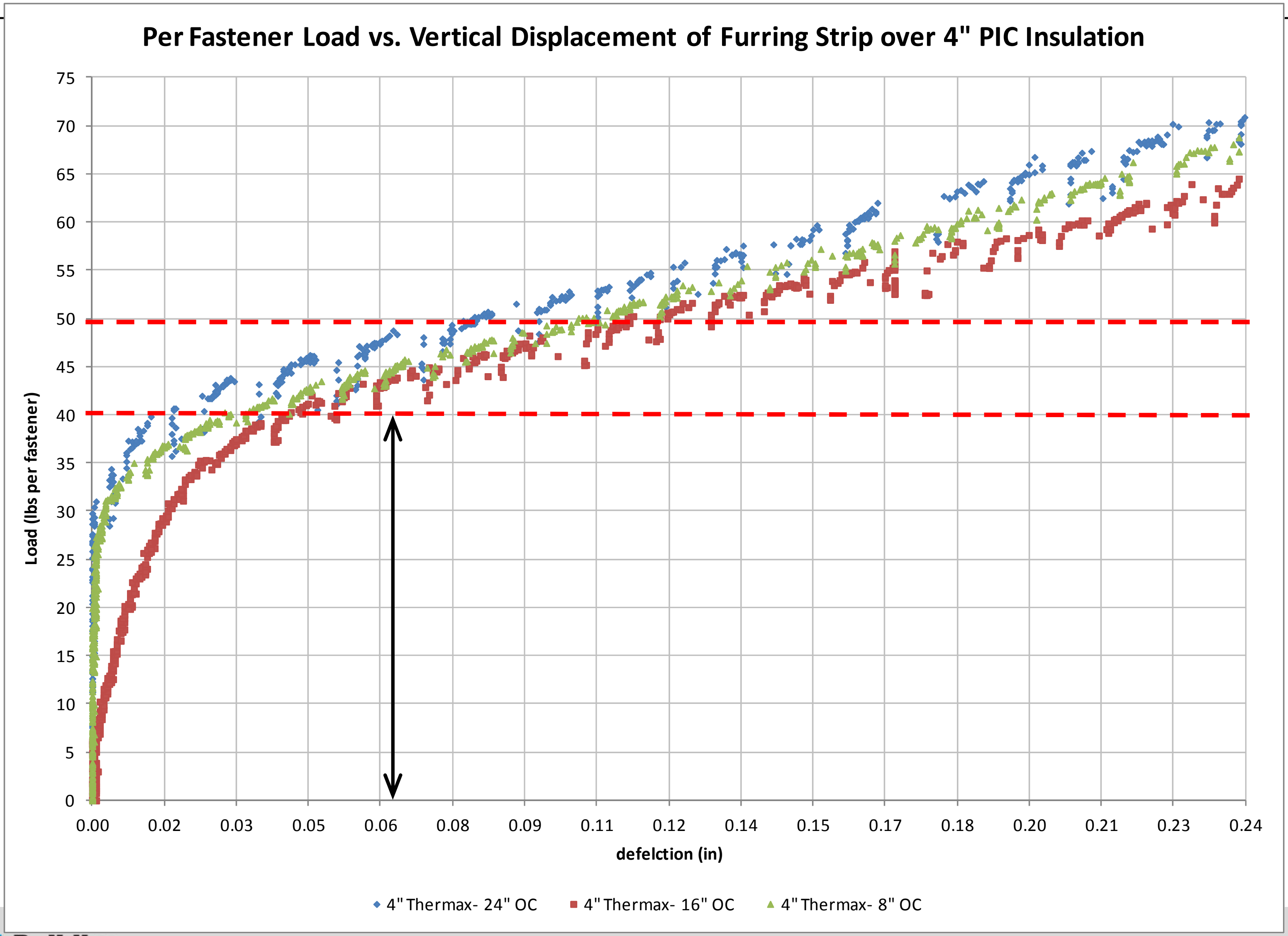
Full System Laboratory Tests

- 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

Full System Laboratory Tests

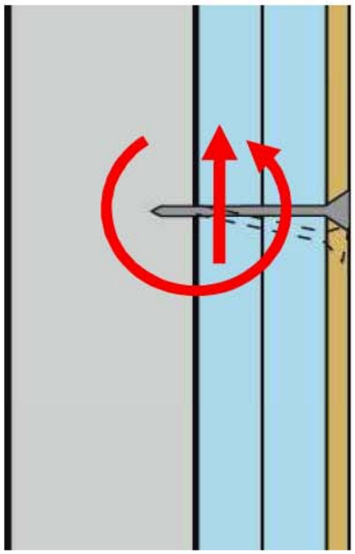


Full System Laboratory Tests

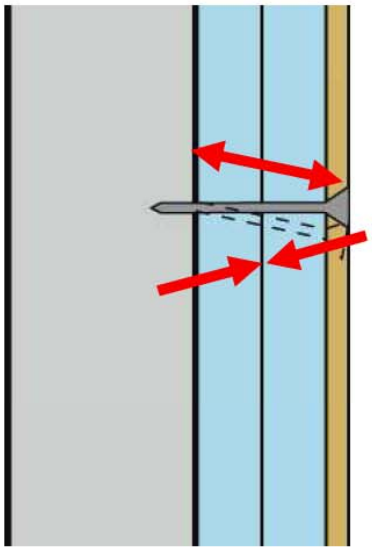


BSC Cladding Attachment Research

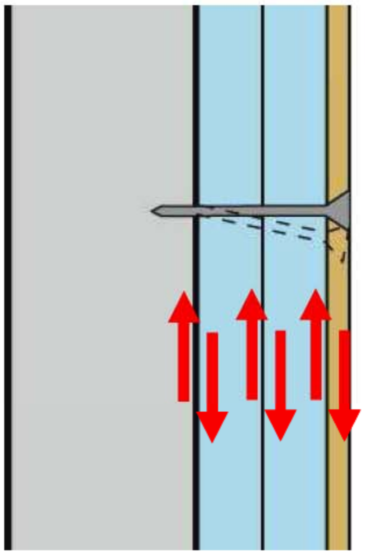
- System Mechanics



