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BE BUILDING ENCLOSURE

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PRISM

Architect's Newspaper

Avoiding Building Enclosure System Failures

Len Anastasi

EXO-TEC Consulting, Inc.

abaa EDUCATION

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Learning Objectives

Upon completing this program, the participant should understand

1. **Learn the importance proper moisture management strategies**
2. **Learn about some pitfalls to avoid in proper moisture management**
3. **Learn how important coordination is in the success of a project**
4. **Learn how important supervision is in the success of a project**

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CONTINUING EDUCATION
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The Wetting Potentials

Liquid Water Ingress (Water Barrier)

Moisture Transport Due To Air Flow (Air Barrier)

Dew Point (Heat Barrier Location)

Vapor Migration (Vapor Barrier)

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How Do We Properly Deal With These Four Wetting Potentials???

Good HAMM!!!

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What the #@$& is HAMM ?

- **HAMM is the 4 barriers needed to protect a building against the effects of weather. These barriers are:**

H	**Heat Barrier**
A	**Air Barrier**
M_L	**Water Barrier (Liquid Moisture)**
M_V	**Vapor Barrier (Gaseous Moisture)**

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HAMM is the <u>WEATHER BARRIER SYSTEM</u>

HAMM Order Of Magnitude

ML	Water Barrier (Liquid Moisture)
A	Air Barrier (Moisture Transport Due To Air Flow)
H	Heat Barrier (Dew Point)
MV	Vapor Barrier (Gaseous Moisture)

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The Condo Building

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The Condo Building

The Problem

Multitude of water leaks through the above grade vertical building enclosure.

The Results

Water damage to the building enclosure components.

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Problems

1. Water leakage through the existing windows.

2. Water leakage into the LGMF stud cavity.

3. Water leakage into the condo units.

4. A structural code issue???

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Background

1. Built in the late 1980's with an EIFS veneer.

2. The building enclosure assembly experienced leaks from day one.

3. Was repaired and re-clad with an ACM panel veneer.

4. The existing windows that were determined to leak by many consultants were not replaced due to budget issues.

5. The building still leaked after the repairs and re-cladding.

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The New Enclosure Assembly

New ACM cladding system

Air / drainage space

New 1 ½” extruded polystyrene insulation

New Vapor permeable fluid applied air and water barrier membrane

New Glass matt faced exterior gypsum sheathing

New 6” foil faced batts insulation in existing 6” LGMF

Existing interior GWB

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Let’s see how it performs!!!

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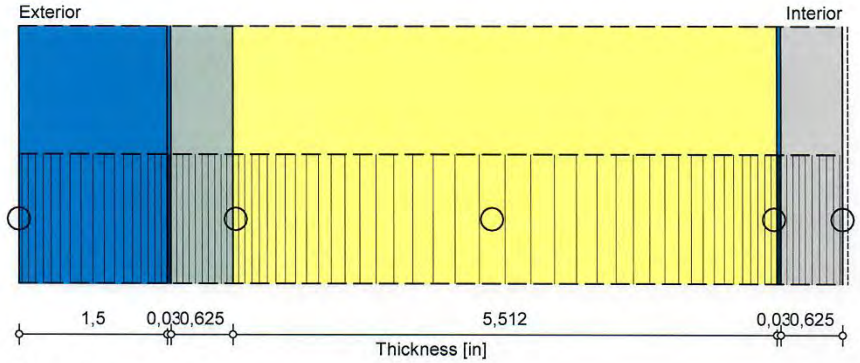
Component Assembly

Case: #1

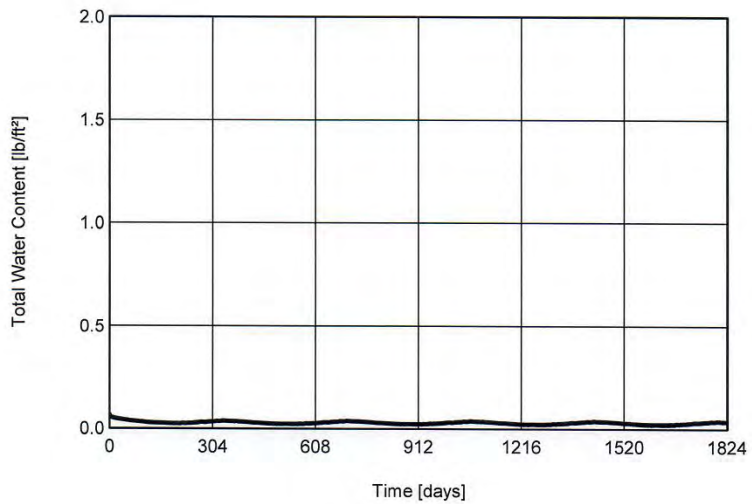


○ - Monitor positions

Materials :

- Extruded Polystyrene Insulation
- vapor retarder (10perm)
- Gypsum Board (USA)
- Low Density Glass Fibre Batt Insulation
- vapor retarder (0.1perm)
- Interior Gypsum Board

Total Thickness: 8,341 in
R-Value: 28,4 h ft² °F/Btu
U-Value: 0,029 Btu/h ft²°F



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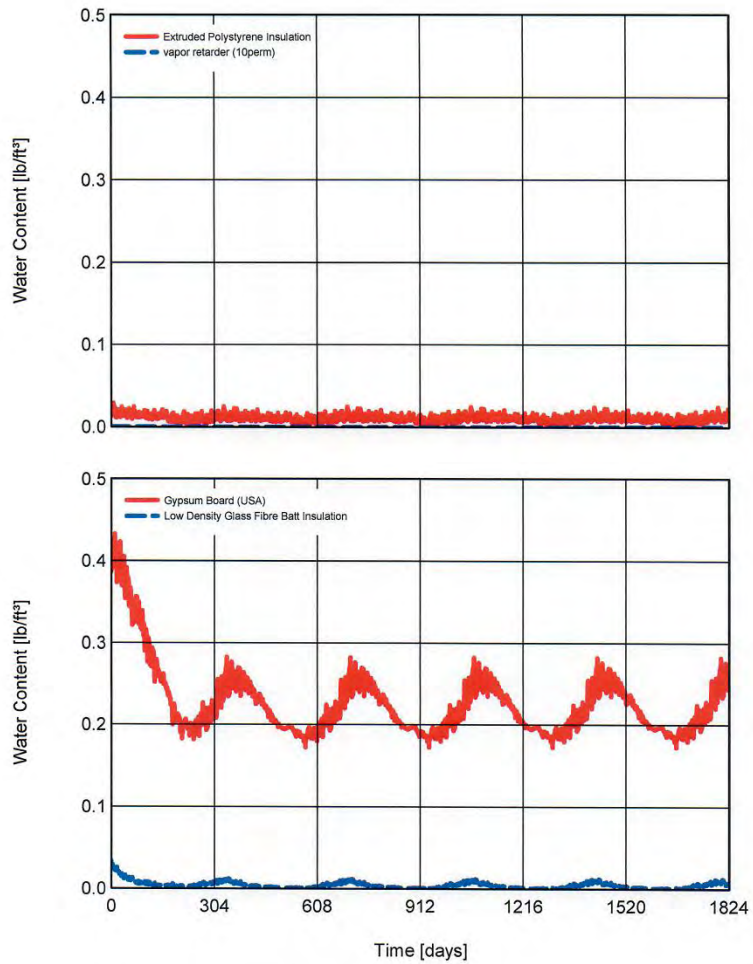

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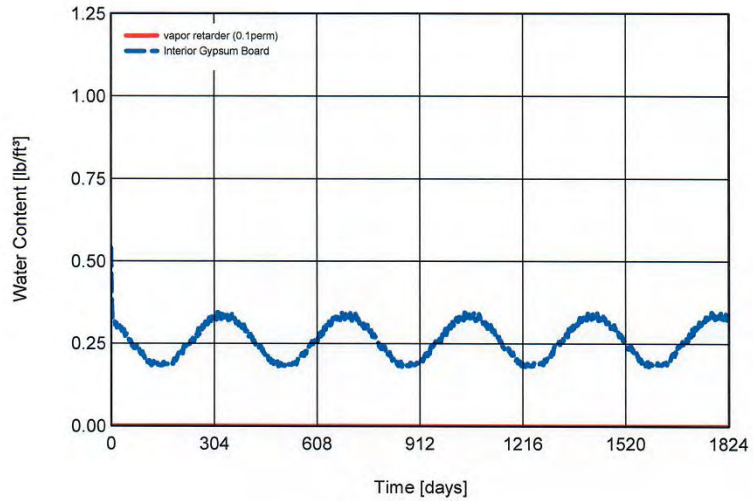

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“ It meets the code!!! “

But it failed!!!

Why???

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Discovery Findings

1. A two level parking garage was located under each of the two building.

2. The garages had exhaust fans installed in them for when the carbon dioxide levels got to high to exhaust the air out of the garage.

3. The garages were not de-coupled from the buildings.

4. The common area pressurization systems for the buildings were de-activated because they did not work.

5. There were no vestibules at the elevator lobbies.

6. The buildings were experiencing significant de-pressurization.

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The Solution?

Blame the contractor!!!

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Inspection Findings

The ACM cladding attachment hardware was surface mounted to the rigid insulation.

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Inspection Findings

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The joints of the rigid insulation were sealed.

Inspection Findings

Mounting hardware fastener penetrations that missed the studs

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Inspection Findings

The structural engineer for the metal panel contractor determined that the gage of the existing LGMF studs was not sufficient to withstand the eccentric load imposed on them if conventional z-furring was used as the ACM cladding mounting hardware. So he designed flat stock galvanized steel plates to be fastened to the studs through the extruded polystyrene insulation thus turning the insulation into a load bearing element.

Materials that burn are not allowed to be load bearing elements in the exterior walls in non-combustible construction classified buildings per the building code.

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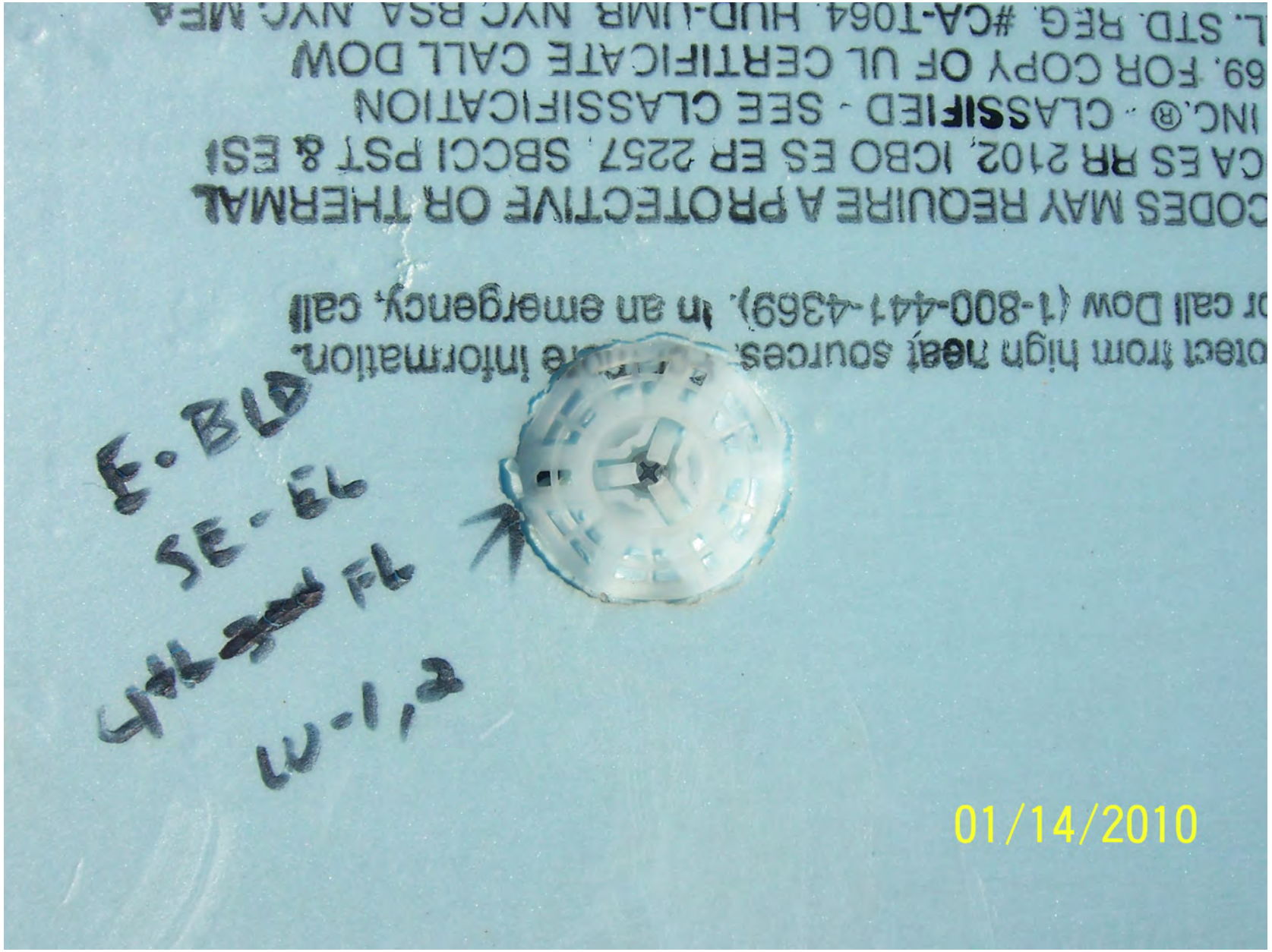
Inspection Findings



Insulation fastener penetrations that missed the studs

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Did this cause all the problems???

