Passive House at the Jobsite: Cost, Inspections, and the Designer-Builder Relationship

Presented by Ryan Sylvia, P.E.

ALLIED COOK CONSTRUCTION

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Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

Course Description

The design principles associated with passive house construction are well documented. Core aspects such as continuous air barriers, heat recovery/fresh air ventilation, and minimizing thermal barriers are being used in multi-family passive house projects to achieve extreme operational energy efficiency. However, proper construction practices are key to achieving expected performance. Presented by a Northeast-based contractor with extensive passive house experience, this webinar will examine the cost and construction of wood-frame, multi-family projects in particular. Topics will include cost differences between traditional and passive house construction, communication aspects that are critical to success, testing and inspections, design details that translate to buildable projects, and lessons learned from the jobsite.

Learning Objectives

1. Review the defining principals of passive house design and how it differs from traditional energy-efficiency design.

2. Highlight common construction tests and inspections that verify passive house-level performance.

3. Explore effective communication practices between design team and contractor that can minimize construction issues on passive house projects.

4. Discuss the role of the framer in achieving passive house designs, from pre-construction planning to cost efficiency to air tightness testing.

Presentation Disclaimer

1. Details presented were developed by design professionals using specific design conditions which may or may not be appropriate to your project.

2. Management techniques presented may not be appropriate for all projects.

3. Timelines and cost information discussed are based on experience with a limited group of installers in specific project scenarios.

Passive House Goals

Thermal Comfort

Low Energy Consumption

Indoor Air Quality

Passive House Principles

Quality Insulation – Air-Tightness

Eliminate Thermal Bridges

Reduce Energy & Water Usage

Compartmentalization of Living Units

Moisture Control & Regular Air Exchange

Reasonable Construction & Cost

Picture Courtesy of Kaplan-Thompson Architects

- **Bayside Anchor**
  - 4-Story Mixed Use w/ 45 Apartments (1-3 Bedrooms)
  - Bayside Neighborhood, Portland, Maine
  - MSHA Low-Income Housing
  - Passive House Certified 2017
- **The Meadows**
  - Two 3-Story Apartment Buildings w/ 48 Apartments (1-Bedroom)
  - Hampton Falls, NH
  - NHHFA Low-Income Senior Housing
  - 2020 Completion, Passive House Certification Pending
- **West End Apartments**
  - 5-Story Mixed Use w/ 63 Apartments (Studio-3 Bedrooms)
  - South Portland, ME
  - MSHA Low-Income Housing & Market Rate
  - 2021 Completion, High Performance/Passive House-Inspired Design

Background Image By Kaplan-Thompson Architects


BAYSIDE ANCHOR
Rendering By Kaplan-Thompson Architects

Picture Courtesy of Kaplan-Thompson Architects

Bayside Anchor's Major Achievement Was A Careful Balance Between Design, Sustainability & Cost

Picture Courtesy of Kaplan-Thompson Architects


Design Element Achieved
With Cost Effective Siding
& Colors
Picture Courtesy of Kaplan-Thompson Architects

THE MEADOWS

Rendering By Lassel Architects

WEST END APARTMENTS

- Energy Efficiency
- Thermal Comfort
- Indoor Air Quality
- Durable / Quality Finishes
- Attractive Aesthetic
- Be Part of Area Revitalization

Rendering By Kaplan-Thompson Architects


Picture Courtesy Of Kaplan-Thompson Architects

Commons Project Themes

- Wood Framed
- Passive House Air-Tightness
- Above-Code Insulation
- Reduction of Thermal Bridging
- Energy Recovery Ventilation Systems

- All required Planning, Managing, & Testing to Passive House Standards
- Lessons Have Been Learned Along The Way

Builder’s Approach to a PH Project

- Be Involved In The Design Process
- Educate Those Doing The Work About the Project’s Objectives
- Provide Communication Aids & Documentation
- Follow-up, Inspect, Trouble-Shoot

Planning

- Researching & Comparing Options
- Modeling
- Detailing
- Cost Comparison
- Schedule Considerations

Passive House & Wood Construction

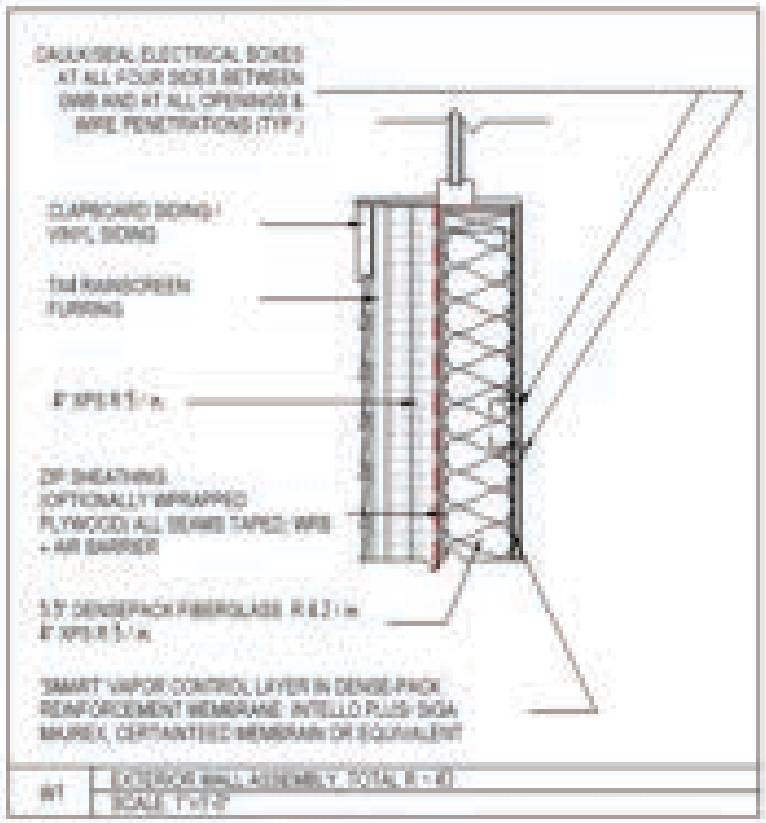
- Readily Available
- Cost Effective
- Familiar & Easy To Work With
- Quickly Modified/Corrected
- Constant Innovation in Wood Industry
  - Wood Treatments
  - Composites
  - Wood & Insulation Assemblies

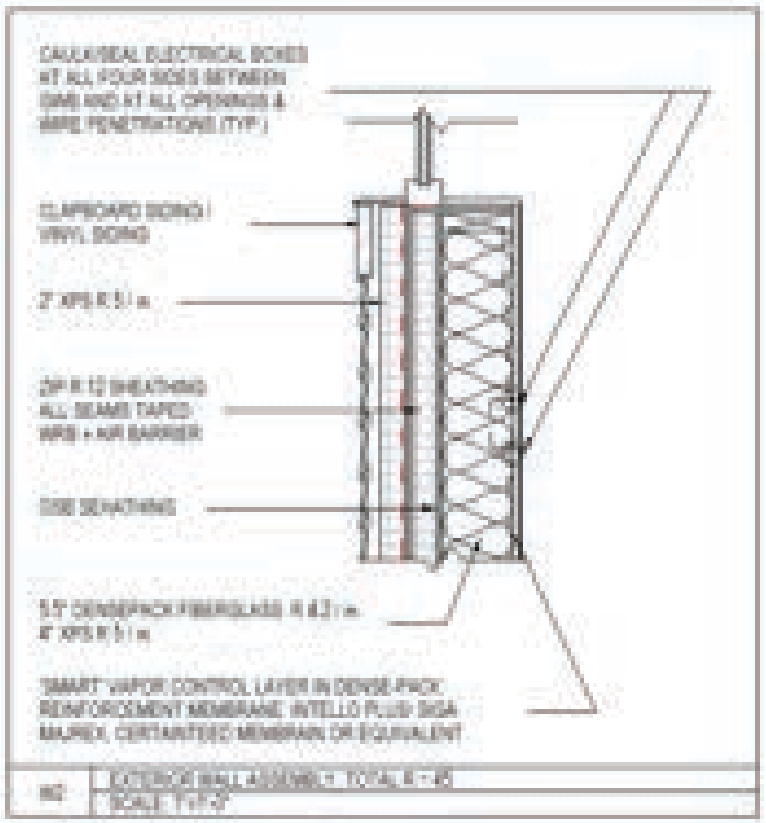
Designing & Planning With Wood

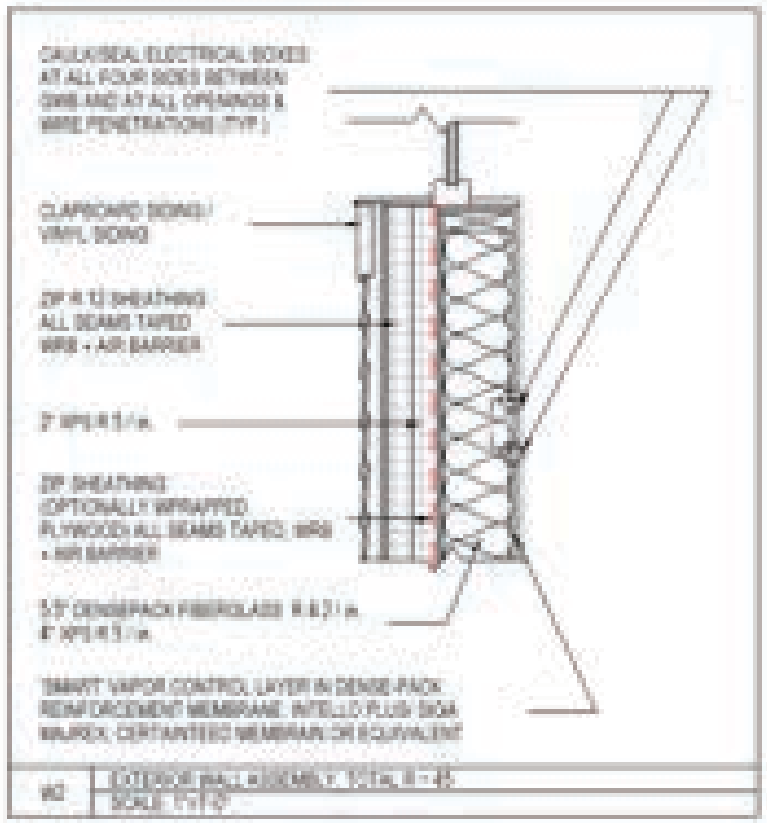
- Wood vs. Metal Framing
- Expansion & Contraction
- Tools From Product Reps
- Manufacturer’s Specs
- Thermal Bridging

Specifics for Panelized Construction

- Bigger Panels = Fewer Joints.
- Exterior Insulation: Field-Applied vs. Factory Installation
- Panel Finish: Field vs. Factory
- Window Installation: Field vs. Factory