Shear and rotational resistance provided by fastener to wood connections



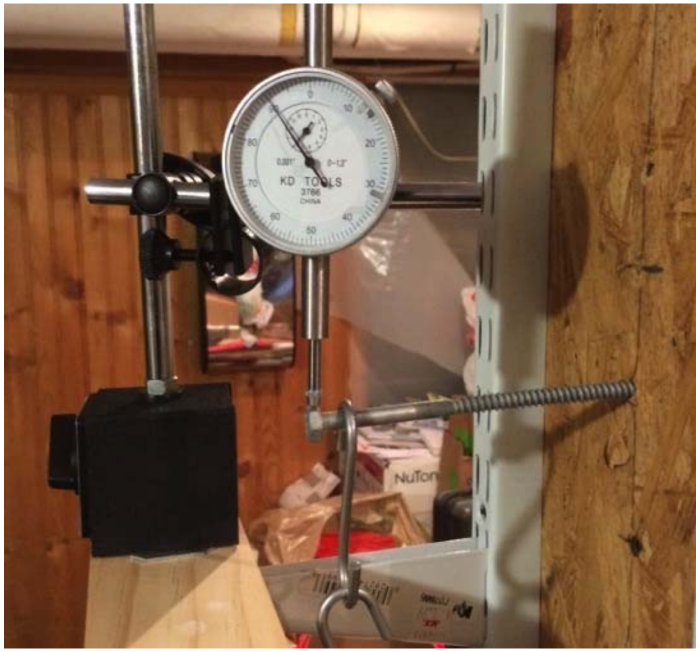
Rotational resistance provided by tension in fastener and compression of the insulation

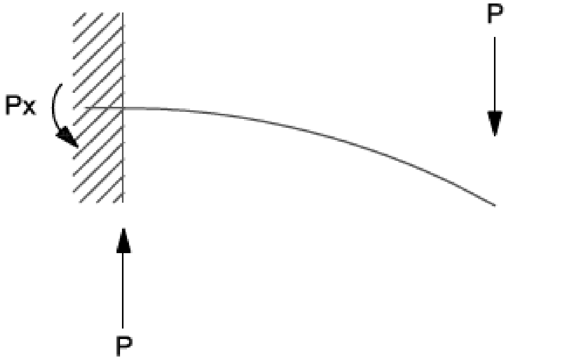


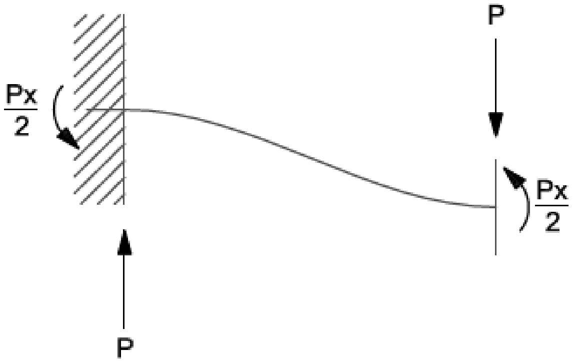
Vertical movement resistance provided by friction between layers