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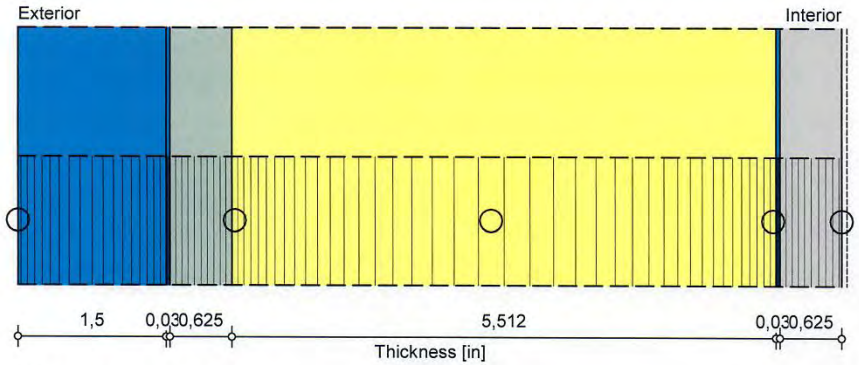
Component Assembly

Case: #1



○ - Monitor positions

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- Gypsum Board (USA)
- Low Density Glass Fibre Batt Insulation
- vapor retarder (0.1perm)
- Interior Gypsum Board

Total Thickness: 8,341 in
R-Value: 28,4 h ft² °F/Btu
U-Value: 0,029 Btu/h ft²°F

Sources, Sinks

Extruded Polystyrene Insulation

Type	Name
Moisture	Source1

vapor retarder (10perm)

Type	Name
Moisture	Source1

Gypsum Board (USA)

Type	Name
Moisture	Source1

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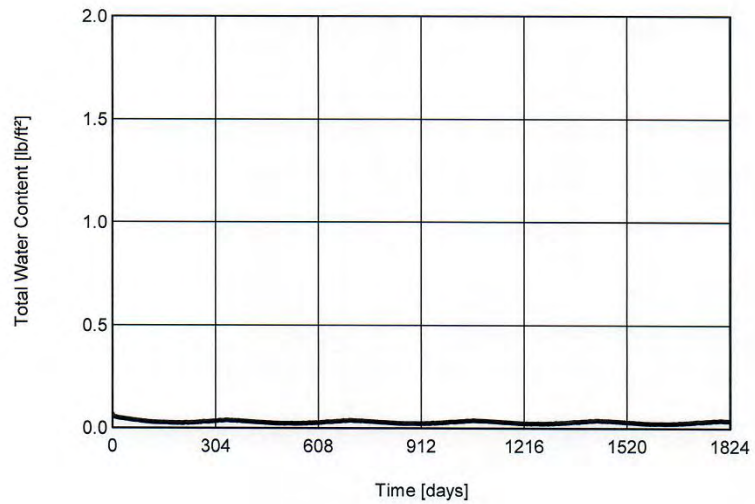

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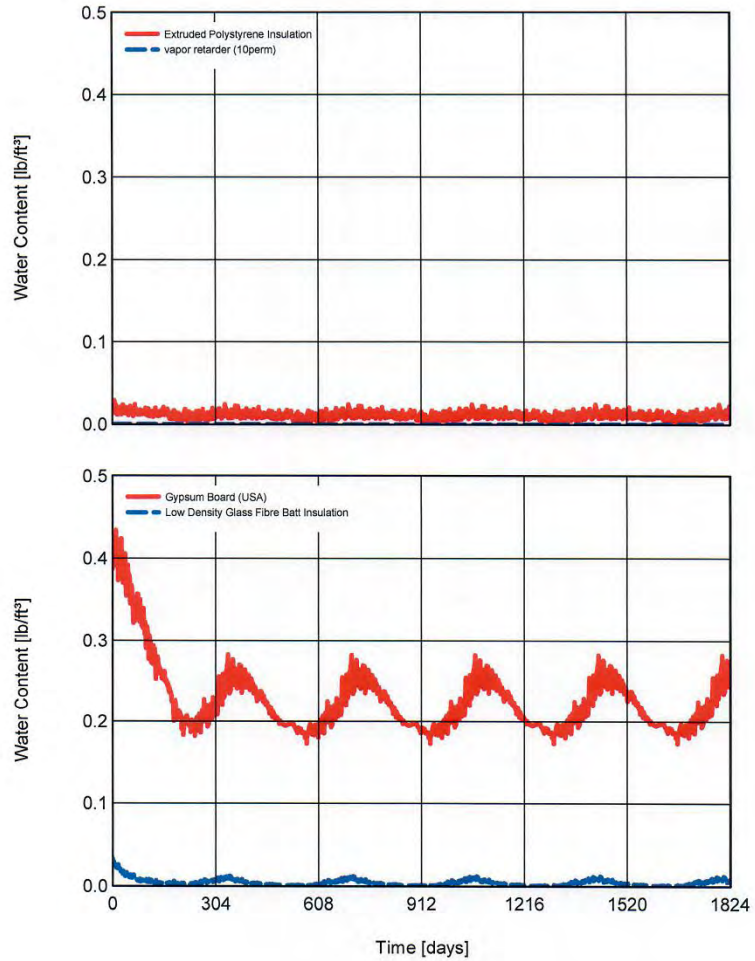

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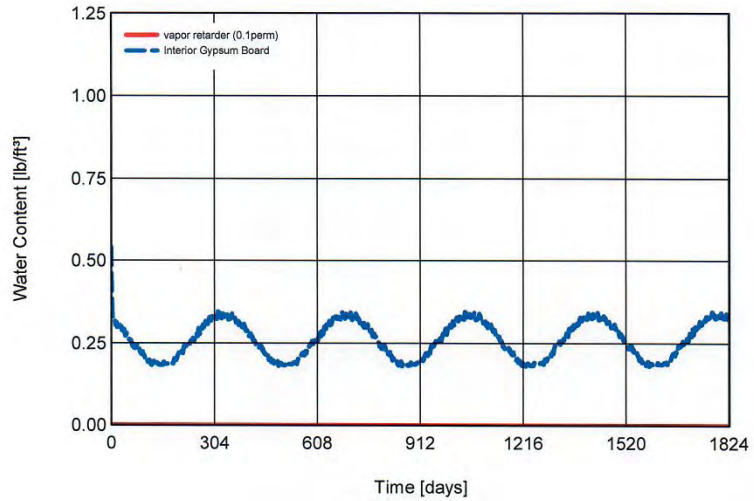

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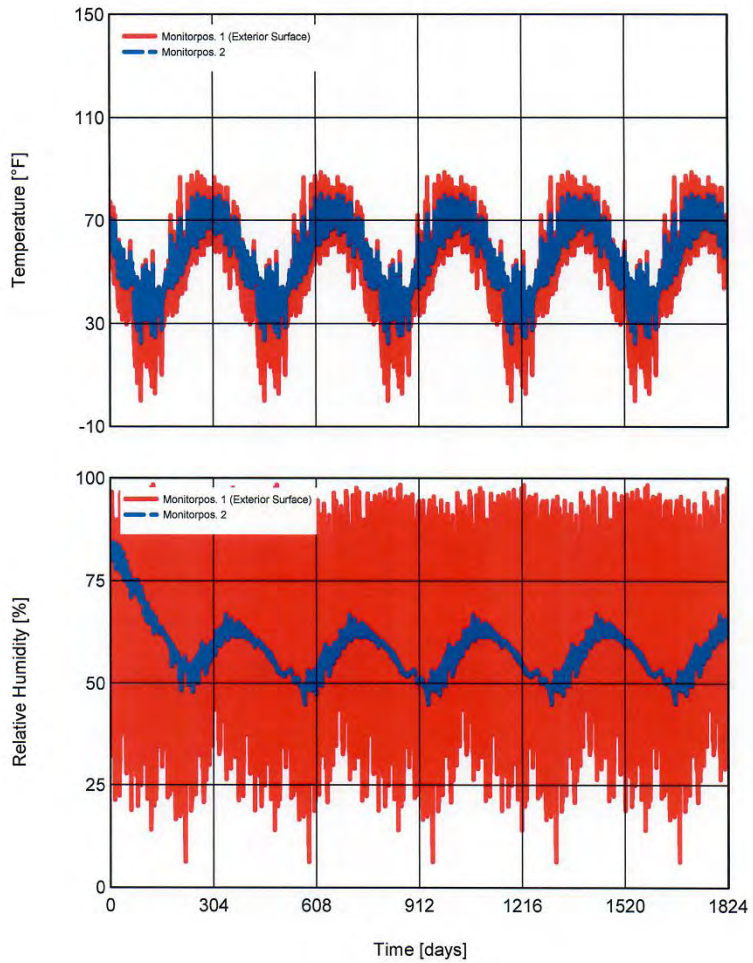

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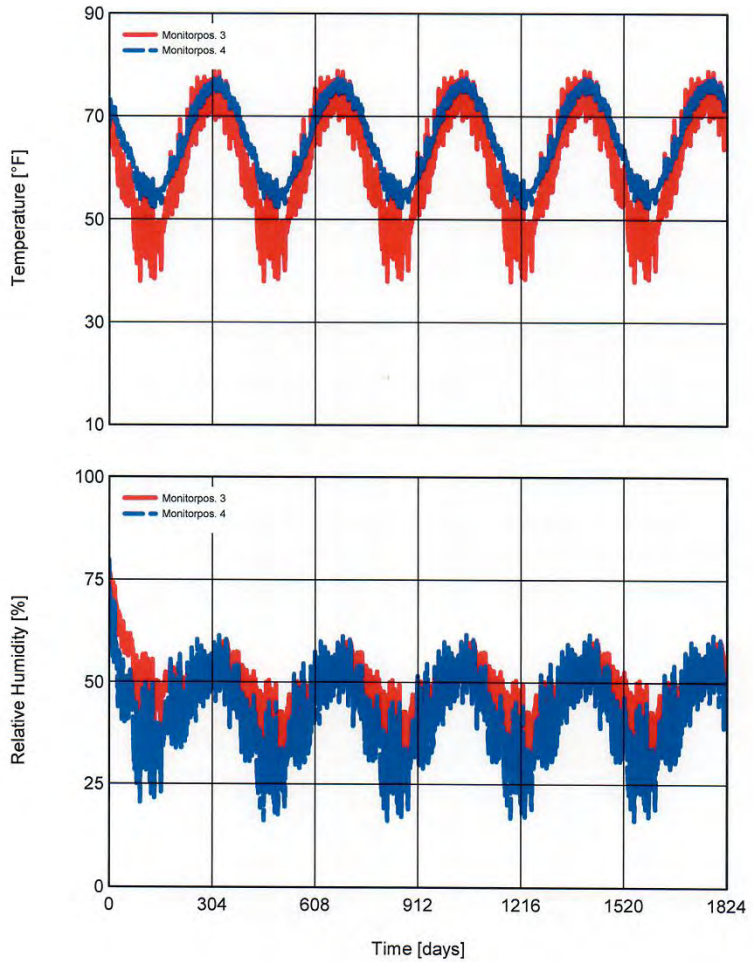

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Inspection Findings

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There were weeps / vents in the ACM cladding, but….

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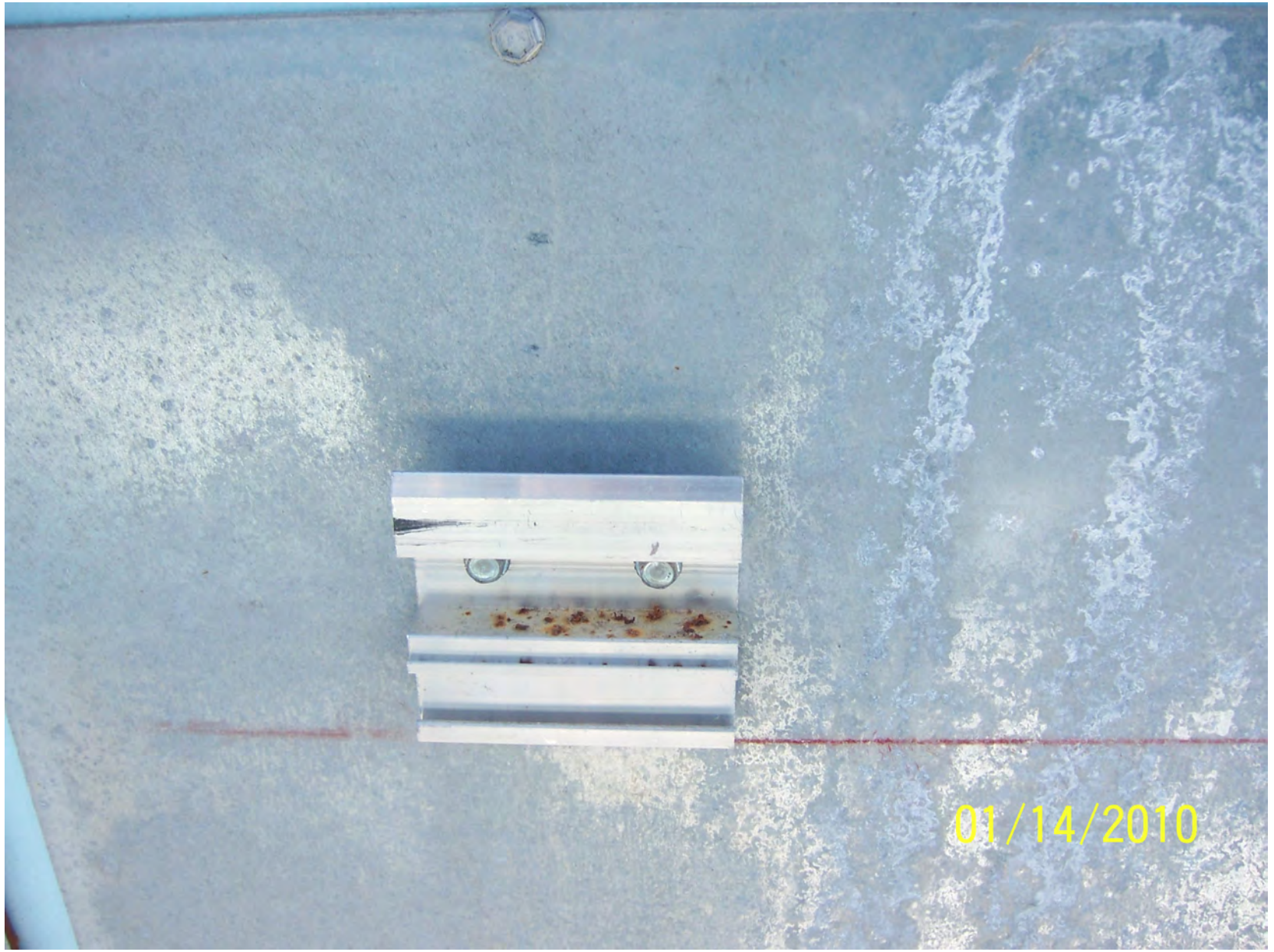
…they did not line up with the weeps in the stiffener plates.