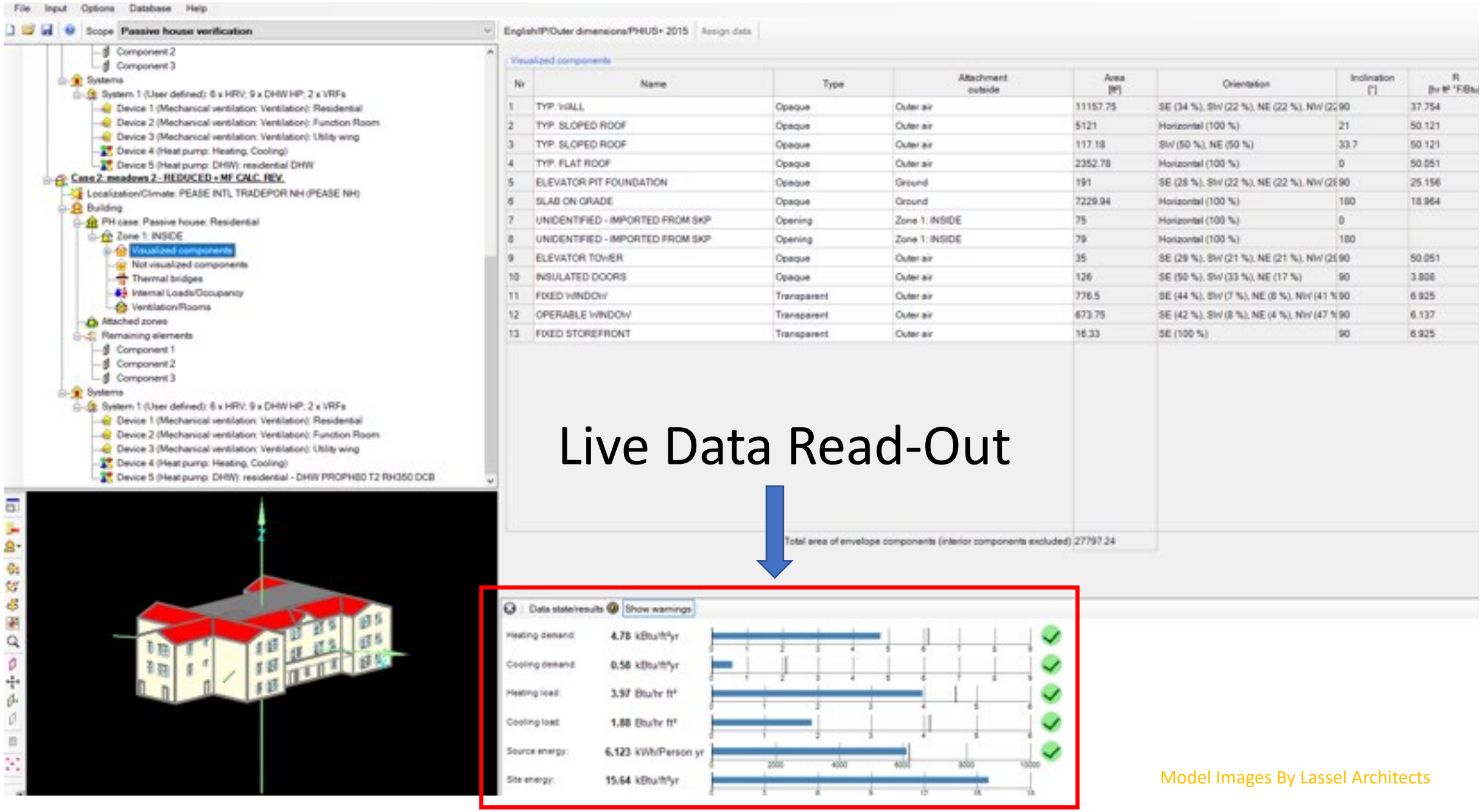




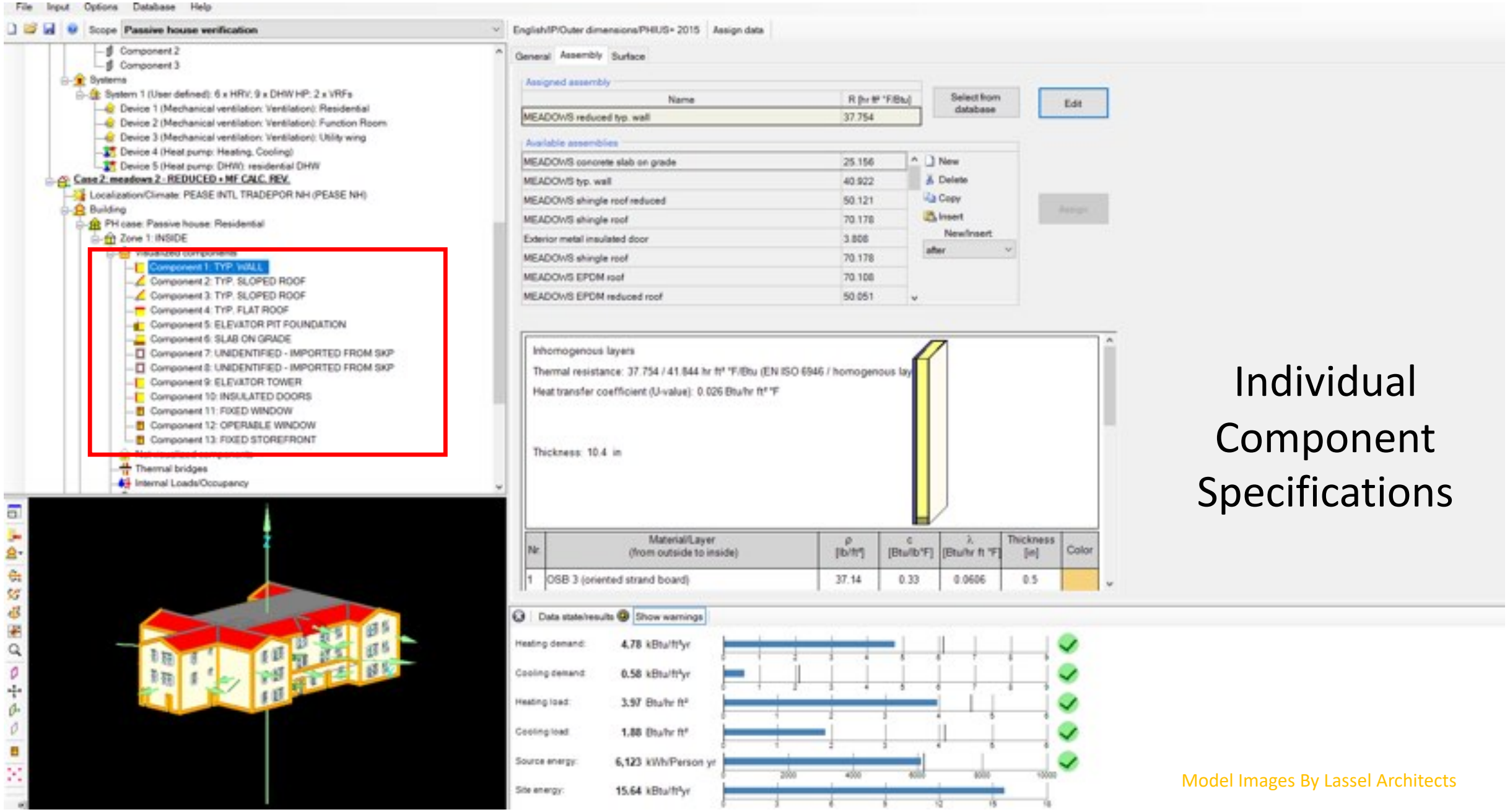
Work Together On Tough Questions

- Do Really Good Suspenders Need Help From A Belt?
- Your **Energy Model** Can Help Cut Cost & Save Time!

Details By Lassel Architects



Model Images By Lassel Architects



Individual Component Specifications

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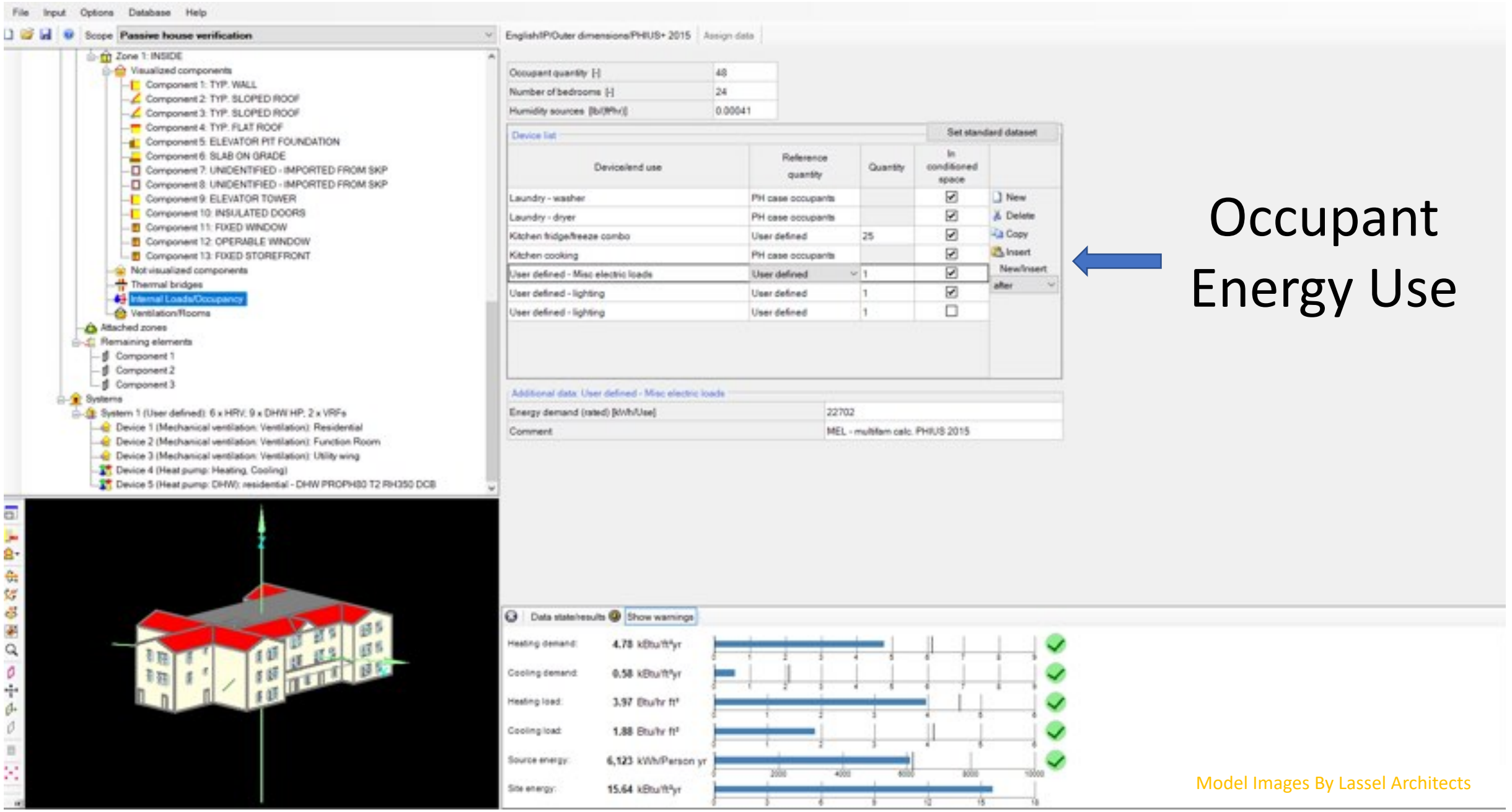