Screw Bending

- Cantilever
- Double Bending
- Screw Shaft Bearing



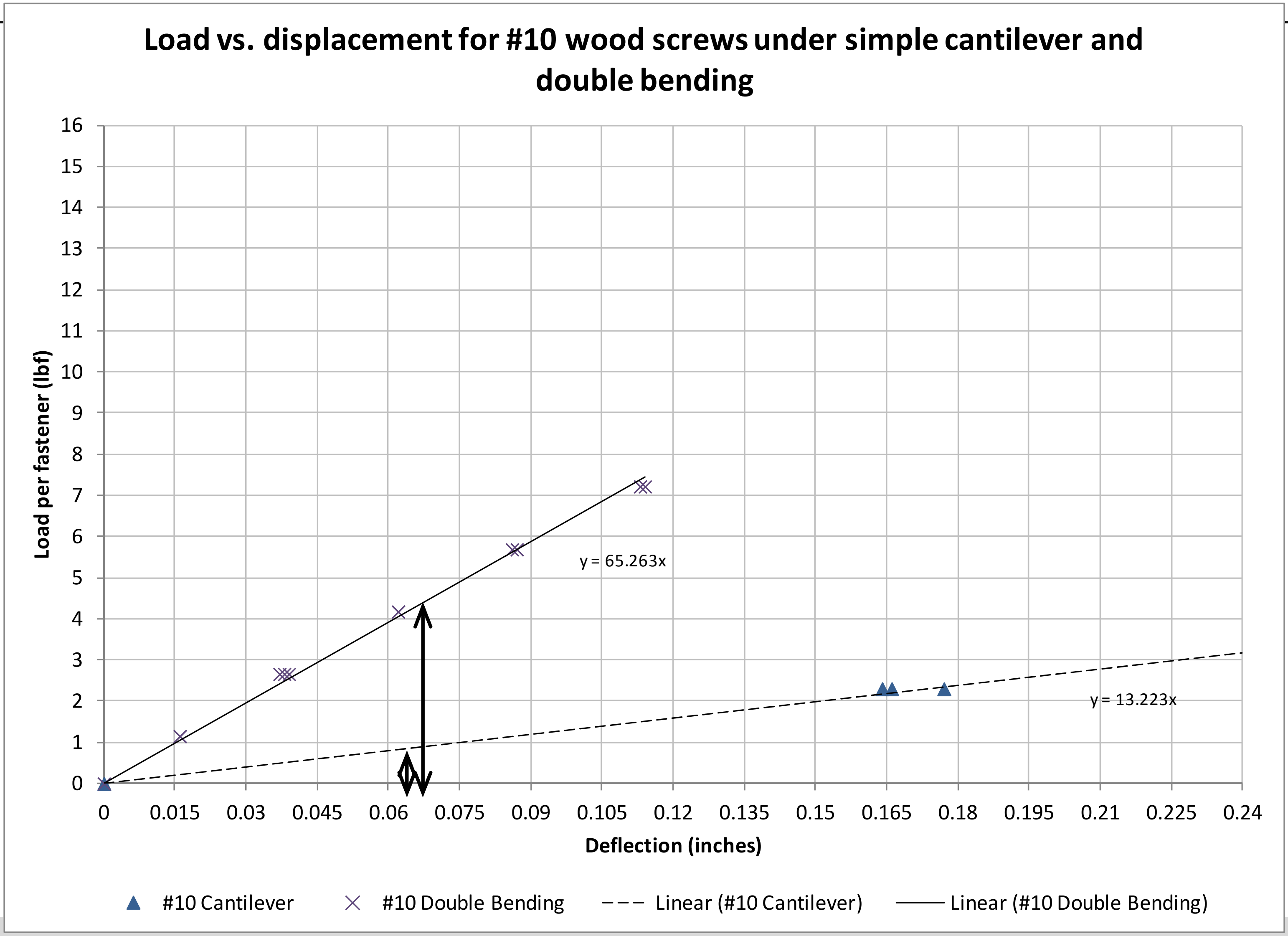




Screw Bending

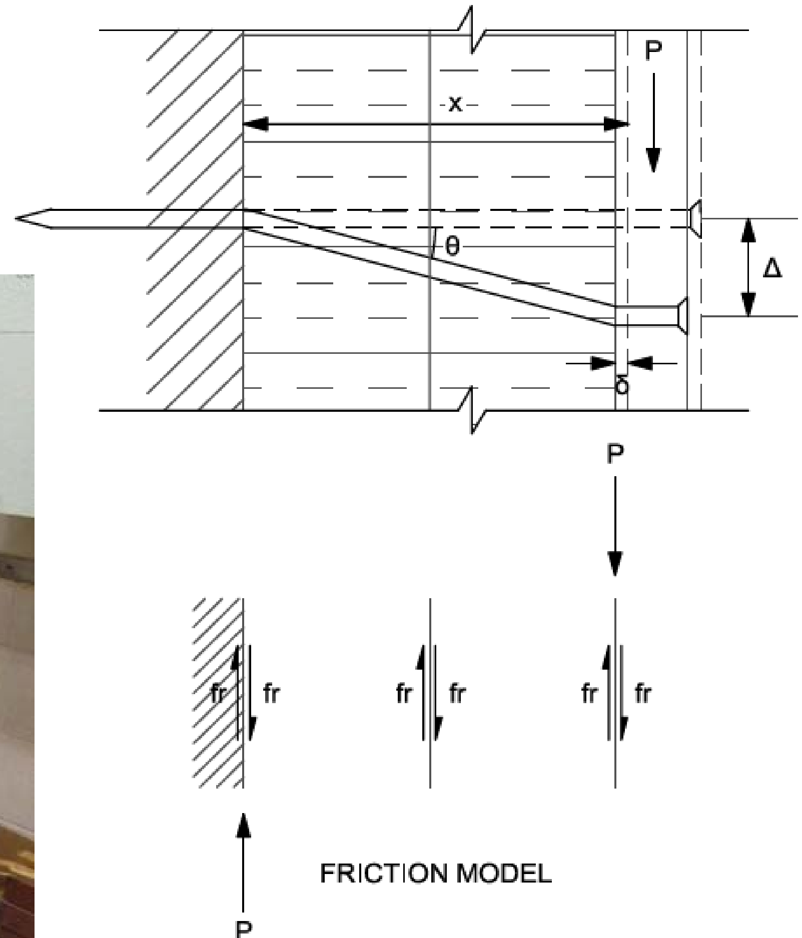
- Double bending resistance was significantly higher (~4 times) than simple cantilever.
- Double bending is more in line with the expected performance of the assemblies but still only accounted for a fraction of the total measured system capacity
- Screw shaft bearing on the insulation was hard to quantify, but appeared to be significant in short term (initial response) tests