Inspection Findings



The corrosion of the mounting hardware seemed fairly significant based on its age.

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Inspection Findings

The corrosion of the mounting hardware seemed fairly significant based on its age.

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Did this cause all the problems???

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High RH levels in the rainscreen cavity are the most likely cause of the premature corrosion of the metal items in the rainscreen caviy.

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Inspection Findings

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The adhesion of the S/A detail membrane was failing at many locations

Inspection Findings

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The adhesion of the S/A detail membrane was failing at many locations

Inspection Findings

01/14/2010

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The metal sill flashing pans were designed and installed to dump the water they collected behind the extruded polystyrene insulation.

Inspection Findings

The “ kick out “ flashing

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Why did the adhesion of the detail membrane to the substrate fail???

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Perm Rating of XPS = 0.75

Perm Rating of vapor permeable air & water barrier = 11.5

Perm Rating of exterior gypsum sheathing = 42

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Where does the water that get trapped between the XPS and the vapor permeable air barrier dry to?

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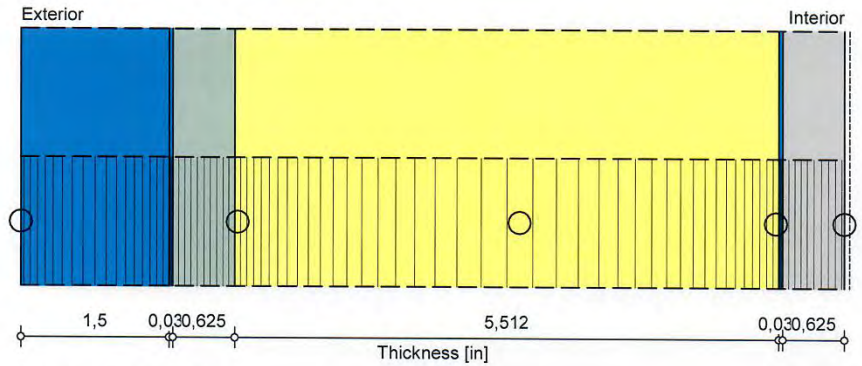
Component Assembly

Case: #3



○ - Monitor positions

Materials :

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- vapor retarder (10perm)
- Gypsum Board (USA)
- Low Density Glass Fibre Batt Insulation
- vapor retarder (0.1perm)
- Interior Gypsum Board

Total Thickness: 8,341 in
R-Value: 28,4 h ft² °F/Btu
U-Value: 0,034 Btu/h ft²°F

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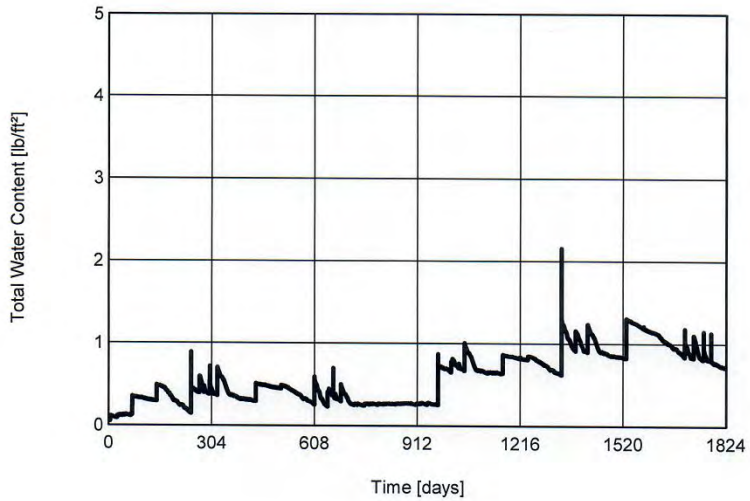
Sources, Sinks

Extruded Polystyrene Insulation

Type	Name
Moisture	Source1



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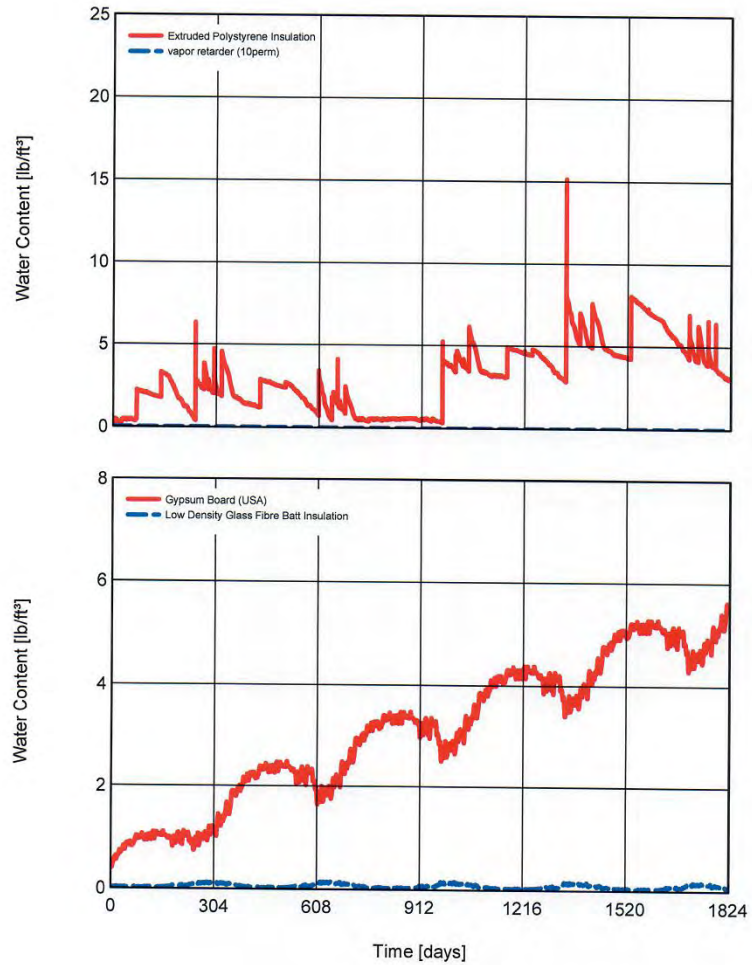

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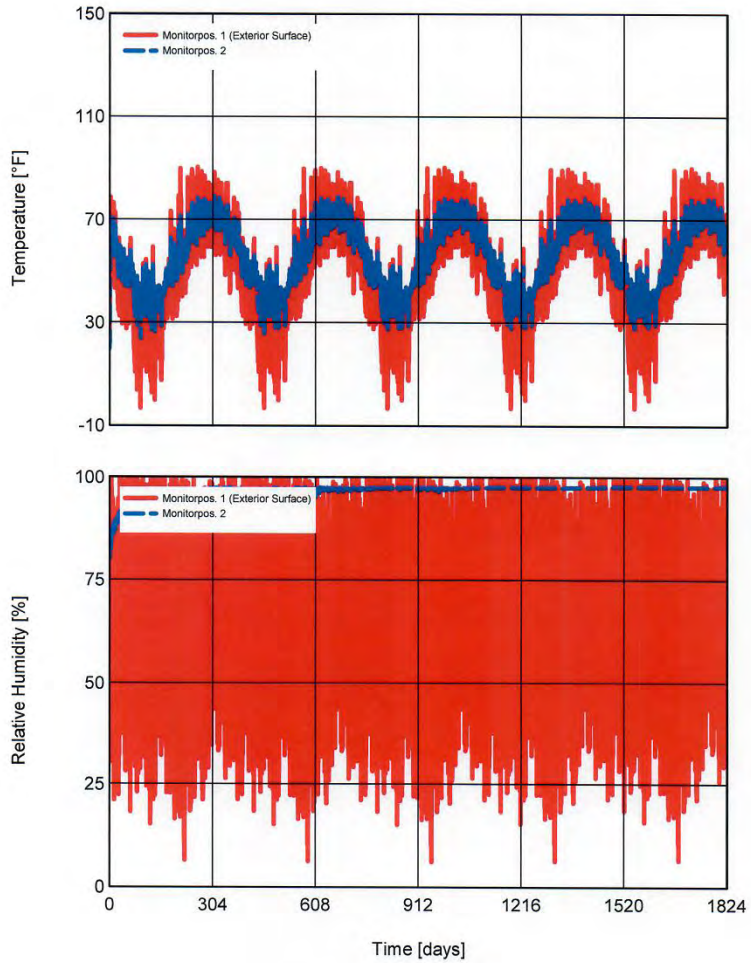

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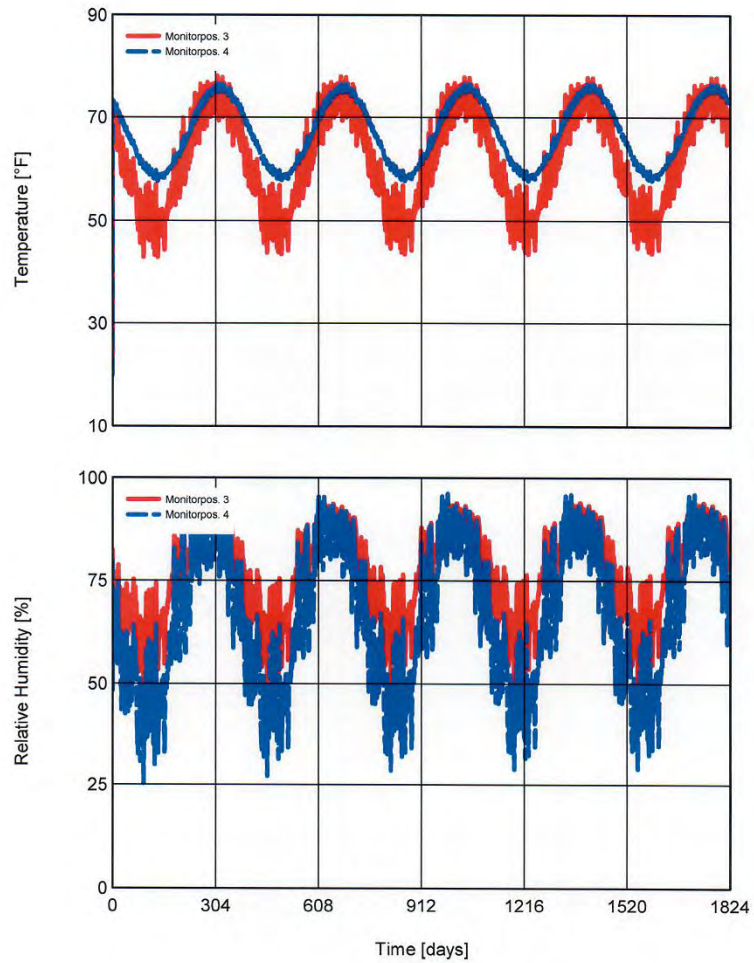

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Dr. Donald M. Onysko

A 1/8” wide drainage space is needed for water to effectively drain out of a wall assembly.

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The above grade building building enclosure assembly meets the building code…

BUT

…did not effectively deal with the four wetting potentials.

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Inspection Findings

The stairwells that were supposed to be positively pressurized were sucking air into them.

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What The #@&% Happened?

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The Common Consensus

1. Water penetration into the interior of the building was caused by the fact that the existing windows leaked and the owners chose not to replace them due to budget concerns and the fact that expensive interior wall coverings would have to be replaced if the windows were replaced.

2. Fastener penetrations that missed the studs were the other main cause of water infiltration into the building.

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Len's Rebuttal

There are really only two types of windows:

Windows that leak, and…..

Windows that are going to leak.

Flash the windows properly and you don't have to worry when they do leak.

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Len's Rebuttal

Random 1/8" diameter holes through the water barrier will not result in the bulk water leakage that the buildings were experiencing unless exacerbated by the force created by the significant negative pressurization of the buildings.

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What The #@&% Happened?

1. The water that was channeled behind the extruded polystyrene insulation by the window sill flashing pans either adhered to the insulation or the vapor permeable air and water barrier or spanned the gap between them and dried into the LGMF stud cavity.

2. This saturated the exterior gypsum sheathing making it an unsuitable substrate for the S/A detail membrane and thus it became un-adhered.

3. Water leaked into the interior of the building when the S/A detail membranes failed. This was exacerbated by the negative pressurization of the building.

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What The #@&% Happened?

4. Holes through the air and water barrier created by fastener penetrations where the studs were missed created a path of water infiltration in the the LGMF stud cavity but the infiltration would have been insignificant if the building was not under significant negative pressure.

5. Trying to install pre-formed metal flashing pans under existing installed windows was probably not effective 100 % of the time thus adding to the water infiltration into the LGMF stud cavity and the building interior.

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What The #@&% Happened?

6. The un-aligned weep holes in the ACM cladding and the ACM cladding stiffeners took away the ability of the cladding system to vent the space behind it adding to the RH of that space and thus creating humidity levels in that space conducive to the accelerated corrosion of the metal items in that space.

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How To Avoid This Disaster

1. Design and exterior wall assembly with an air, water and vapor barrier (AVB) on exterior sheathing and install all of the insulation to the exterior of the AVB.

2. If you can’t or do not want to do the above, make sure every component of the assembly that is to the exterior of the next layer is more permeable that the layer before it.

3. If you can’t or do not want to do the above, make sure no water can get between a layers where the layer to the exterior is less permeable than the layer to the interior.

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How To Avoid This Disaster

4. If the building is experiencing significant negative pressurization when it is supposed to be positively pressurized…..

Fix it!!!

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What is the fix?