Occupant Energy Use

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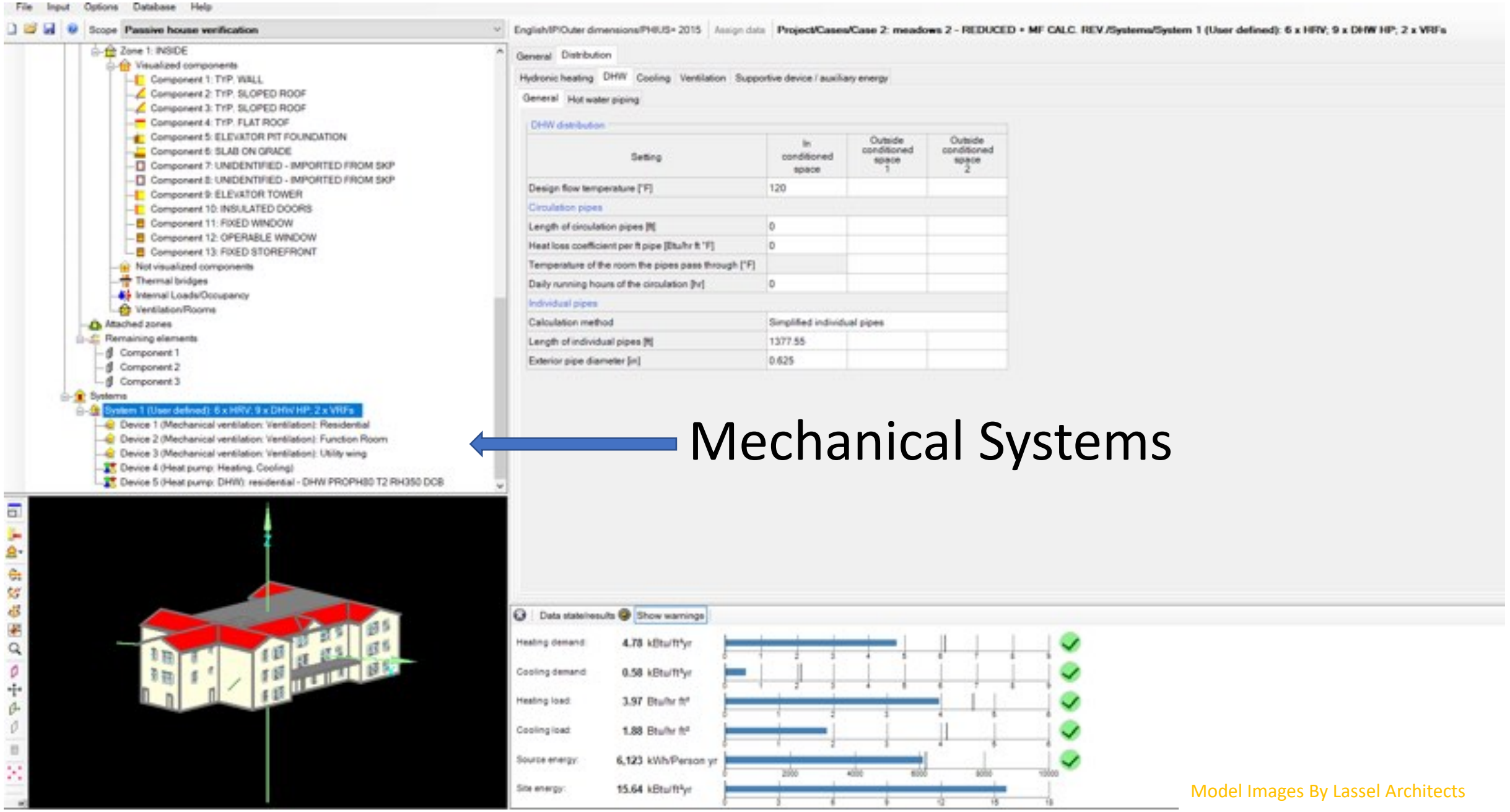

Mechanical Systems

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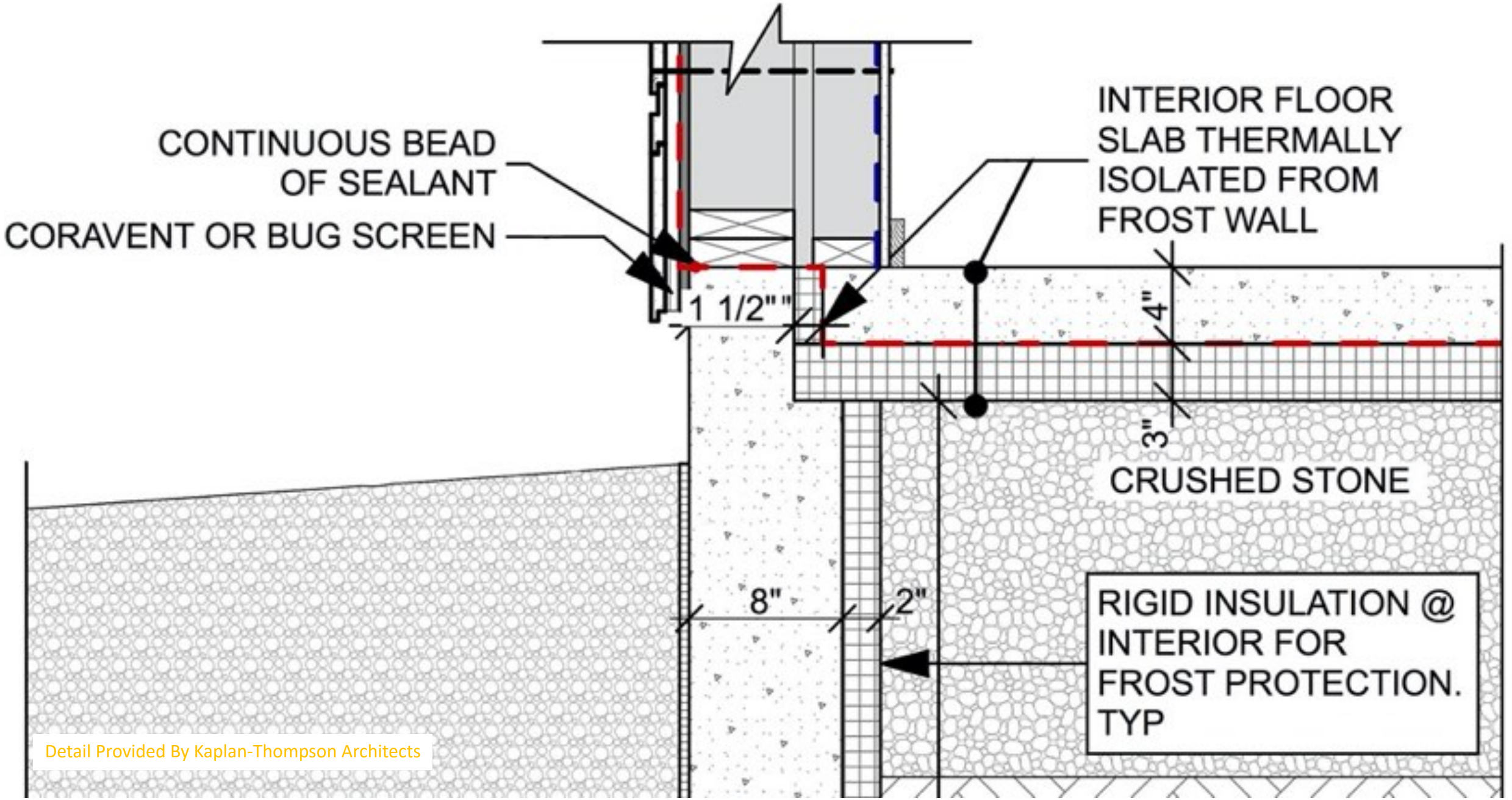

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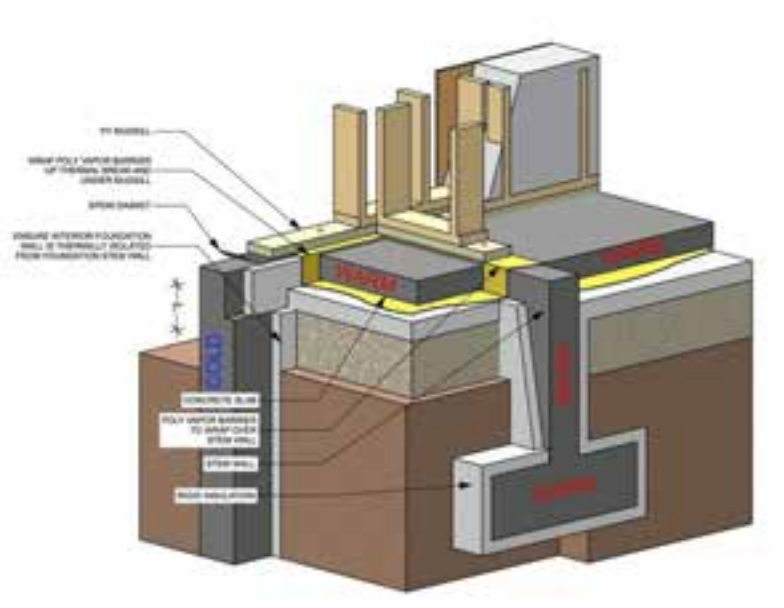
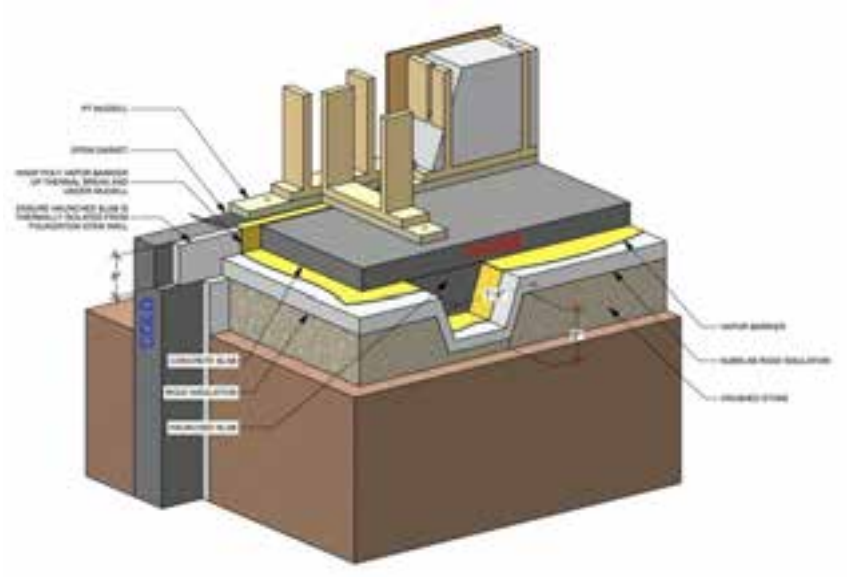
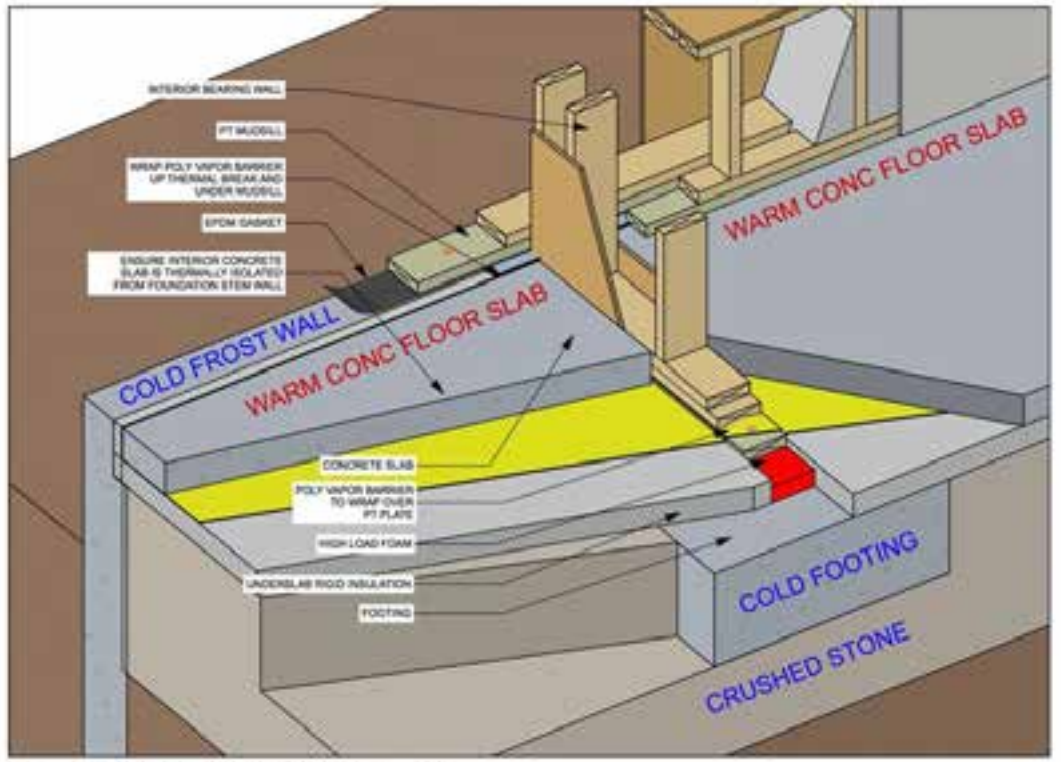