Screw Bending



System Friction

- Compression Forces
- Coefficients of Friction

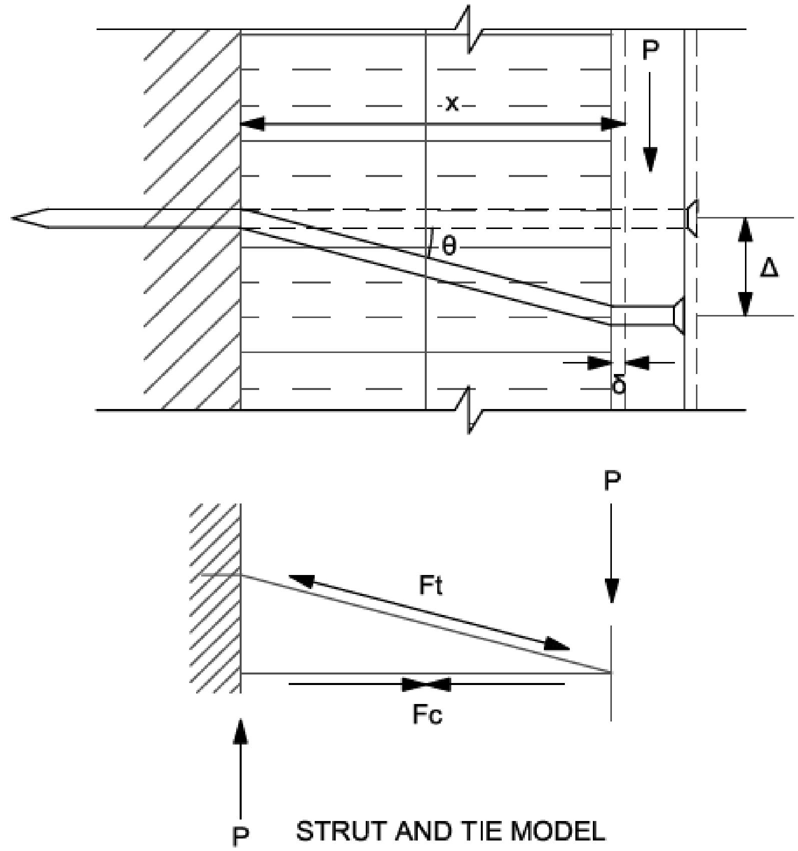


System Friction

- Compression Forces were measured at around 150lbf/fastener to drive a #10 wood screw flush with face of furring
- Coefficients of frictions were typically around 0.25
- Compression forces were also measured to drop off over time (around 20% to 30%) after initial loading and be highly sensitive to environmental conditions

Compression Strut

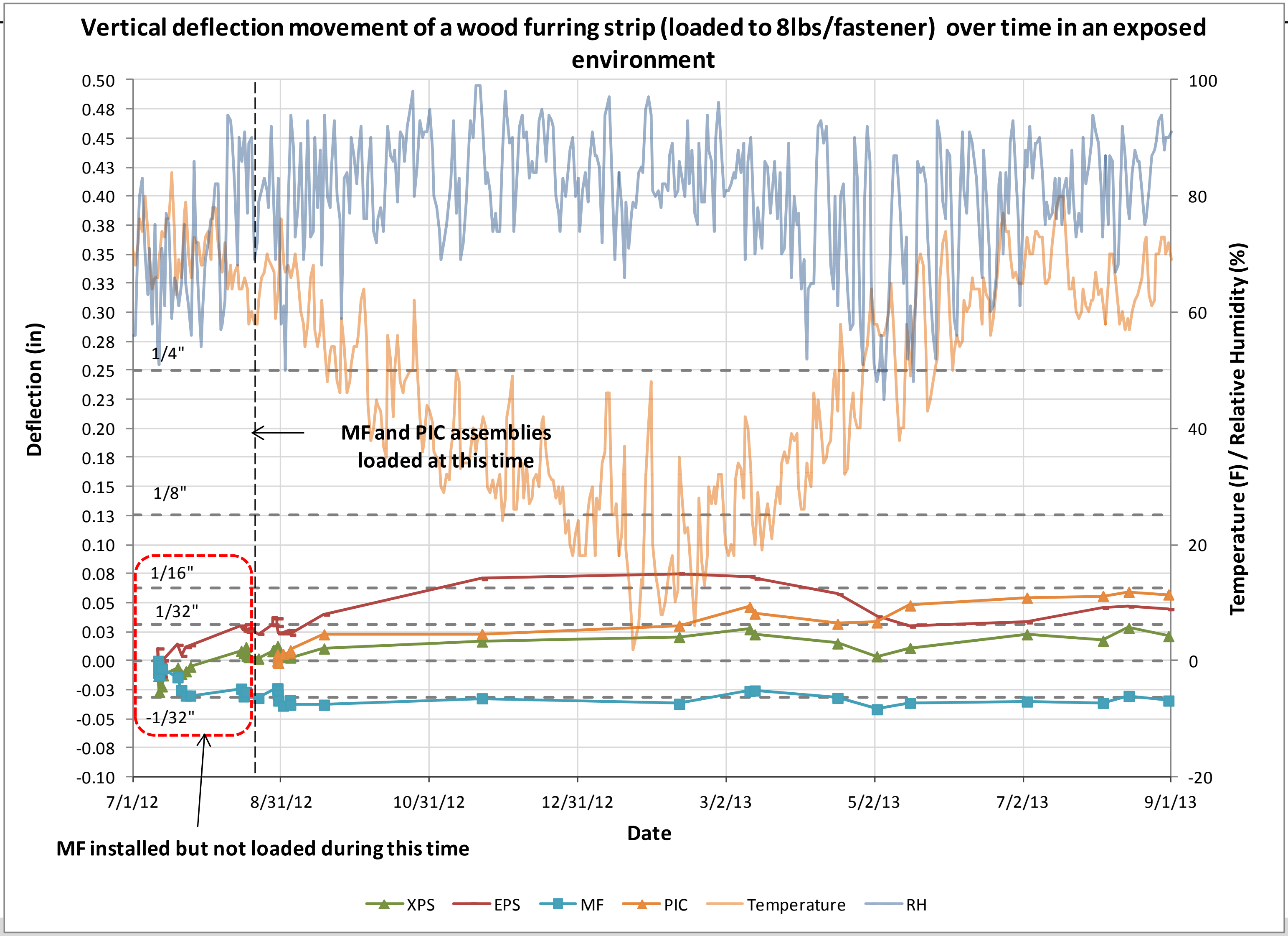
- Function of fastener tension and insulation compression
- Measured insulation compression properties
- Difficult to measure directly
  - Fastener bending present
  - Hard to create a “frictionless” system
- May have a more significant contribution in the form of additional friction than compression resistance