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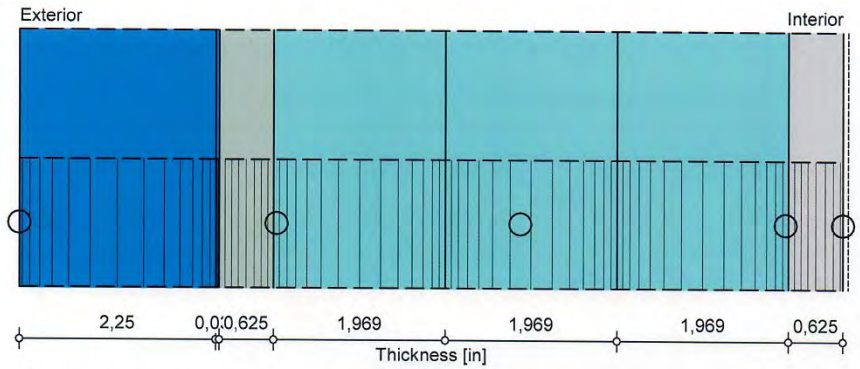
Component Assembly

Case: #4

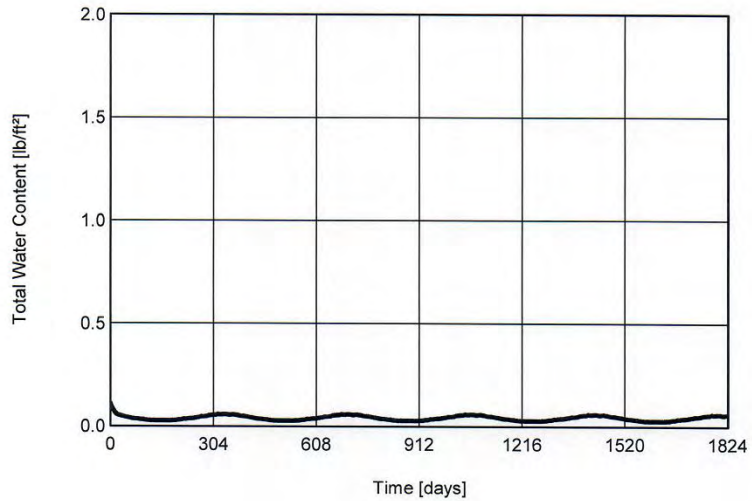


○ - Monitor positions

Materials :

- Extruded Polystyrene Insulation
- vapor retarder (0.1perm)
- Gypsum Board (USA)
- Air Layer 50 mm
- Air Layer 50 mm
- Air Layer 50 mm
- Interior Gypsum Board

Total Thickness [in]: 9,411
R-Value: 17,52 h ft² °F/Btu
U-Value: 0,054 Btu/h ft²°F



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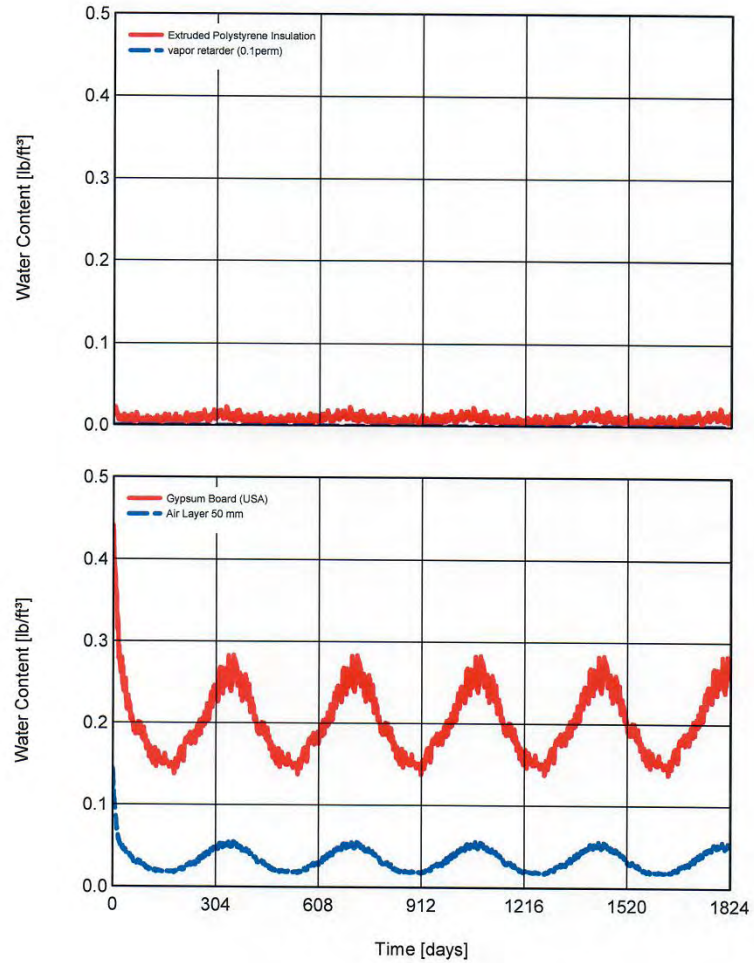

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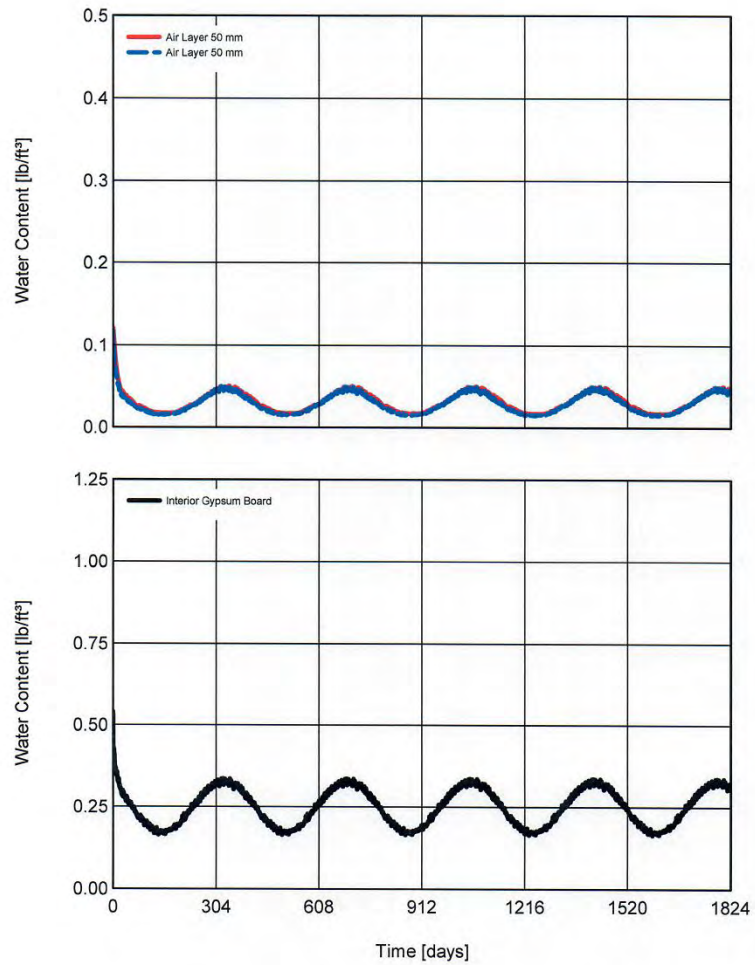

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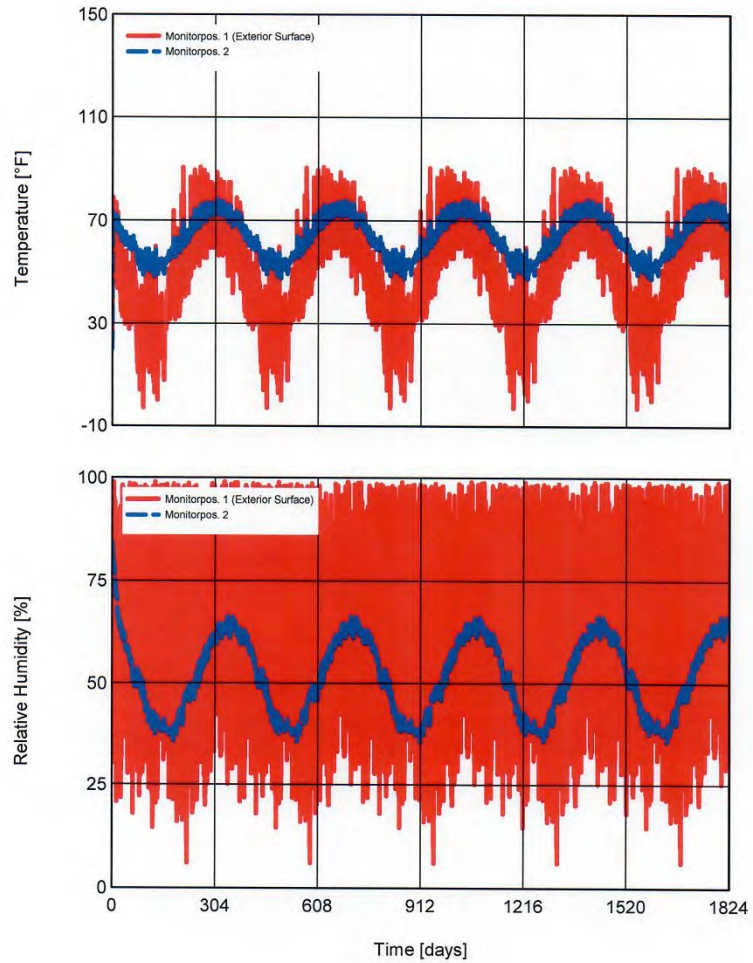

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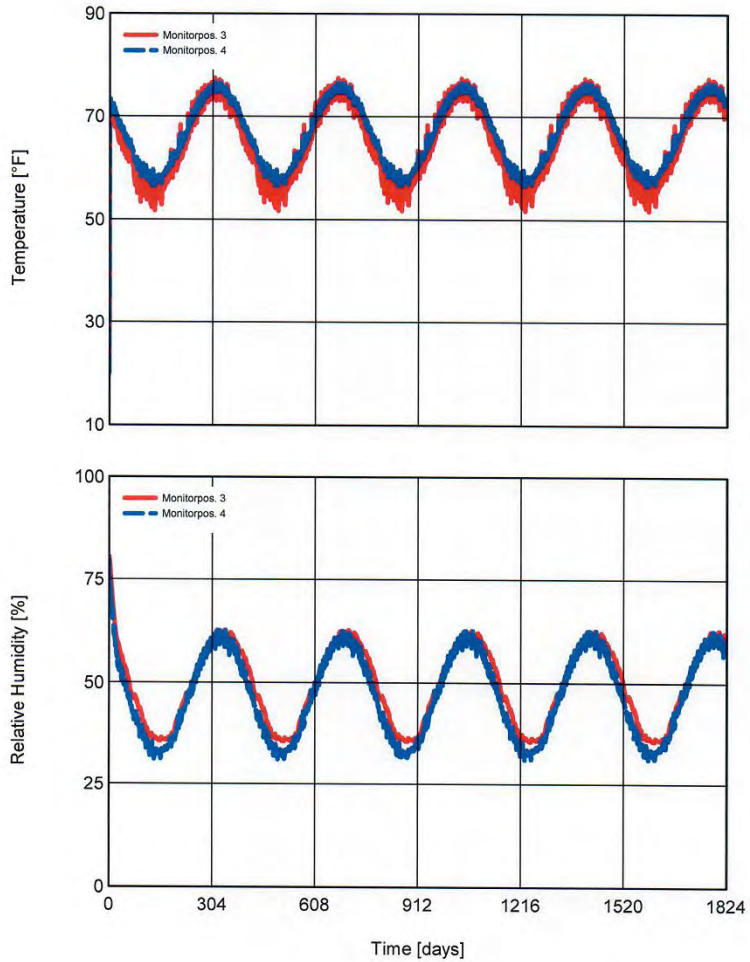

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How We Classify This Repair?

Do over!!!

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The Apartment Building

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The Apartment Building

The Problem

Multitude of water leaks through the above grade vertical building enclosure.

The Results

Water damage to the building enclosure components.

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Problems

1. Water leakage into the building from several sources.

2. Rotting OSB sheathing.

3. Design issues.

4. Developer issues.

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Background

1. Built in 2006.

2. The Architect had one design for many of the same apartment complexes in various climate regions.

3. The developer was also the contractor and decided what materials and assemblies would be used.

4. The construction superintendent decided what waterproofing details would be used on the project.

5. The OSB sheathing was completely rotted out in many location by 2012.

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“ It meets the code!!! “

But it failed!!!

Why???

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The Failed Exterior Wall Assembly

Thin stone veneer on mortar setting bed with wire lathe

15 lb felt paper (water-resistant barrier)

Spun-bonded polyolefin building wrap (air & water barrier)

Oriented strand board (OSB) exterior sheathing

6” wood studs with 6” batts insulation (R-19)

6 mill polyethylene (vapor barrier)

Interior GWB

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The Failure

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The Failed Exterior Wall Assembly

All of the sheathing behind the thin stone veneer exhibited water damage and had to be replaced.

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Let’s see how it performs!!!