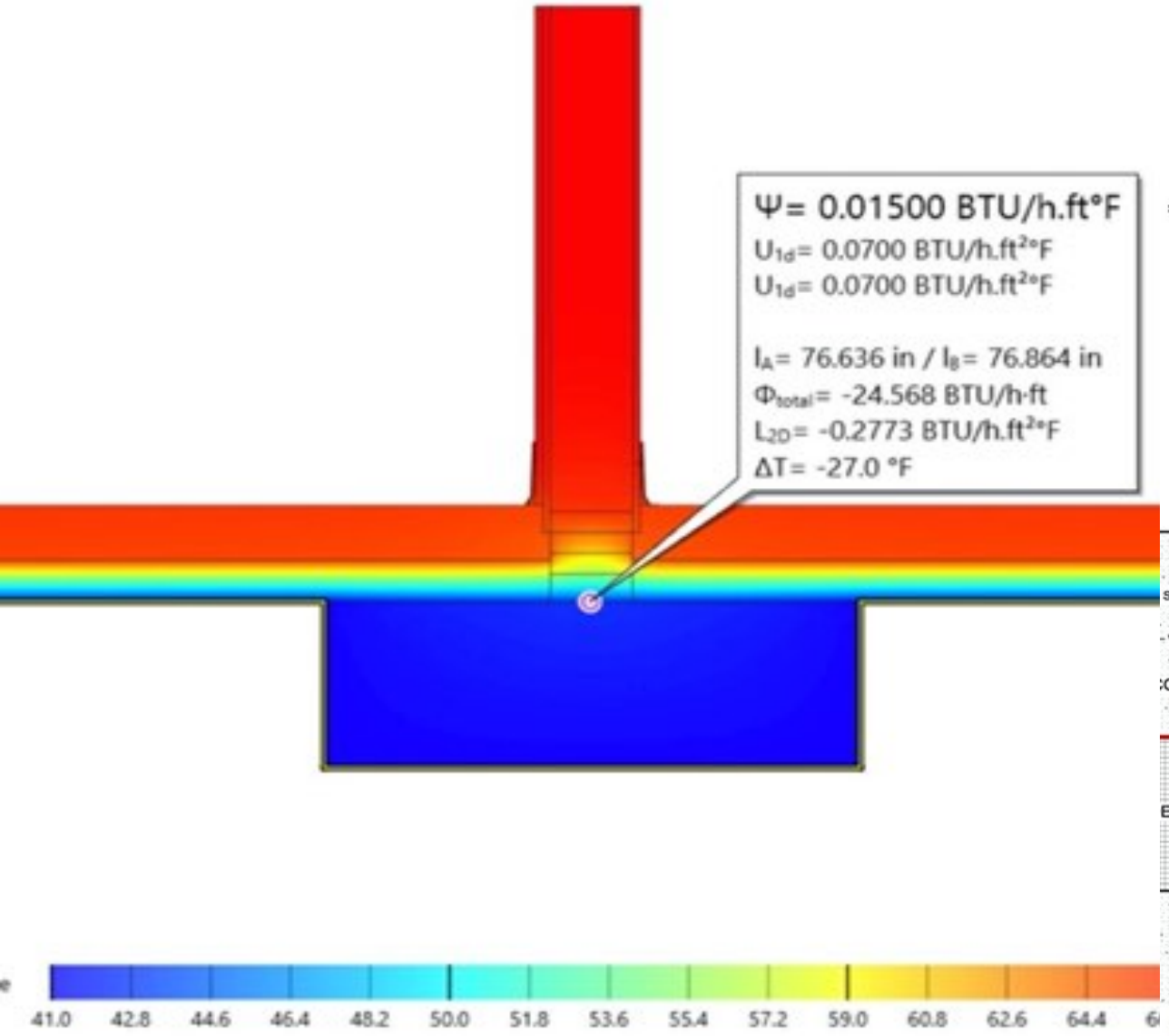


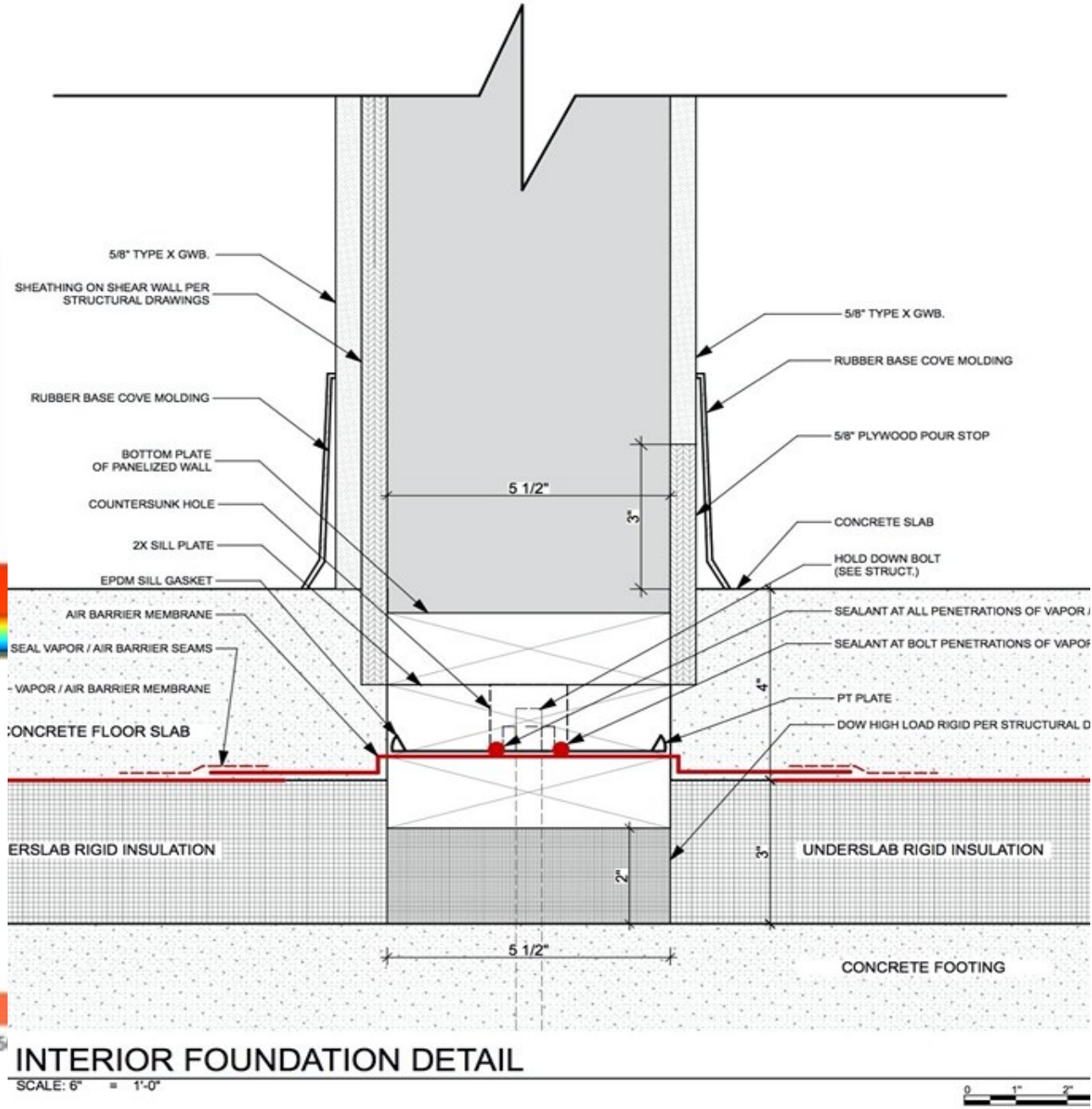


3 FOUNDATION DETAIL - 3D

SCALE: 1" = 1'-0"

Details Provided By Kaplan-Thompson Architects





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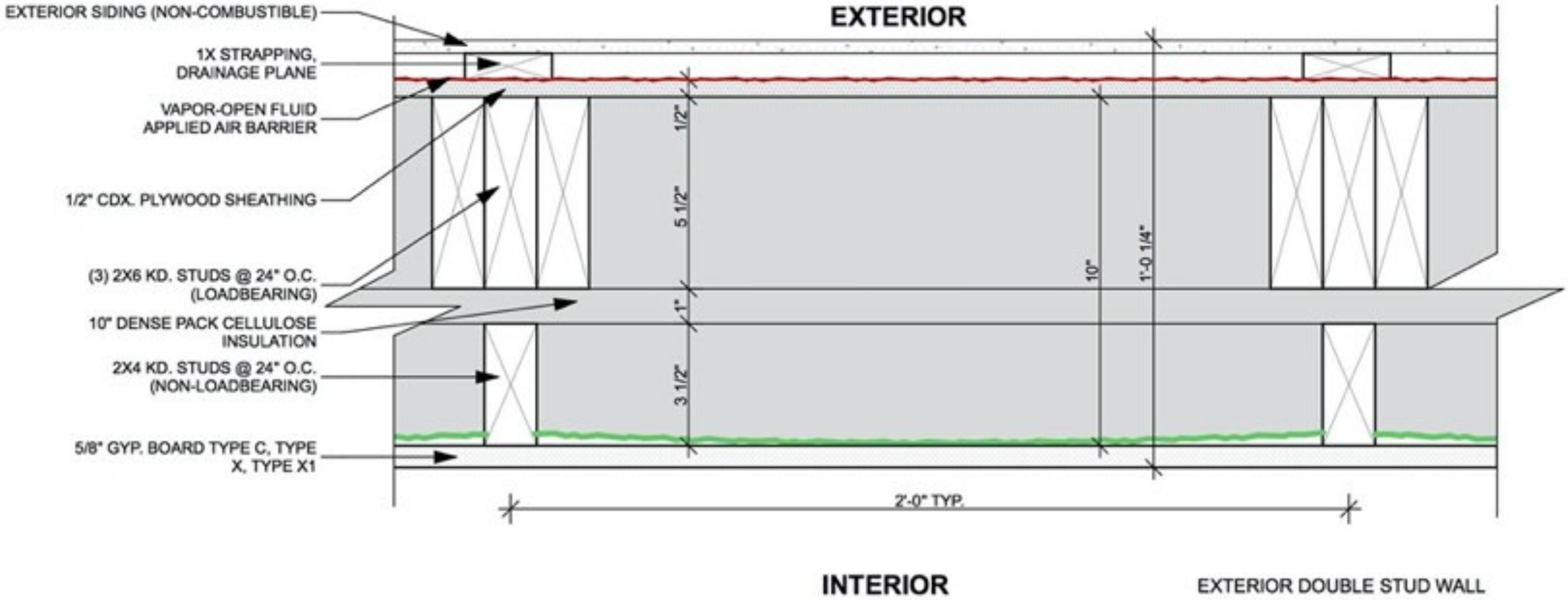
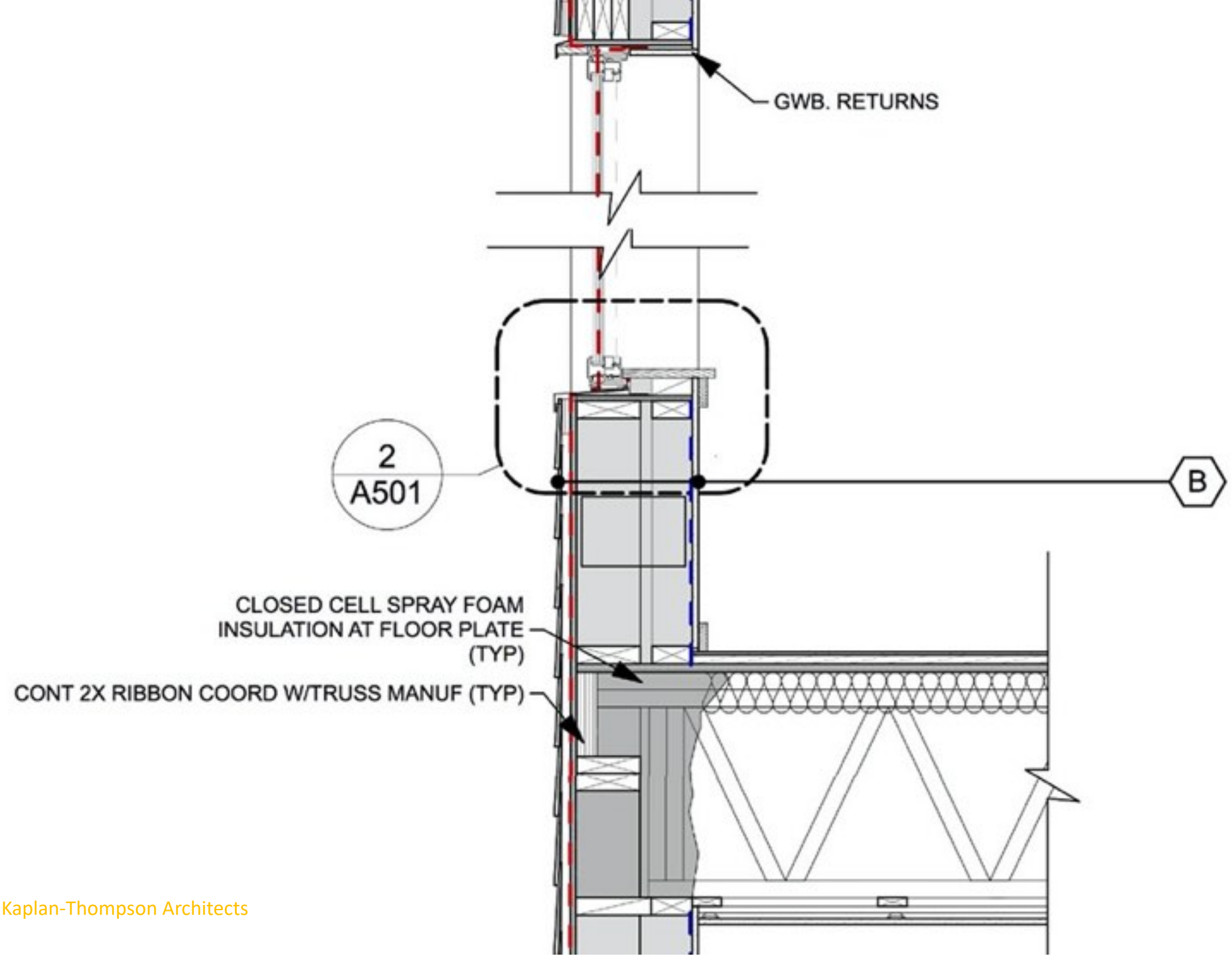
Picture Courtesy Of Kaplan-Thompson Architects