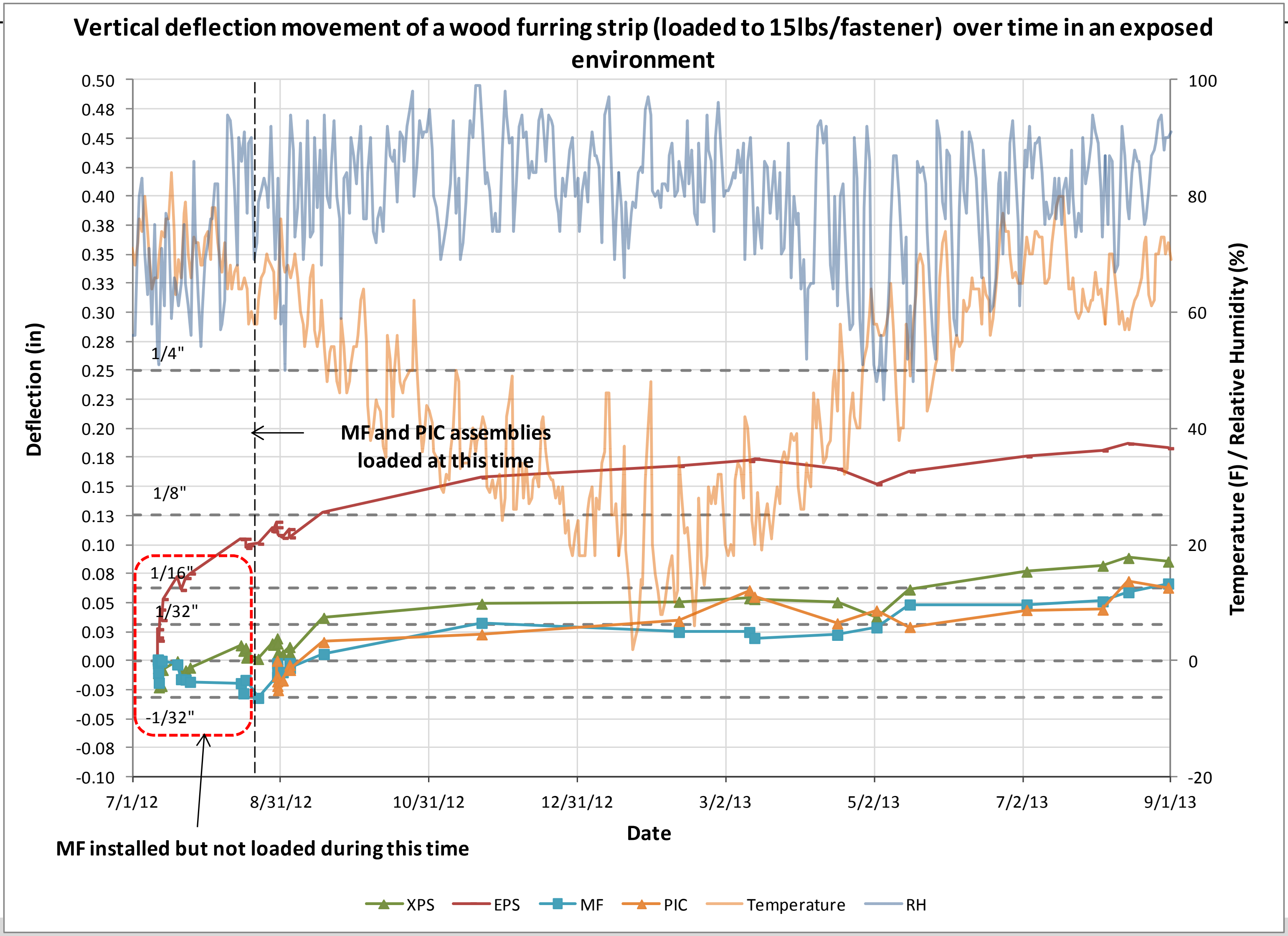
Exterior Exposure Testing

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

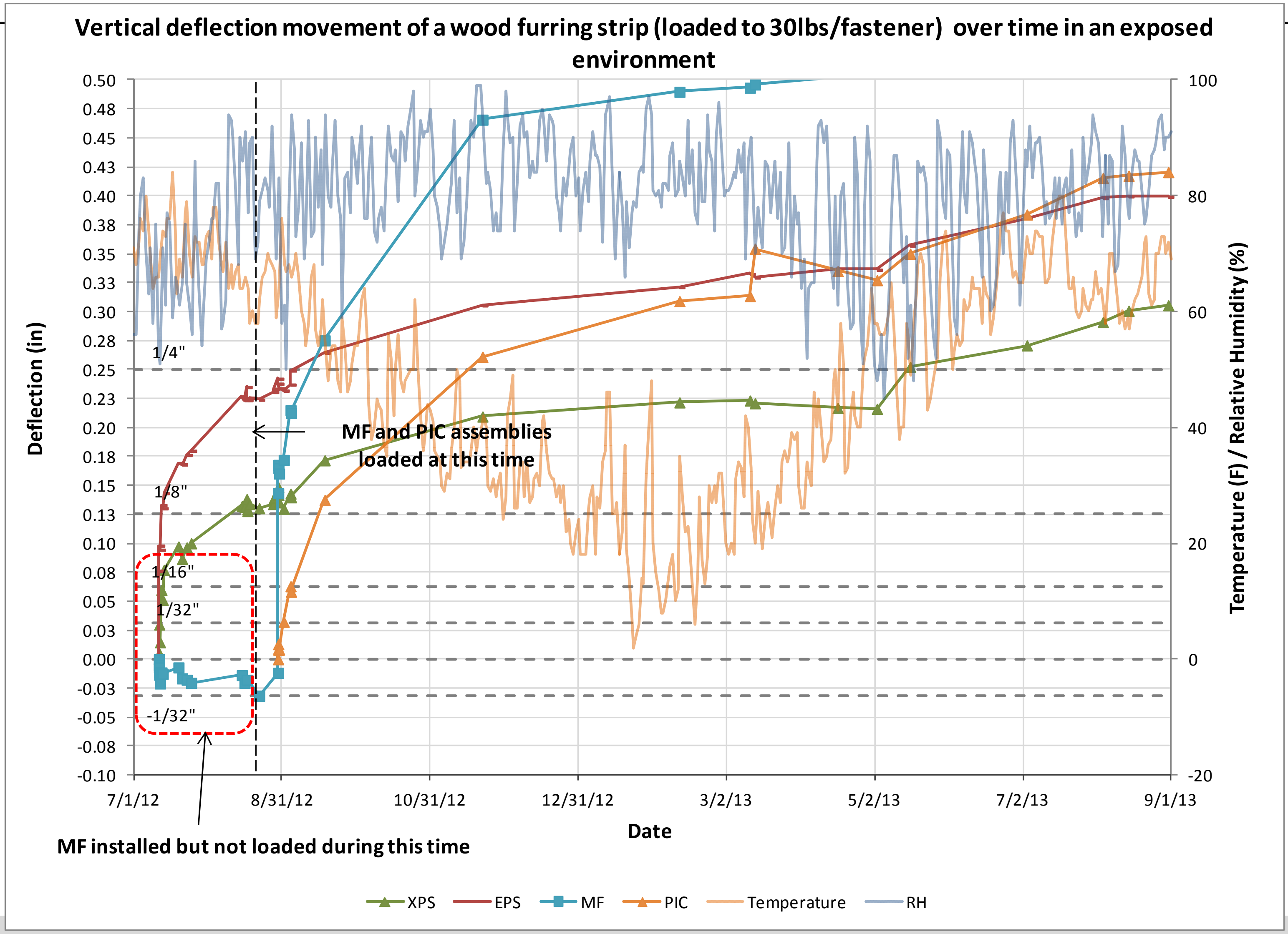
Exterior Exposure Testing



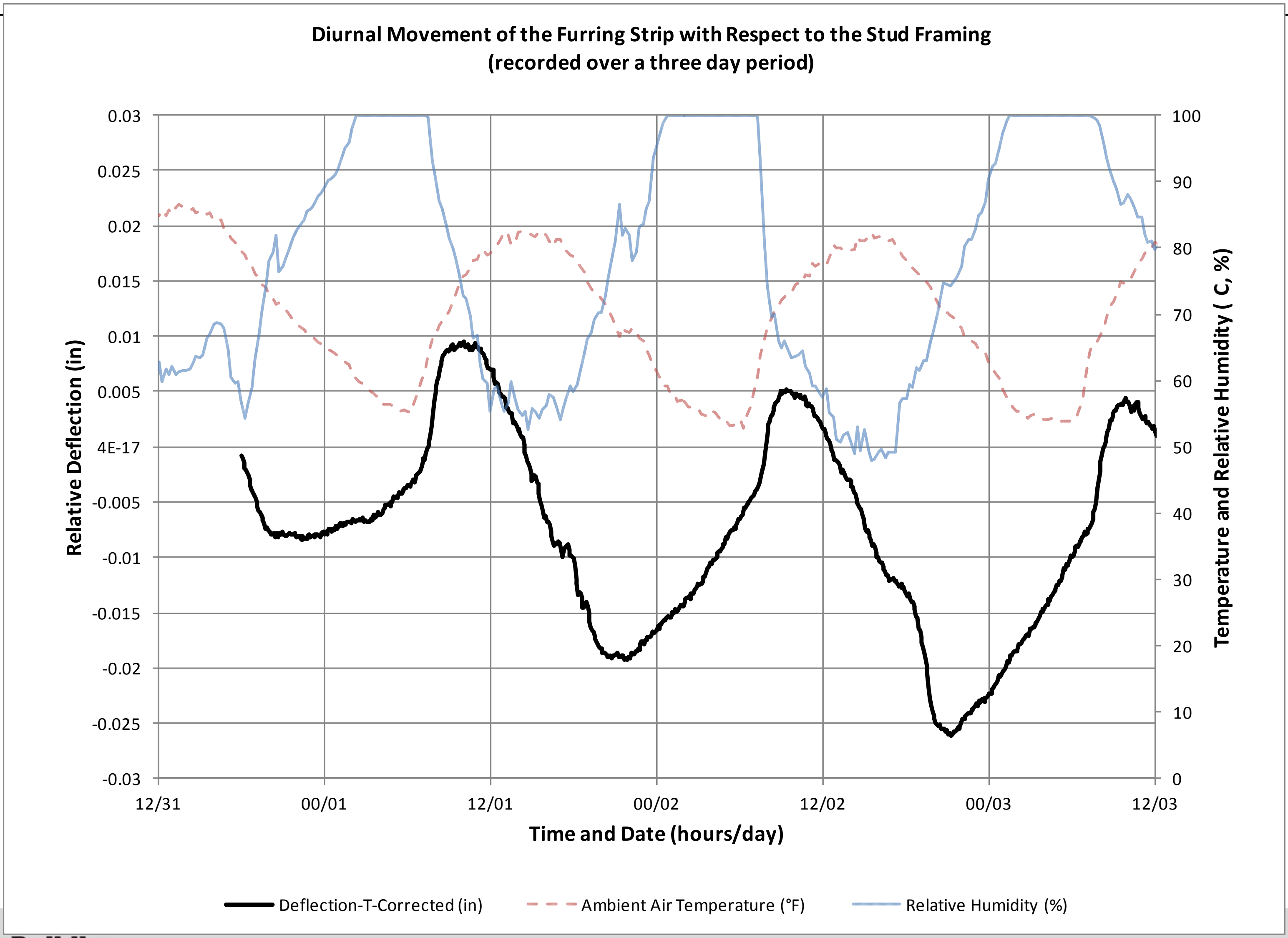
Exterior Exposure Testing



Exterior Exposure Testing



Exterior Exposure Testing



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Conclusions (System Mechanics)

- Initial load response measurements are on the order of 40 to 50lbf/fastener at 1/16” 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
- 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.

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

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

Questions?

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