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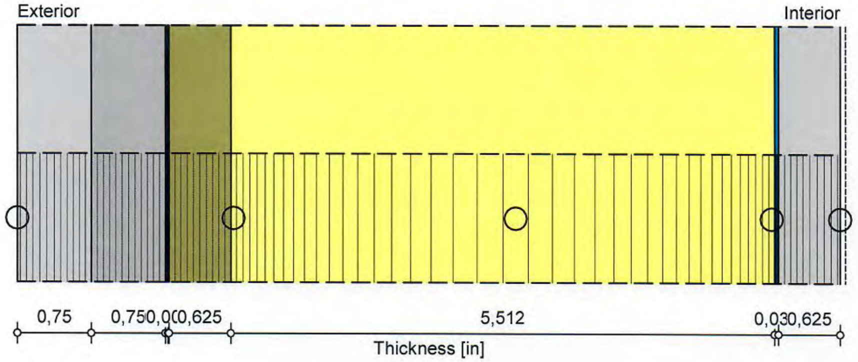
Component Assembly

Case: #1

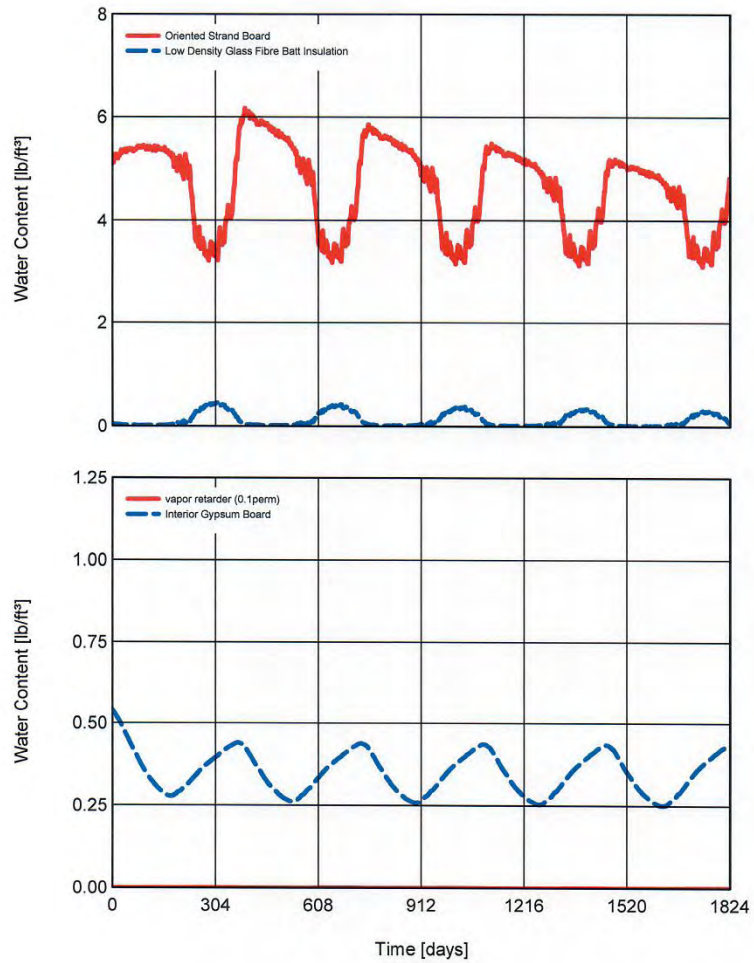


○ - Monitor positions

Materials :

- Limestone (Georgian Bay Limestone)
- Masonry Cement Mortar - Type N
- Bituminous Paper (#15 Felt)
- Spun Bonded Polyolefine Membrane (SBP)
- Oriented Strand Board
- Low Density Glass Fibre Batt Insulation
- vapor retarder (0.1perm)
- Interior Gypsum Board

Total Thickness: 8,34 in
Sd-Value [perm]: 0,10
R-Value: 20,31 h ft² °F/Btu
U-Value: 0,038 Btu/h ft² °F



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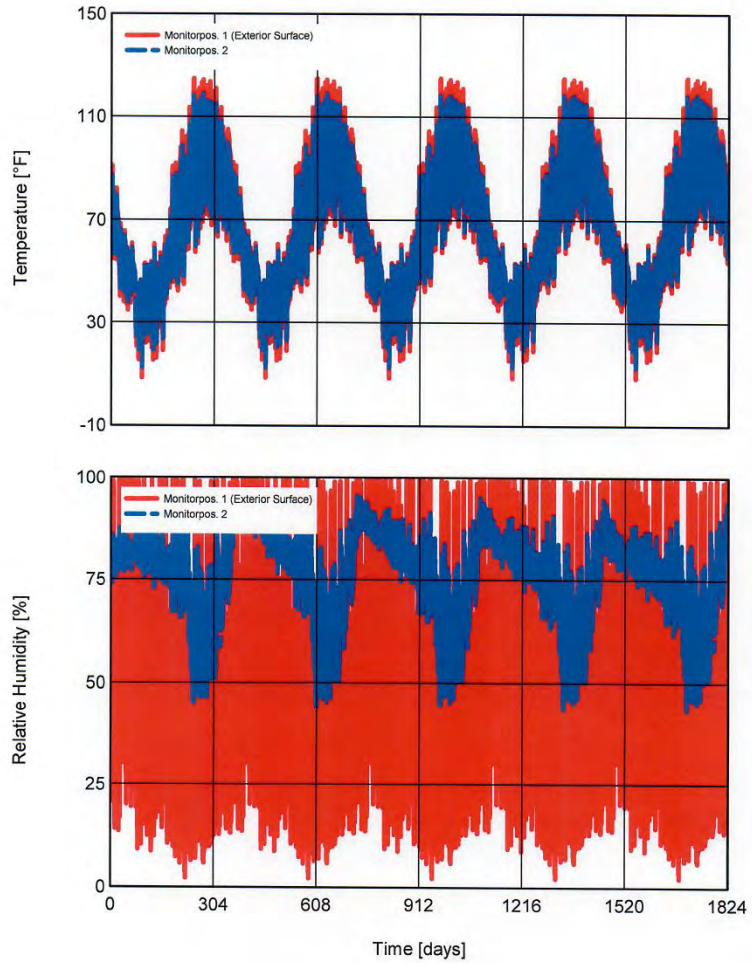

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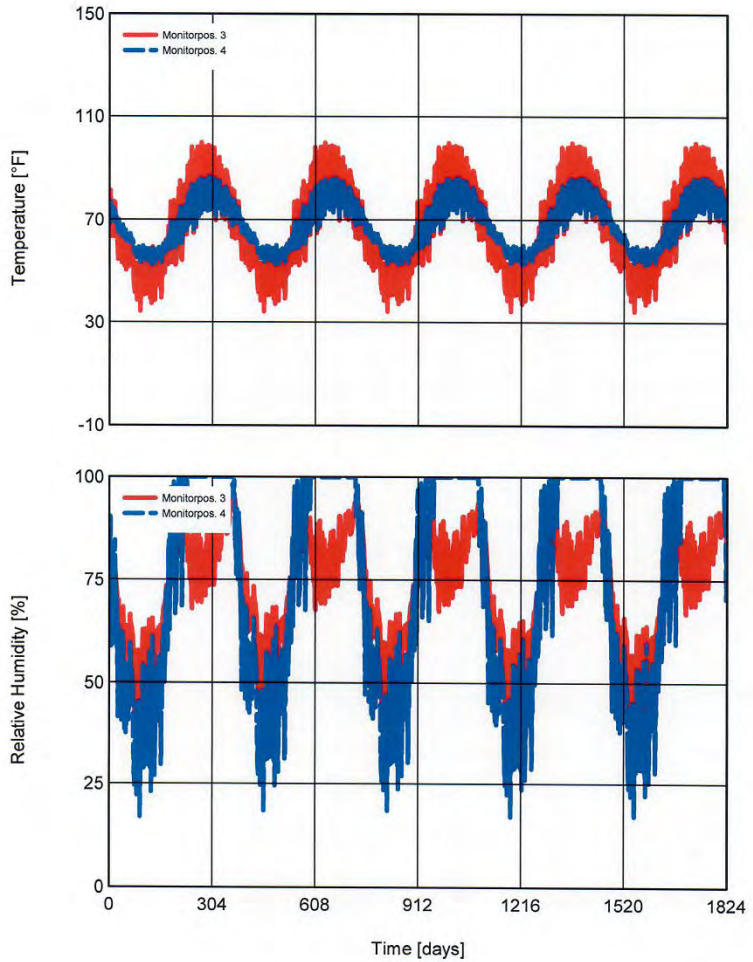

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The Solution?

Blame the contractor!!!

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The above grade building building enclosure assembly meets the building code…

BUT

…did not effectively deal with the four wetting potentials.

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What is the fix?

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Properly drain and vent the veneer (absorportive cladding system).

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Dr. Donald M. Onysko

A 1/4” wide drainage space is needed for water to effectively drain and vent an absorptive cladding system.

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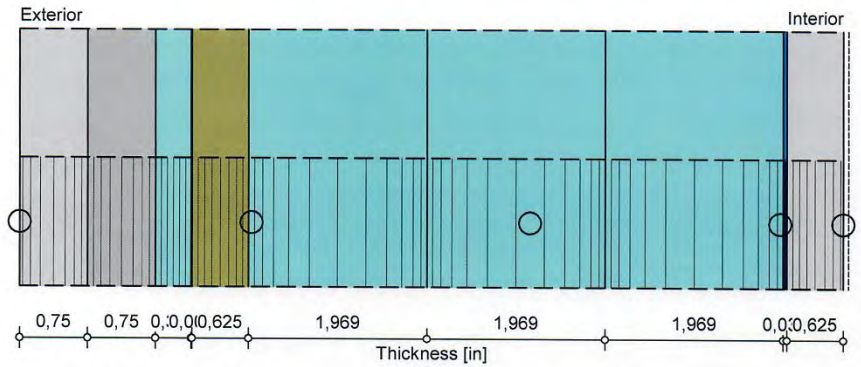
Component Assembly

Case: #2

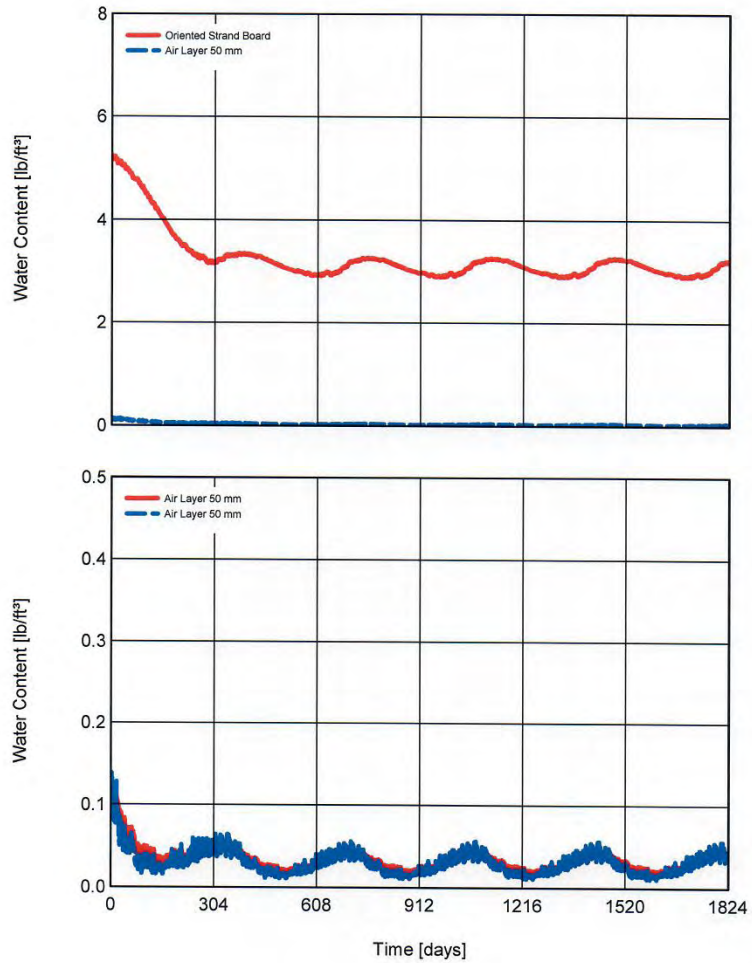


○ - Monitor positions

Materials :

- Limestone (Georgian Bay Limestone)
- Masonry Cement Mortar - Type N
- Air Layer 10 mm
- Spun Bonded Polyolefine Membrane (SBP)
- Oriented Strand Board
- Air Layer 50 mm
- Air Layer 50 mm
- Air Layer 50 mm
- vapor retarder (0.1perm)
- Interior Gypsum Board

Total Thickness [in]: 10,0
R-Value: 5,78 h ft² °F/Btu
U-Value: 0,147 Btu/h ft²°F



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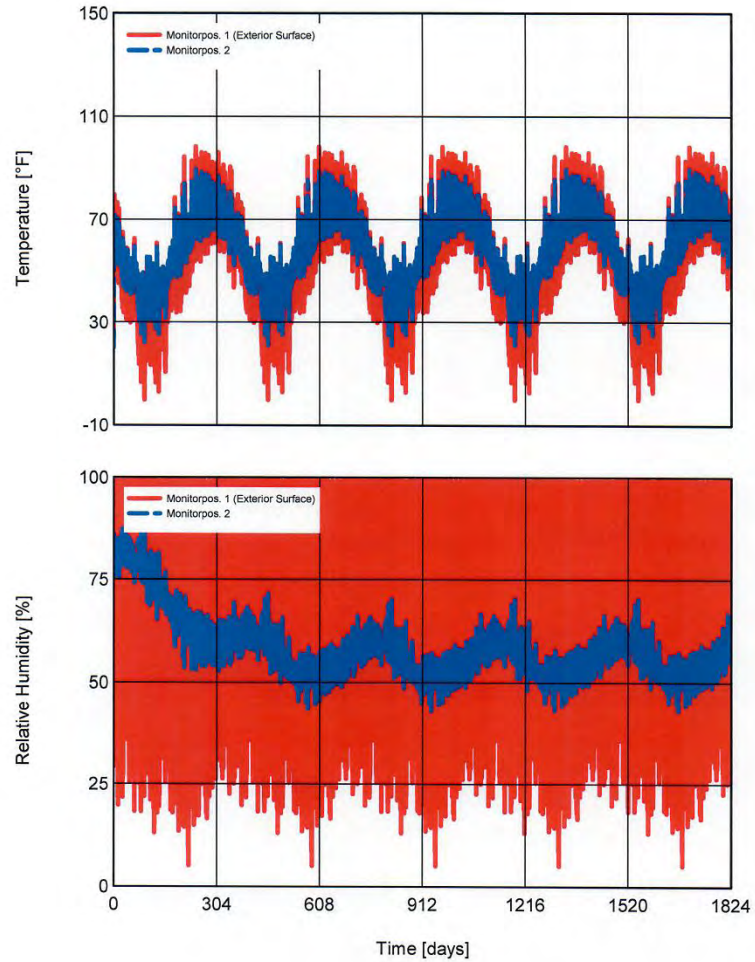