EXTERIOR DOUBLE STUD WALL

Detail Provided By Kaplan-Thompson Architects



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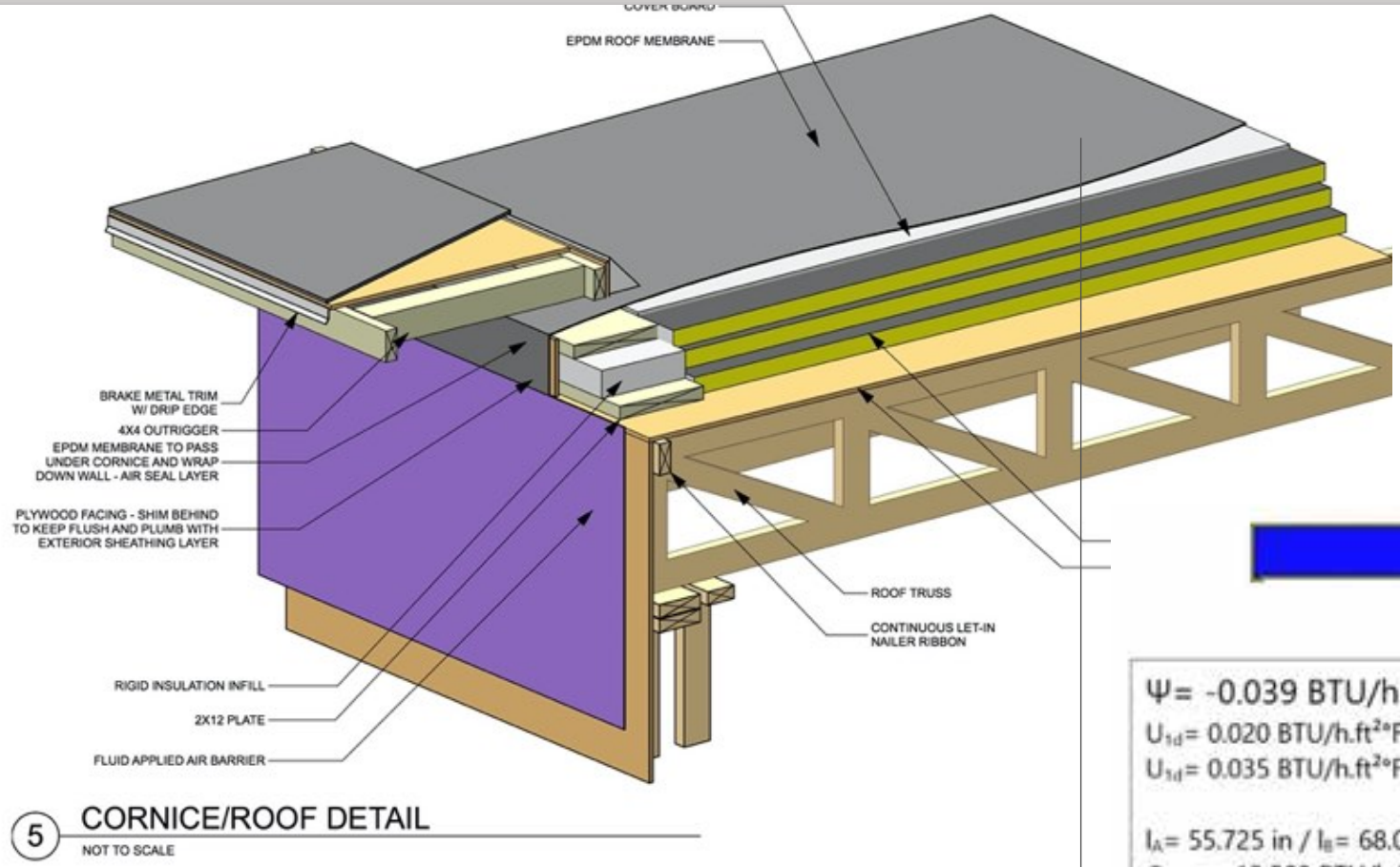
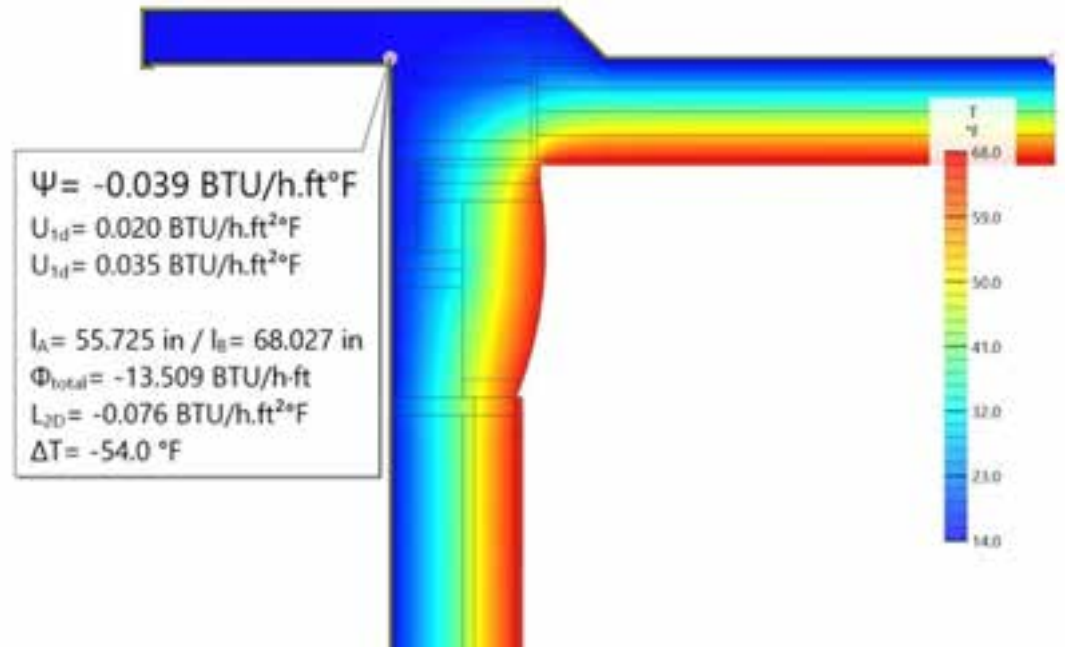


5 CORNICE/ROOF DETAIL

NOT TO SCALE



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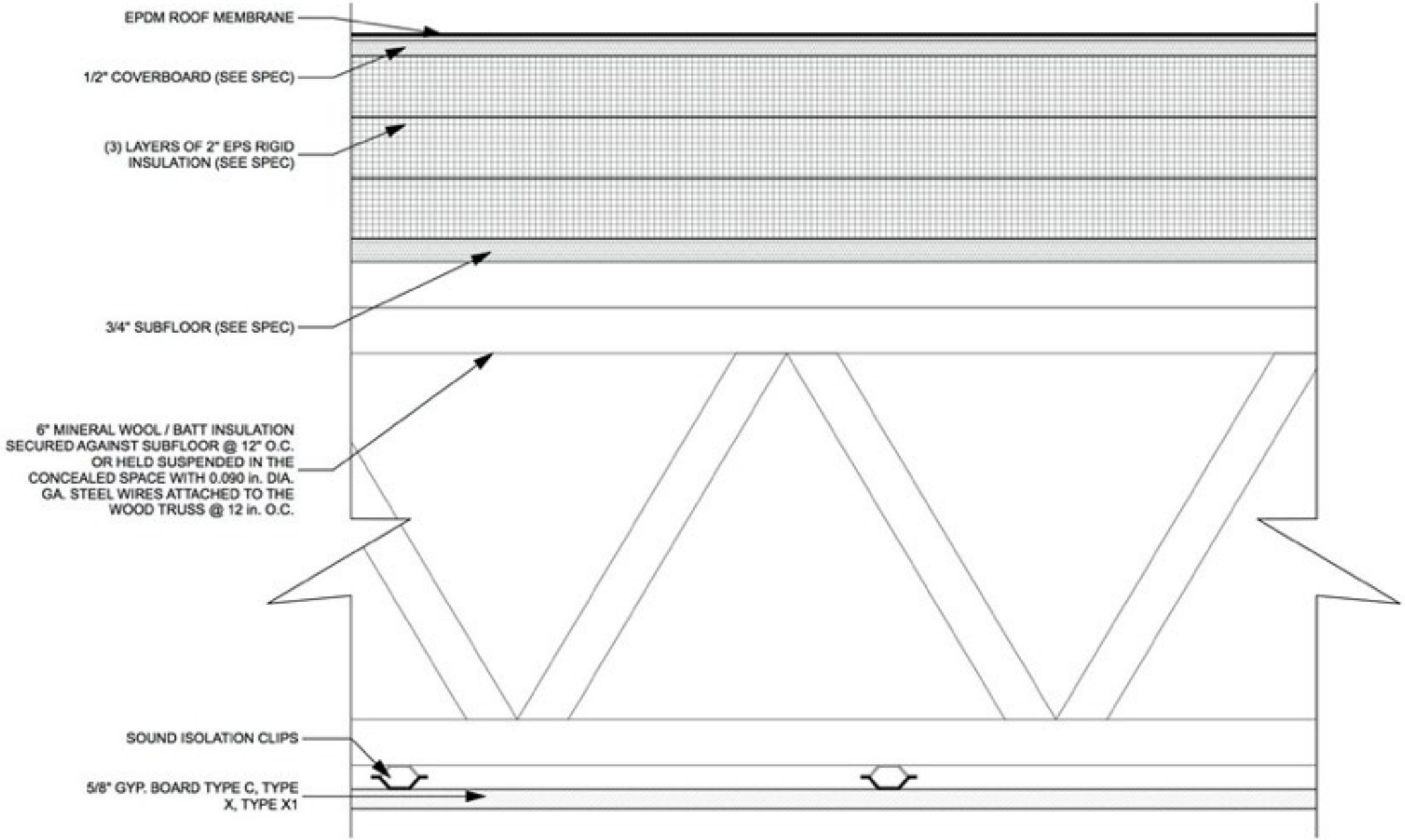