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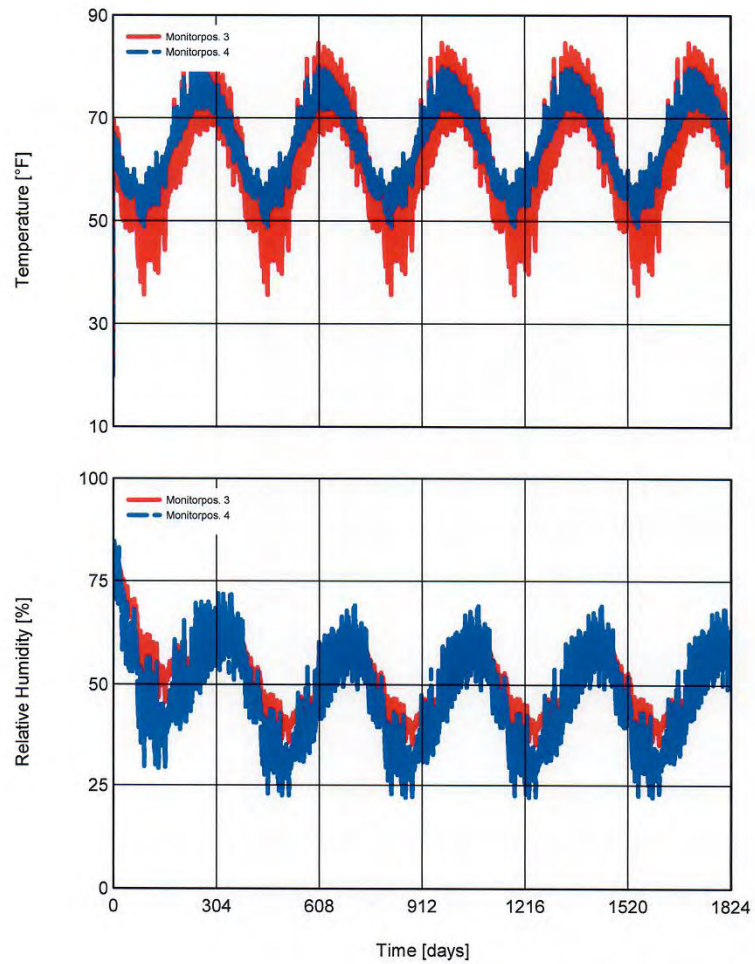

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How We Classify This Repair?

Do over!!!

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The Mikvah Building

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What's A Mikvah?

Mikveh or mikvah is a bath used for the purpose of ritual immersion in Judaism to achieve ritual purity.

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What's A Mikvah?

Three open pools of water on the first floor and apartments on the second floor.

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The Mikvah Building

The Save!!!

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The Original Exterior Wall Assembly

Calcium silicate block and fiber cement board siding

2” mineral wool insulation

Air, water and vapor barrier

Oriented strand board (OSB) exterior sheathing

6” wood studs with 6” batts insulation (R-19)

Interior GWB

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Let’s see how it performs!!!

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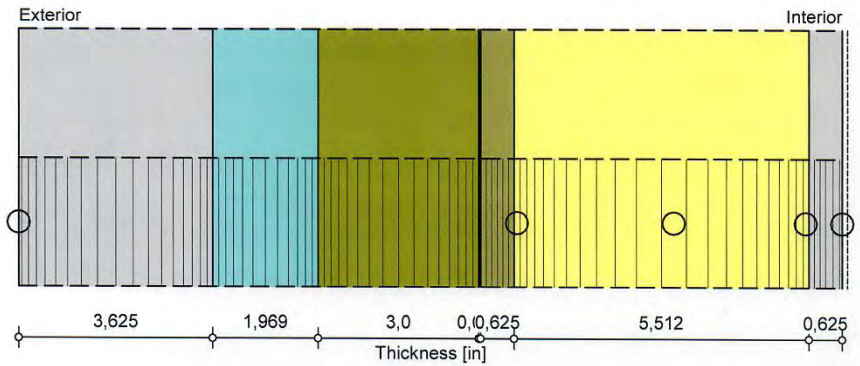
Component Assembly

Case: #1



○ - Monitor positions

Materials :

- Limestone (Georgian Bay Limestone)
- Air Layer 50 mm
- Roxul CavityRock DD
- vapor retarder (0.1perm)
- Oriented Strand Board
- Low Density Glass Fibre Batt Insulation
- Interior Gypsum Board

Total Thickness: 15,390 in
R-Value: 35,55 h ft² °F/Btu
U-Value: 0,024 Btu/h ft²°F

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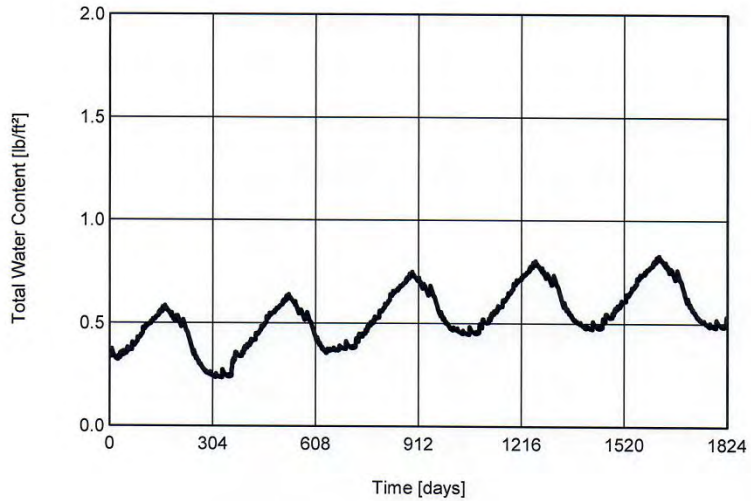

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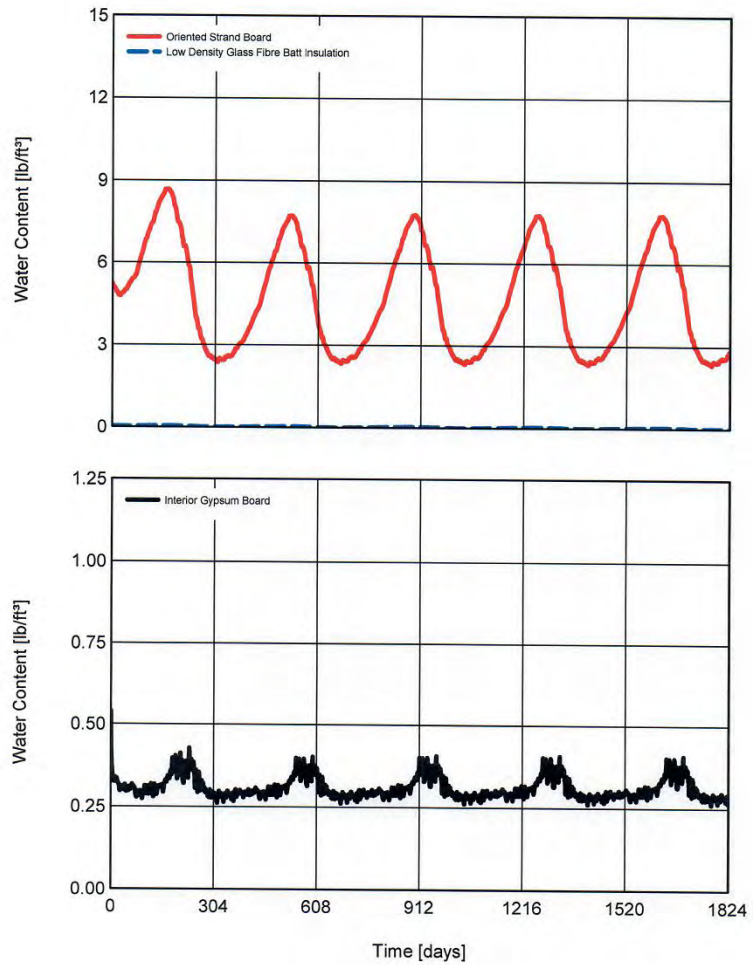

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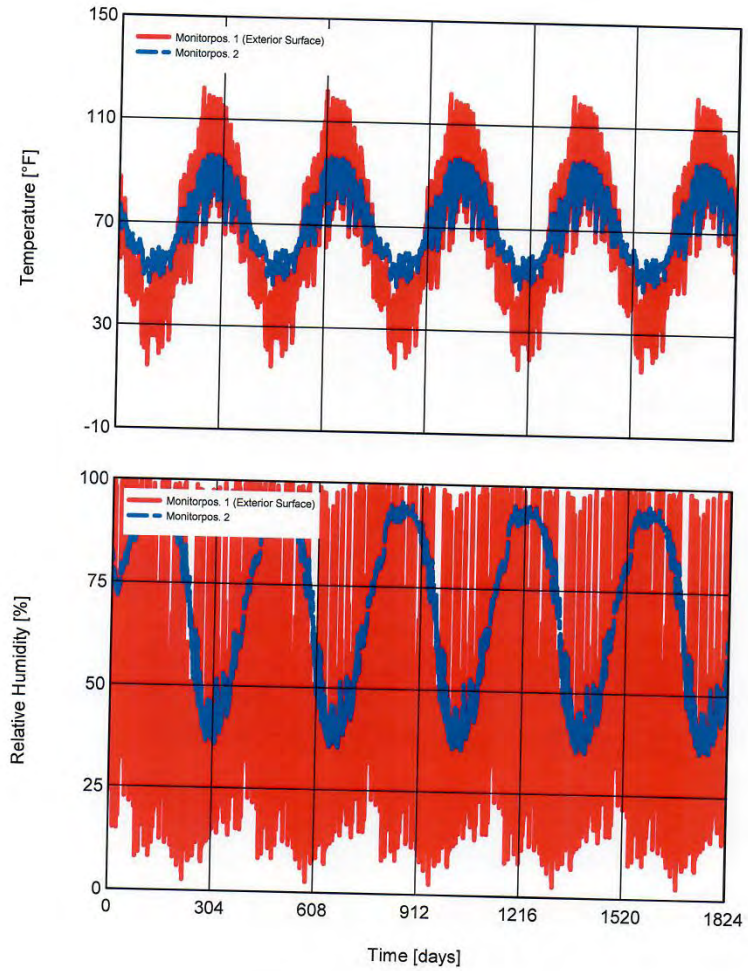

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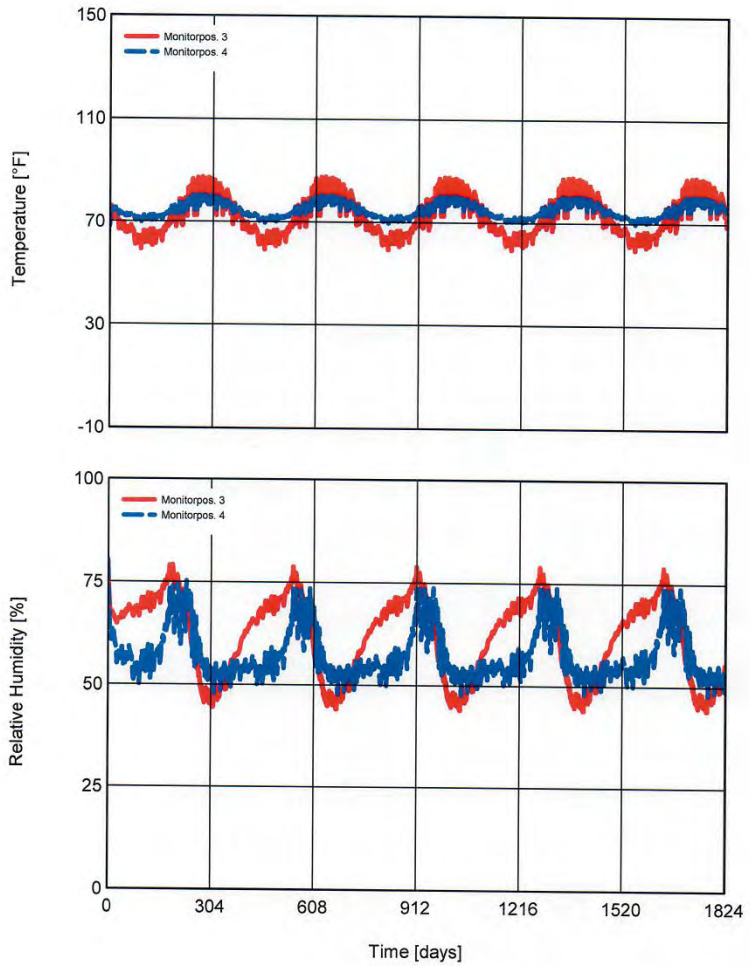

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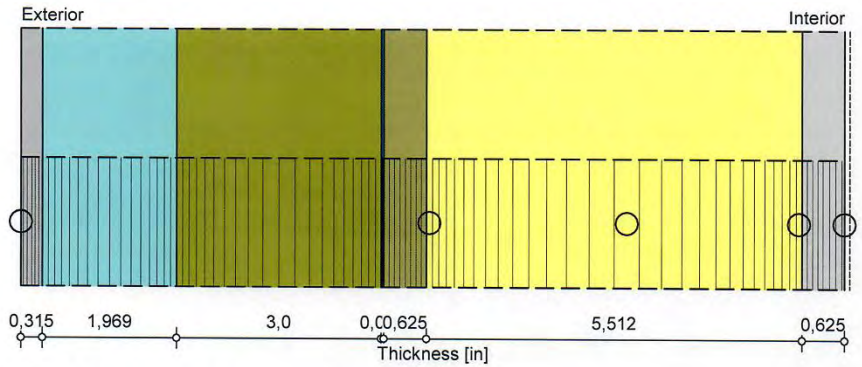
Component Assembly

Case: #2

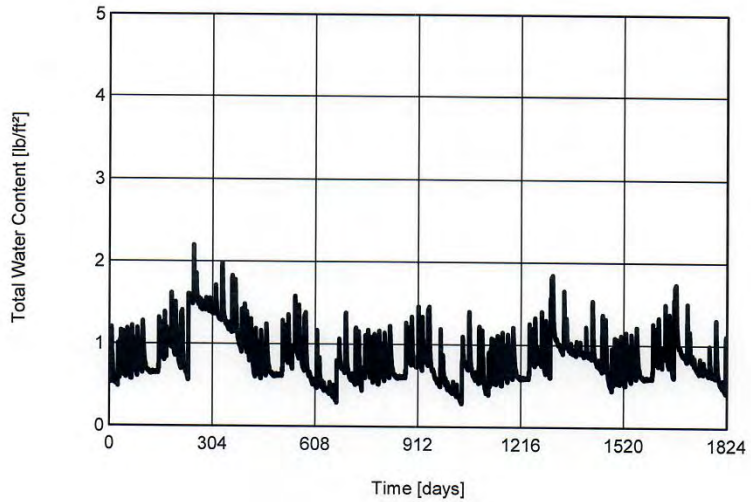


○ - Monitor positions

Materials :

- Fibre Cement Sheathing Board
- Air Layer 50 mm
- Roxul CavityRock DD
- vapor retarder (0.1perm)
- Oriented Strand Board
- Low Density Glass Fibre Batt Insulation
- Interior Gypsum Board

Total Thickness: 12,080 in
R-Value: 35,01 h ft² °F/Btu
U-Value: 0,024 Btu/h ft²°F



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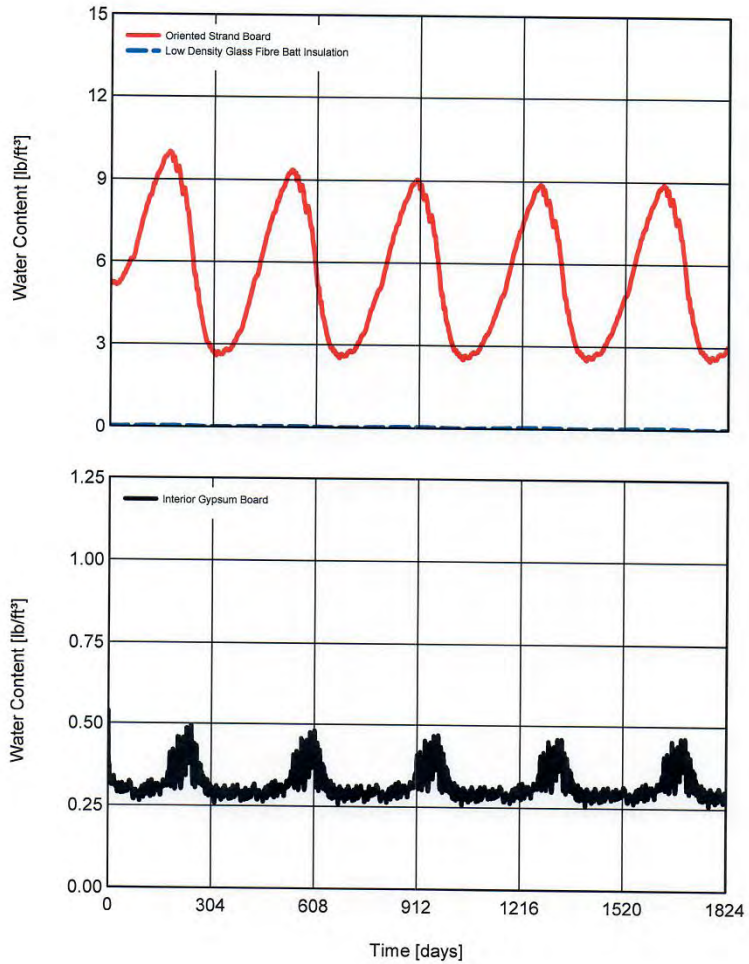

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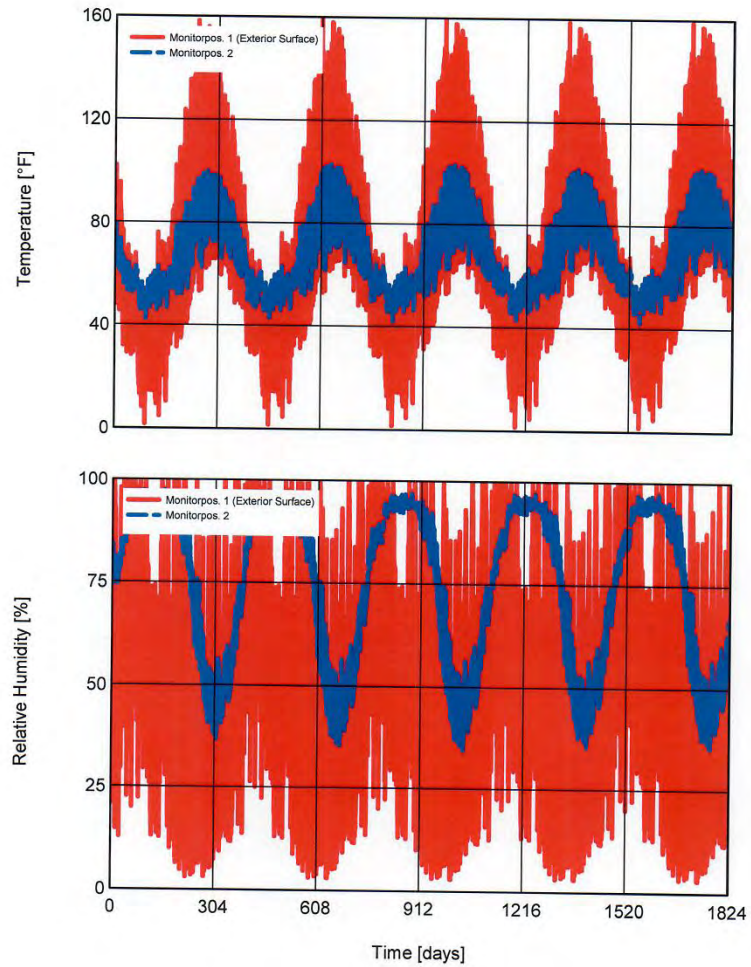

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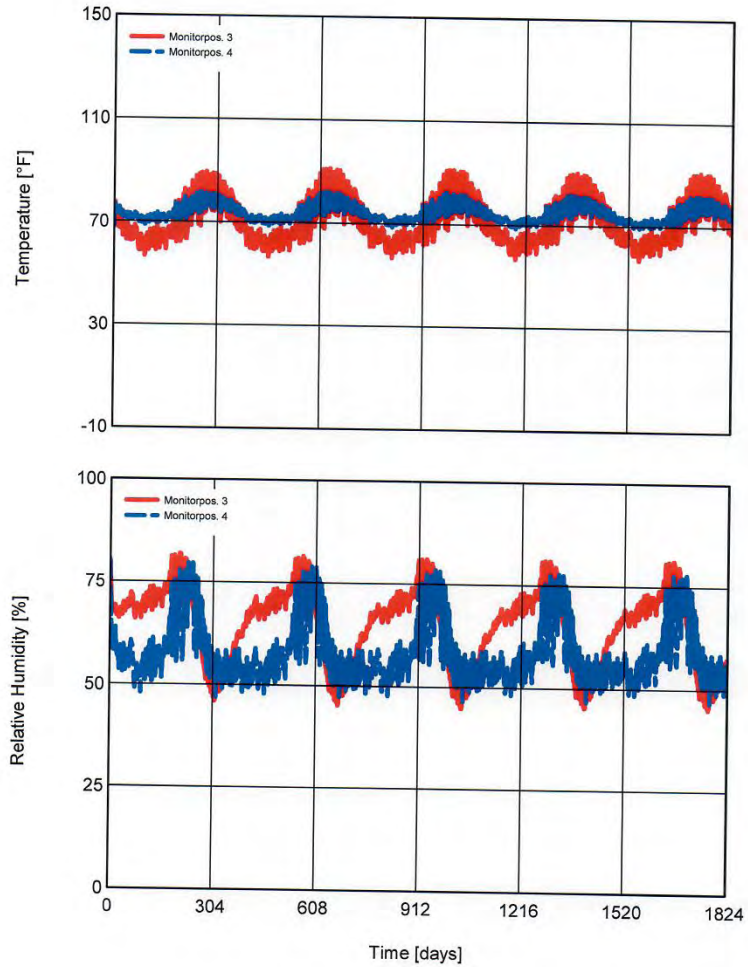

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“ It meets the code!!! “

But it failed!!!

Why???

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The Fix Exterior Wall Assembly

Calcium silicate block and fiber cement board siding

3” of 2 lb. density closed cell polyurethane foam insulation

Oriented strand board (OSB) exterior sheathing

6” wood studs with no insulation

Interior GWB

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Let’s see how it performs!!!

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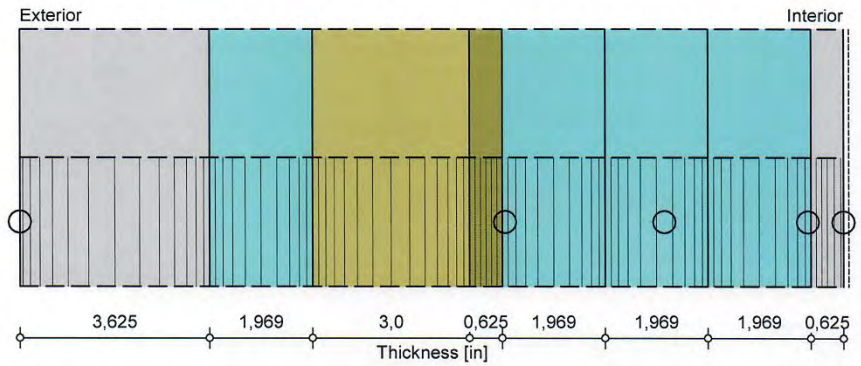
Component Assembly

Case: #3



○ - Monitor positions

Materials :

- Limestone (Georgian Bay Limestone)
- Air Layer 50 mm
- Sprayed Polyurethane Foam; closed cell
- Oriented Strand Board
- Air Layer 50 mm
- Air Layer 50 mm
- Air Layer 50 mm
- Interior Gypsum Board

Total Thickness: 15,750 in
R-Value: 24,18 h ft² °F/Btu
U-Value: 0,023 Btu/h ft² °F

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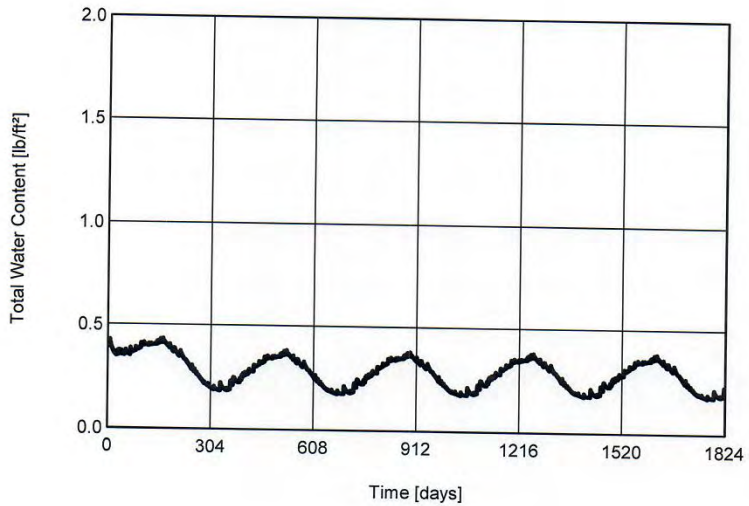

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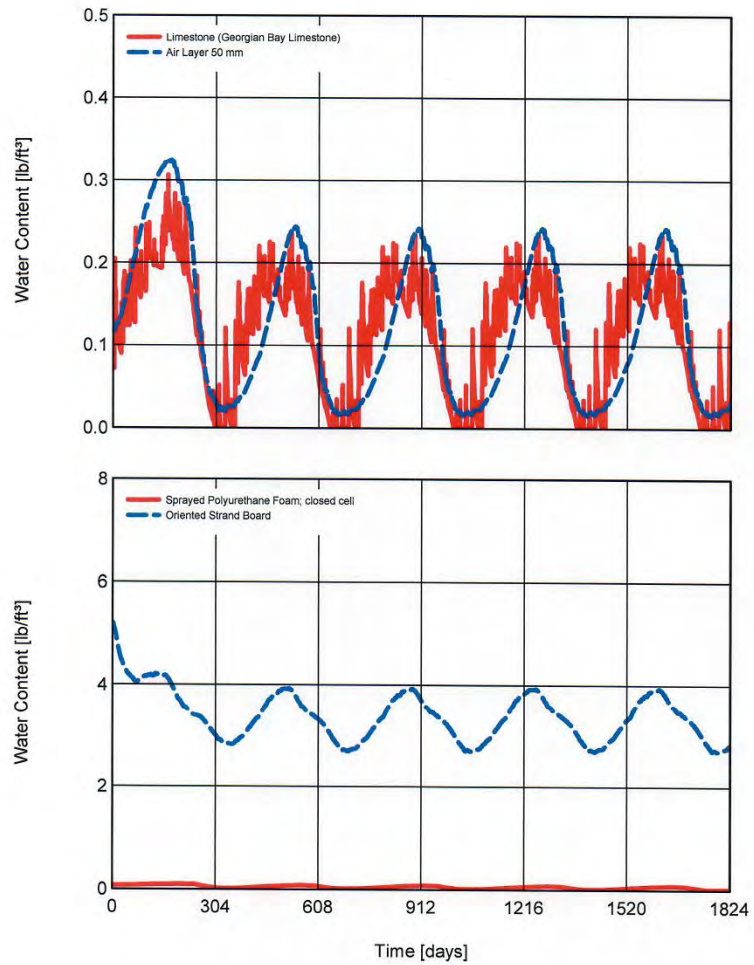