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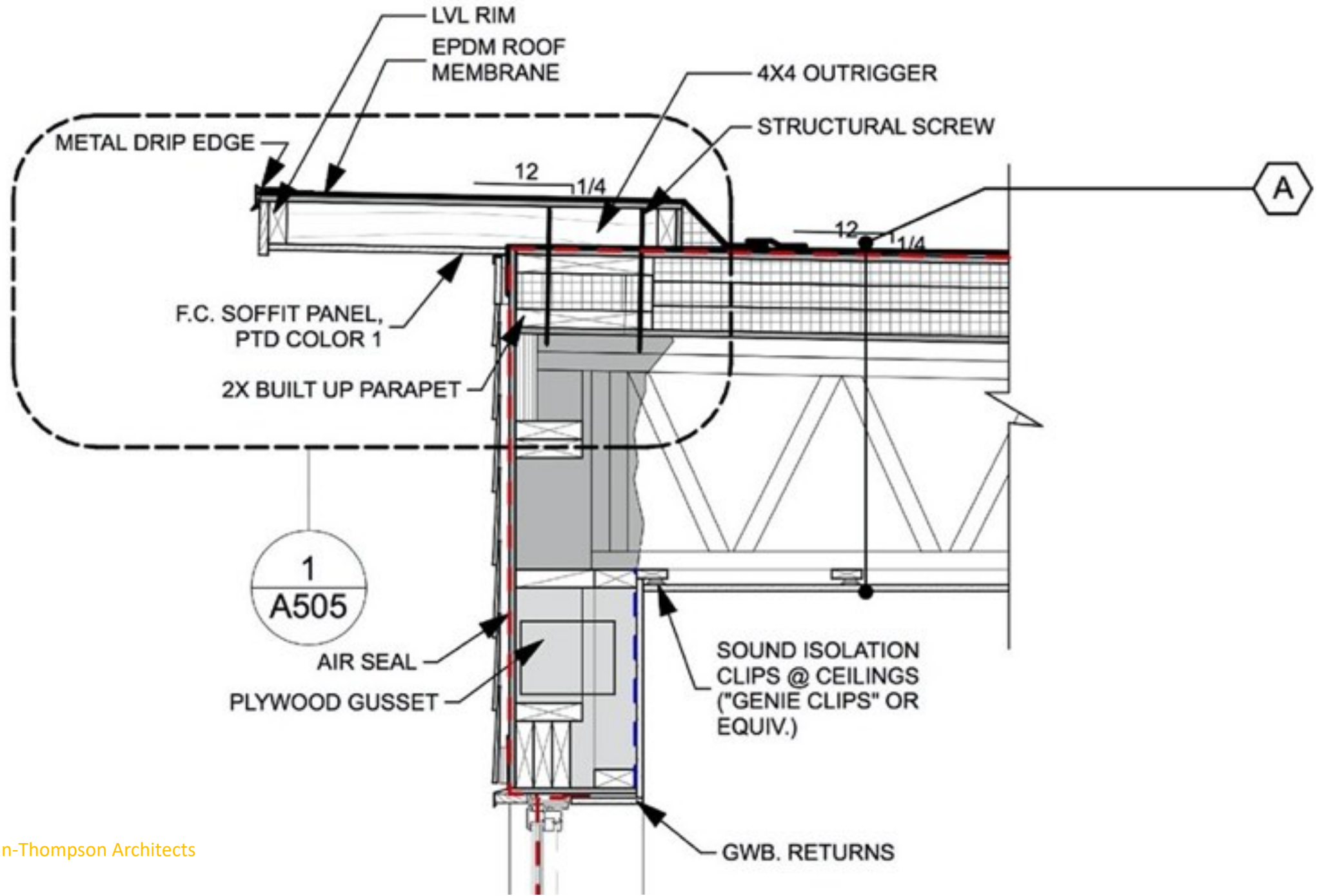

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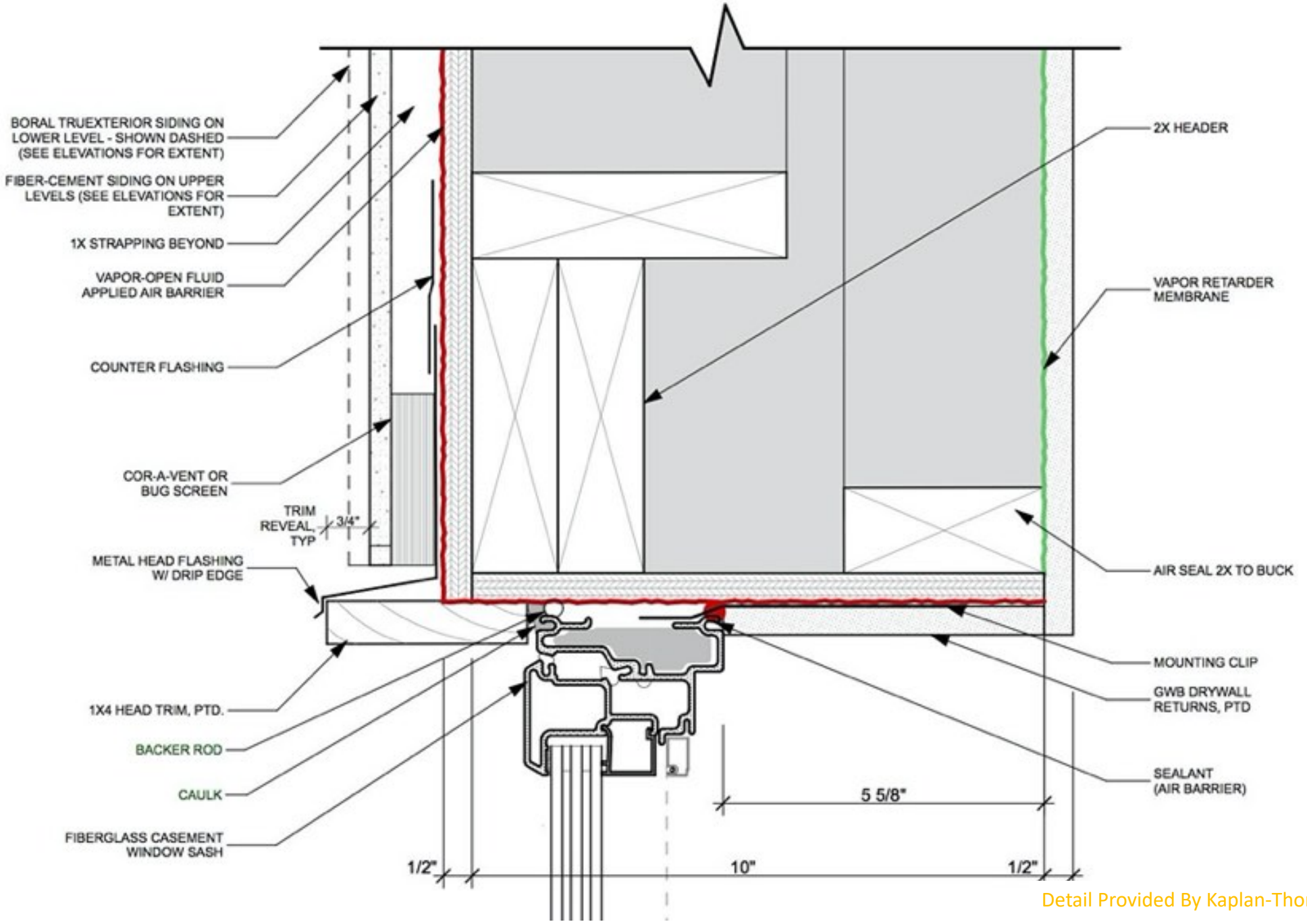

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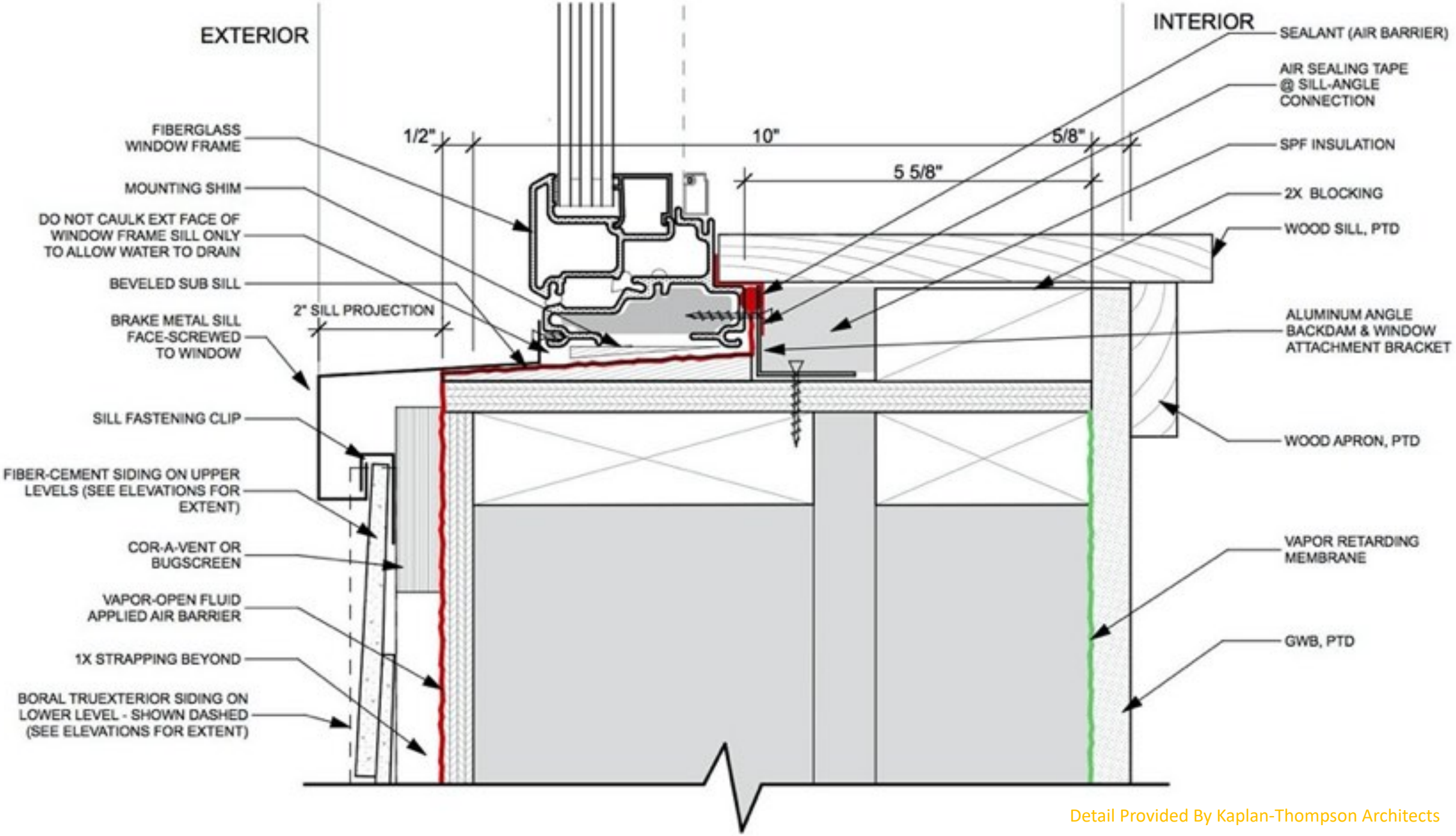


Detail Provided By Kaplan-Thompson Architects

Collaborate On Details That Work

- Use The Team's Experience
  - Roof Eaves
  - Avoiding Exterior Penetrations
- Pick Up Cheap Insurance – Double Taping
- Lining Up Air Barriers & Insulation

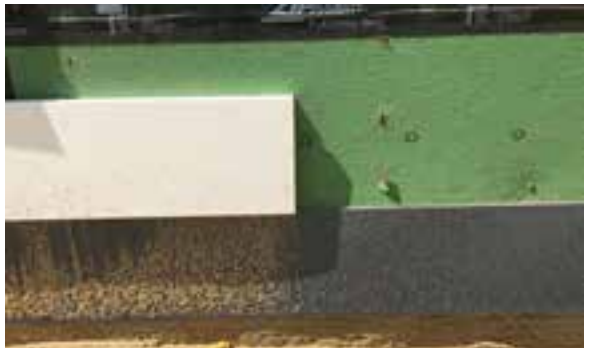
Draw On All of The Knowledge Available

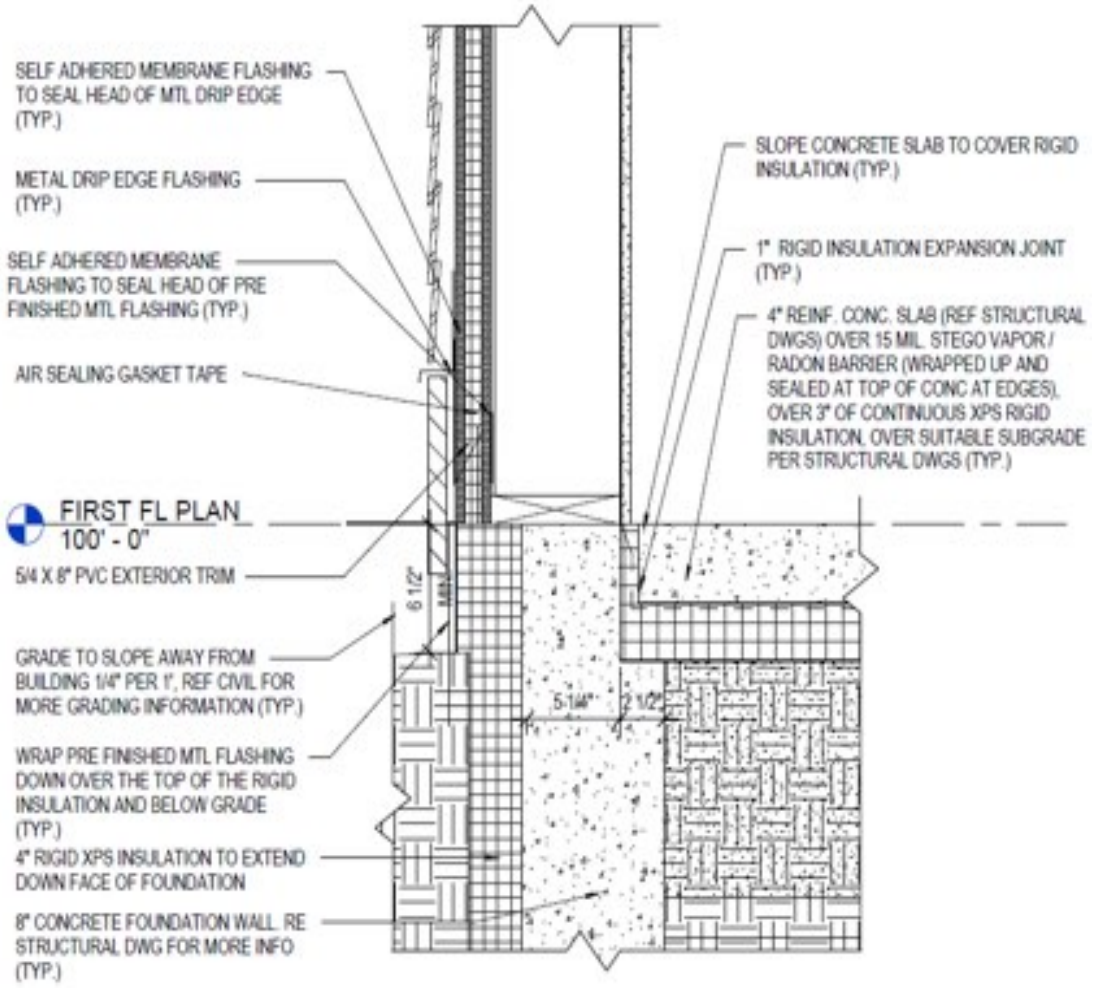
Good afternoon gentlemen
I'm following up with a quick note after yesterday's site meeting, please see the 3 discussion items from my list below:

1. After the discussion between the GC, the designer and the Rater, we've came up with a more cost effective and simple way to achieve the same R value and airiness with wall assembly. The revised exterior wall will have the following assembly:
   - GWB + CertainTeed MemBrain vapor barrier
   - 2x8 framing with CertainTeed TrueComfort densepack fiberglass cav insulation (R-31)
   - Zip sheathing, **all seams taped** (structural Sheathing)
   - **Zip R 9, all seams taped (air control layer, WRB, Continuous insulation)**

   Such assembly reduces number of XPS continuous insulation layers (no layer overlapping) in lieu of additional taping on the interior sheathing
   I will soon follow up with the revised sheet A1.0 to reflect those changes
2. Fiberglass insulation desity at wall cav. is specified to be 2.0 lb/cu.ft weight to be at 1.2 lb/sq.ft. please access the manuf. specification at the link below:
   https://www.certainteed.com/resources/30-49-189%20TrueComfort.pdf
   please refer to the bottom chart showing the closed cavity conditions, R value of 31 in 2x8 cav.
3. Reviewing different framing sealant products, I found couple good reviews on the Nova Flex MP 100 (as discussed)
   https://buymbs.com/p-4198-novagard-solutions-novaflex-advanced-polymer-paintable-sealant-101oz-carton-of-12-tubes.aspx
   And also a few really promising reviews on the Contega HF sealant:
   https://foursevenfive.com/contega-hf/
   source: https://kimchiandkraut.net/2017/01/25/framing/
   please let me know if the Contega product seems to be the reasonable alternate
   kind regards

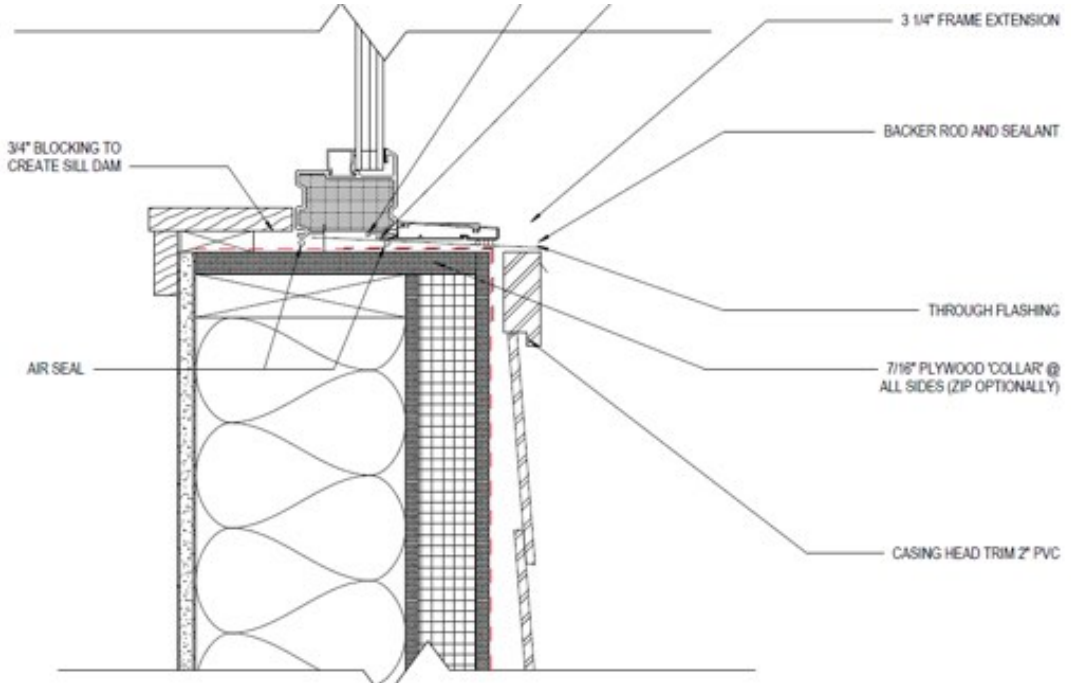
Our Energy Raters Is AWESOME And Always Lending Us A Hand Every Step of The Way





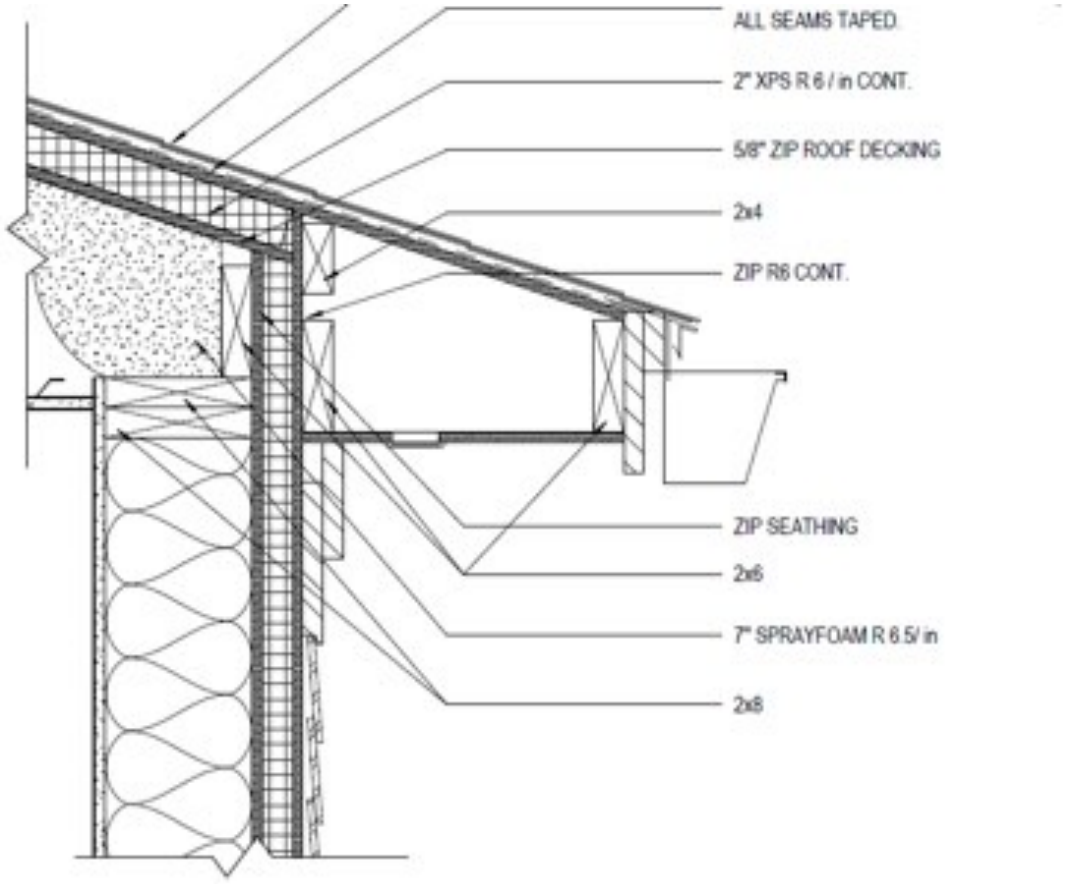
Detail Provided By Lassel Architects


R-15
Under Slab
Walls
3 inch Thickness
FOAMULAR
250



Detail Provided By Lassel Architects


R- SHEATHING
STRETCH TAPE
STRETCH TAPE
STRETCH TAPE
30
AdvanTech Flooring



Detail Provided By Lassel Architects

Air-Sealing Options & Approaches

- Belts & Suspenders Theory
- Flawless Execution
- Hybrid (Recommended)

Products & Systems

Fluid-Applied Air Barrier
Taped WRB-Impregnated Sheathing
Sheet-Applied WRB
Taped Building Wraps
Air-Borne Sealant Systems
Air-Tight Device Boxes

Techniques

"Air-Tight Drywall Approach"
Fully Adhered Sheathing
Caulk Framing Joints
Caulking Interior Penetrations (Device Boxes)
Oversized Wall Sleeves w/ Caulking Joint

Air-Sealing Reality Check

- Window & Door Tightness
- Wall Area vs. Window Area
- Mechanical Units & Penetrations (PTACs)

Pictures Courtesy Of Kaplan-Thompson Architects

Pictures Courtesy Of Kaplan-Thompson Architects

Cost Considerations

- Manage value at a system level.
  - Wall Assembly, Roof Assembly, Slab/Foundation, Fenestration, Mechanical Systems
- Tight budgets should focus on function first.
- Start with the basics, add features as budget allows and energy model requires.
  - Window Awnings, Light Shelves, Solar Panels
- Make sure all systems get design attention.
- Time is money. Extravagant, cumbersome details waste both.
- Seek out new products and solutions.