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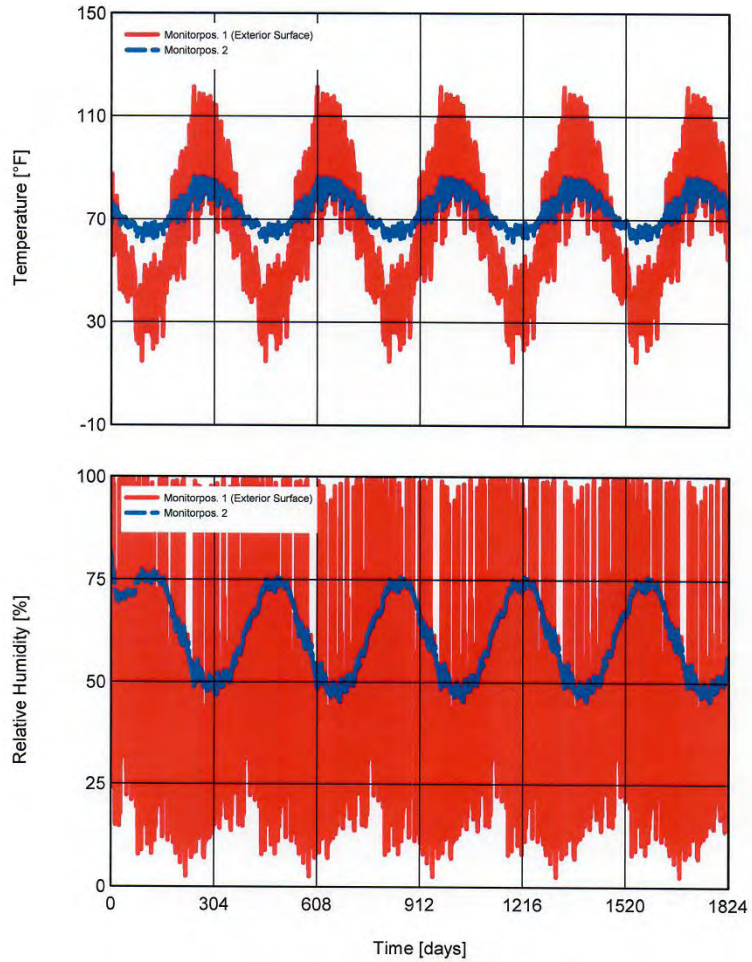

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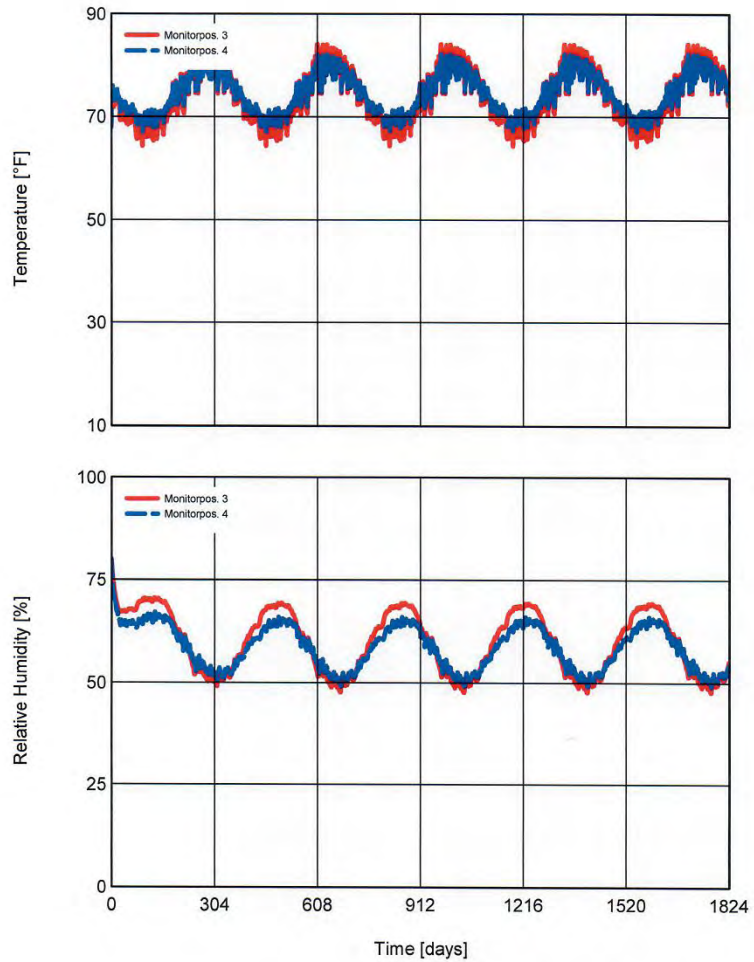

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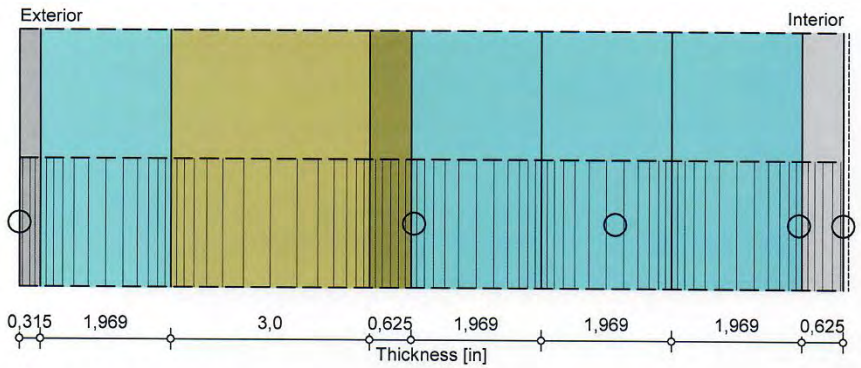
Component Assembly

Case: #5



○ - Monitor positions

Materials :

- Fibre Cement Sheathing Board
- Air Layer 50 mm
- Sprayed Polyurethane Foam; closed cell
- Oriented Strand Board
- Air Layer 50 mm
- Air Layer 50 mm
- Air Layer 50 mm
- Interior Gypsum Board

Total Thickness: 12,440 in
R-Value: 23,64 h ft² °F/Btu
U-Value: 0,024 Btu/h ft² °F

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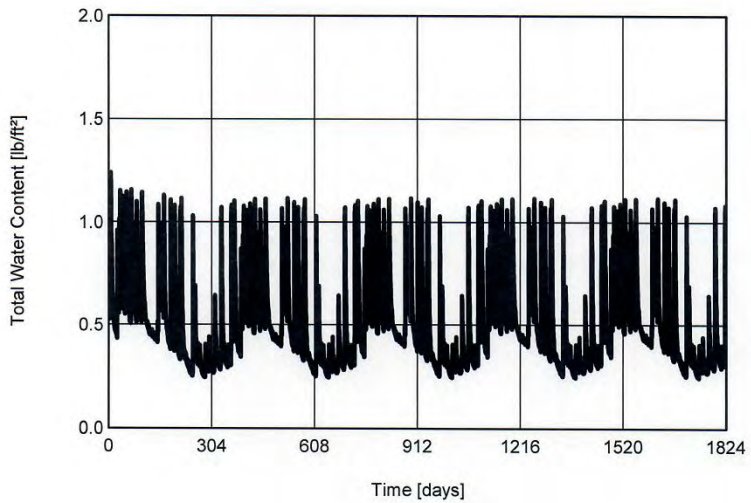

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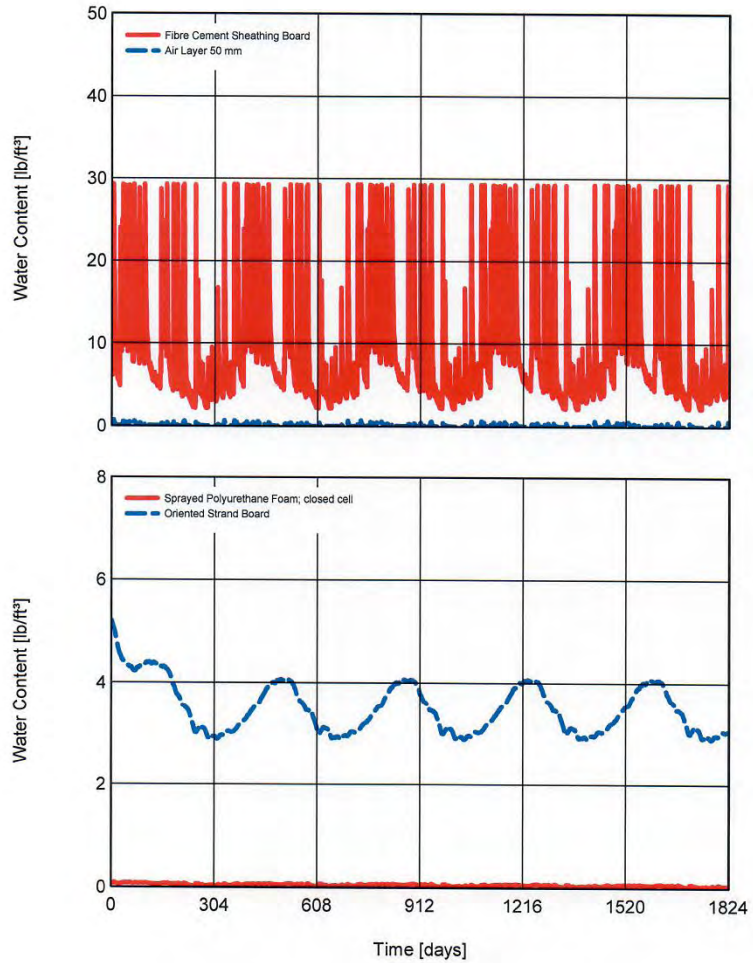

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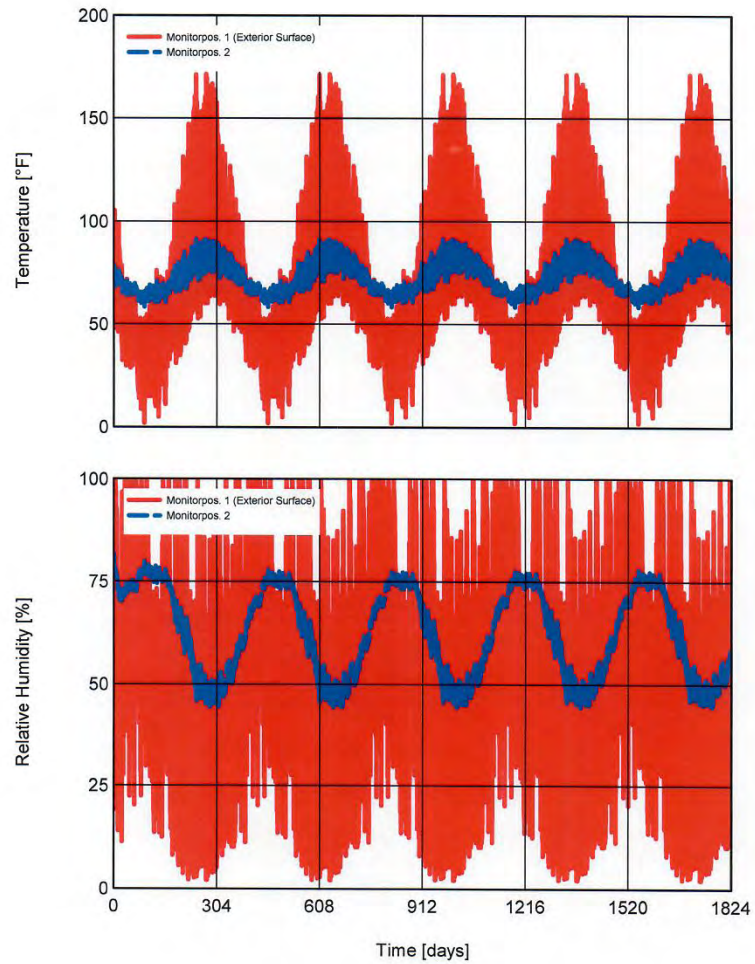

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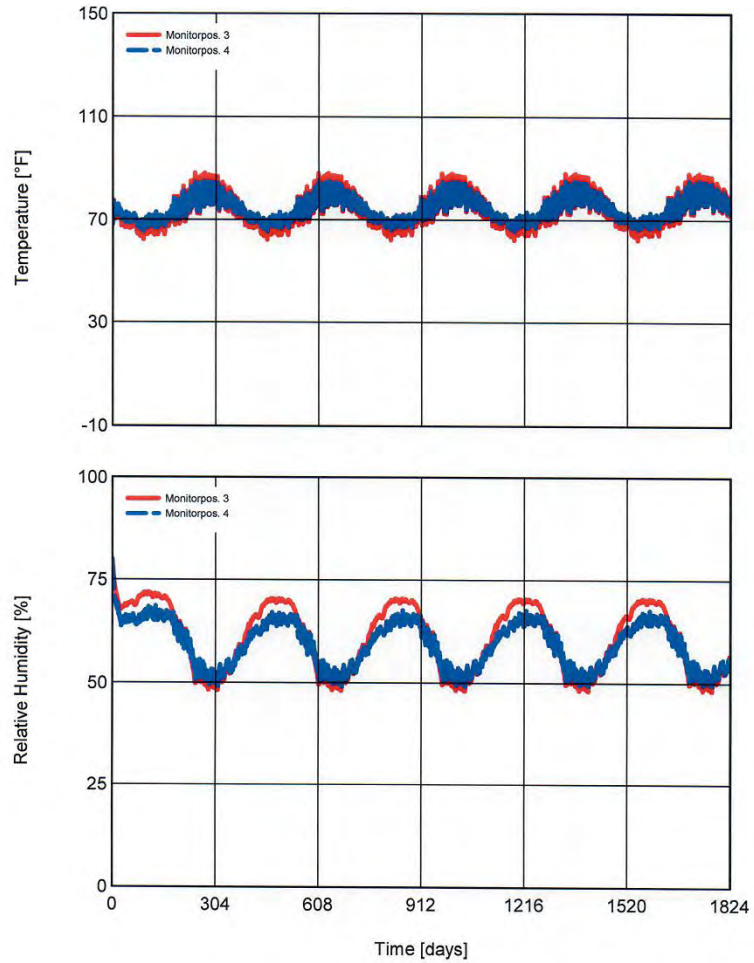

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The Mikvah Building

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