Cost of Air-Sealing Wall Assemblies

- The Meadows:
  - Adhered Wall Sheathing $4k
  - Framing Sealants $5,200
  - A/V Barrier Tape x 2 w/ Openings $17,100
  - Opening Caulking $12k

0.5% of Total Job Cost

Caulking – 768 Tubes / 60 Gallons

Sealing Tape – 551 Rolls / 9.4 miles

- Bayside Anchor:
  - Adhered Wall Sheathing $5k
  - Framing Sealants $4,600
  - Fluid-Applied Air Barrier $65k
  - Opening Caulking $15k

1.6% of Total Job Cost

(Includes Complete A/V Barrier)

Exterior vs. Cavity Insulation

Insulated Sheathing	Closed-Cell Spray Foam
• Integrated WRB • Air-Sealing Layer • Continuous R-Value • R4.5/in w/ Sheathing (Based on 2” Thickness)	• Cavity Insulation • Not Air-Tight • About R6.5/in
$0.22 / R-1 $2.00 / SF @ 2”	$0.19 / R-1 $1.25 / SF @ 1”

Window Cost Comparisons

Considerations:

U-Factor
SHGC
Air-Infiltration
Design Pressure Rating

Thermal Performance of Spacers
Thermal Performance of Frame
Orientation of Windows
North/South
Climate Zone

Approach:

Define project requirements, seek out multiple alternatives, and compare pricing.
Cast a wide net. The window market is highly competitive.

Rules of Thumb:

Double-Hung to Casement/Hopper/Awning: 0 – 20% Cost Increase
Double Pane to Triple Pane: 10% +/- Cost Increase

Wall Assembly Cost Comparisons

Double Wall	2x8 Wall	2x6 Wall
• 2x6 Outer Wall • 2x4 Inner Wall • 10” Dens-Pak Cellulose • Fluid-Applied A/V Barrier • Smart Vapor Retarder	• 2x8 Wall Framing • Blown-In Fiberglass Insulation • 2” Exterior Insulated Sheathing • Smart Vapor Retarder	• 2x6 Wall Framing • Dens-Pak Cellulose • 2” Exterior Insulated Sheathing • Smart Vapor Retarder
R-37 Effective	R-34 Effective	R-29 Effective
2015 ($129/sf)	2018 ($192/sf)	2019 ($200/sf)

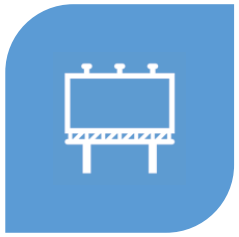
Design Has Adapted To Steep Cost Increases Over 4 Yrs.

Education & Communications

PASSIVE HOUSE EDUCATION – BETTER UNDERSTANDING LEADS TO BETTER PROJECTS
0.034 CFM@50PA

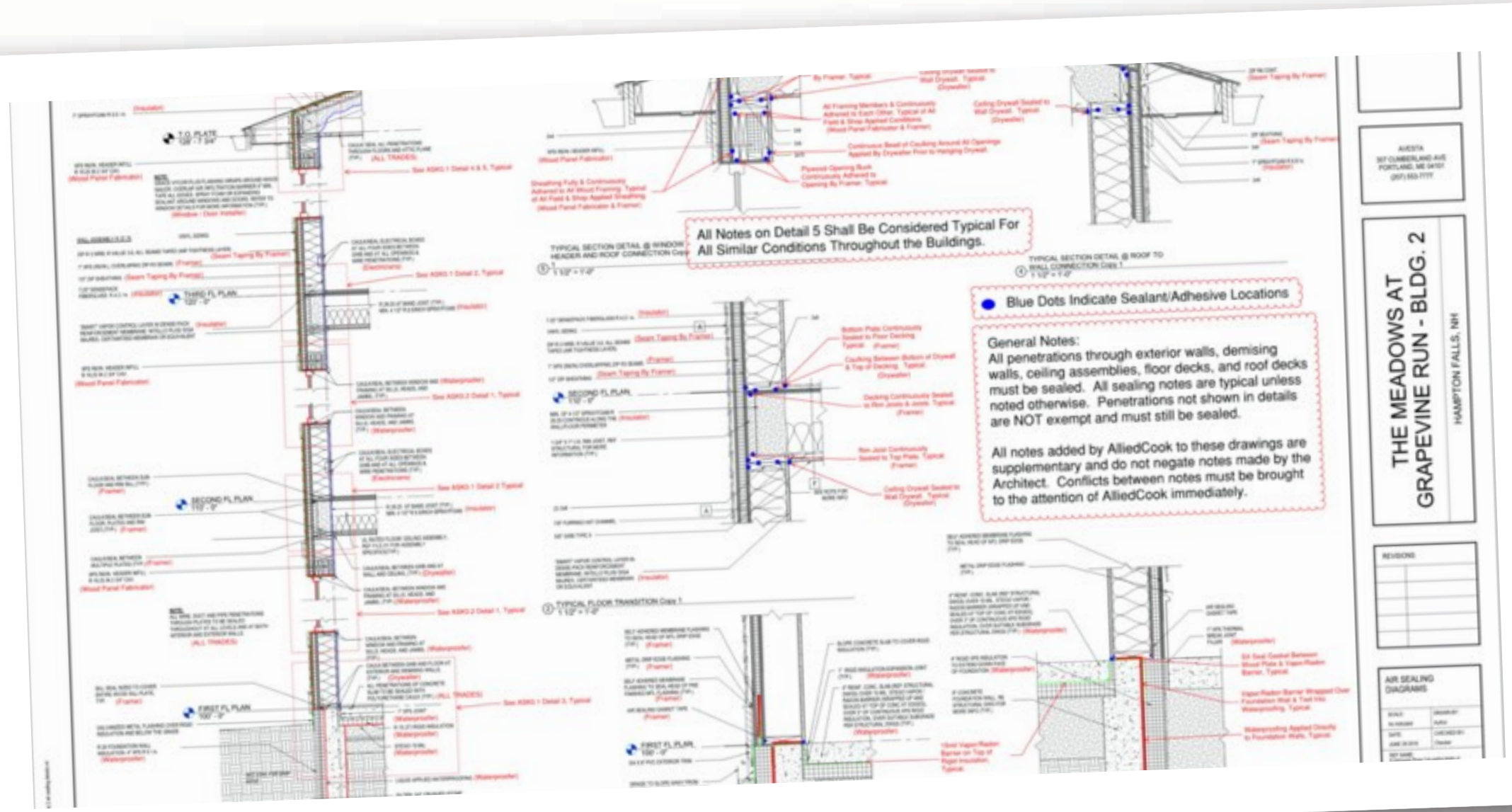
WRITE CONTRACTS SPECIFIC TO PASSIVE HOUSE OBJECTIVES

PRECONSTRUCTION MEETINGS – AIR SEALING IS FOR EVERYONE



REMINDERS & UPDATES – RESEALING AIR BARRIERS AT PENETRATIONS

COORDINATE SUPPLIERS AND/OR SINGLE-SOURCE WHERE FEASIBLE TO REDUCE OPPORTUNITIES FOR CONFUSION


All Notes on Detail 5 Shall Be Considered Typical For All Similar Conditions Throughout the Buildings.
Blue Dots Indicate Sealant/Adhesive Locations
General Notes:
All penetrations through exterior walls, demising walls, ceiling assemblies, floor decks, and roof decks must be sealed. All sealing notes are typical unless noted otherwise. Penetrations not shown in details are NOT exempt and must still be sealed.
All notes added by AlliedCook to these drawings are supplementary and do not negate notes made by the Architect. Conflicts between notes must be brought to the attention of AlliedCook immediately.
THE MEADOWS AT GRAPEVINE RUN - BLDG. 2
HAMPTON FALLS, NH
REVISIONS
AIR SEALING DIAGRAMS

Project-Specific Inspection Log

2 - Foundations	Insulation	Passive House & Energy Rating
2 - Underslab	Plumbing/Electrical	Code Enforcement
2 - Slabs	Subgrade Inspection	Town Engineer
	Insulation	Code Enforcement
	Underslab VB & Insulation	Passive House & Energy Rating
	Concrete & Rebar	Materials Testing & Inspection
	Rebar	Code Enforcement
2 - Elev Shaft	Masonry	Materials Testing & Inspection
2 - 1st Floor	Steel	Materials Testing & Inspection
2 - Entire Bldg	Shear Walls	Materials Testing & Inspection
	Structural Punch List Inspection	Design Engineer
2 - 3rd Floor	Plumbing/Electrical	Code Enforcement
	Insulation	Code Enforcement
	Firestopping	Code Enforcement
	Insulation, Sealing, Roofing, Windows	Passive House & Energy Rating
2 - 2nd Floor	Plumbing/Electrical	Code Enforcement
	Insulation	Code Enforcement
	Firestopping	Code Enforcement
	Insulation, Sealing, Roofing, Windows	Passive House & Energy Rating
2 - 1st Floor	Plumbing/Electrical	Code Enforcement
	Insulation	Code Enforcement
	Firestopping	Code Enforcement
	Insulation, Sealing, Roofing, Siding	Passive House & Energy Rating
2 -Final Inspections	Final Inspections & Testing	Passive House & Energy Rating
	Fire Alarm Inspection	Fire Department
	Fire Sprinkler & Egress	Fire Department
	Elevator Inspection	State Elevator Inspector
	Site Inspection	Town Engineer
	Certificate of Occupancy Inspection	Code Enforcement

Mock-ups Sort Out Details & Add Value To Overall Project

Practicing Details Improves Quality & Points Out Flaws In The Plan

More Cheap Insurance

Pictures Courtesy Of Kaplan-Thompson Architects

Passive House on The Schedule

- More time spent planning in preconstruction.
- More time reviewing envelope details during design.
- Plug-in Inspections in Master & Look-ahead Schedules
- Make time for inspecting and correcting details
- Include inspectors/raters on schedule distribution
- Impact on the critical path comes down to details

Tests & Inspections

- Preliminary Shell Blower Door Testing
- Insulation Continuity, Thickness & Density
- Air-Sealing Inspection
- Final Blower Door Testing
- Bucket Test
- Air Balancing

Follow-Up & Follow-Through

- Constant Inspection
  - Zip System Install
  - Insulation Thickness, Density & Consistency
  - Air Sealing
  - Sealed Outlet Boxes
  - Panel Fabrication
- Upgrading Details
  - Insulated Sleeves
- Blower Door Testing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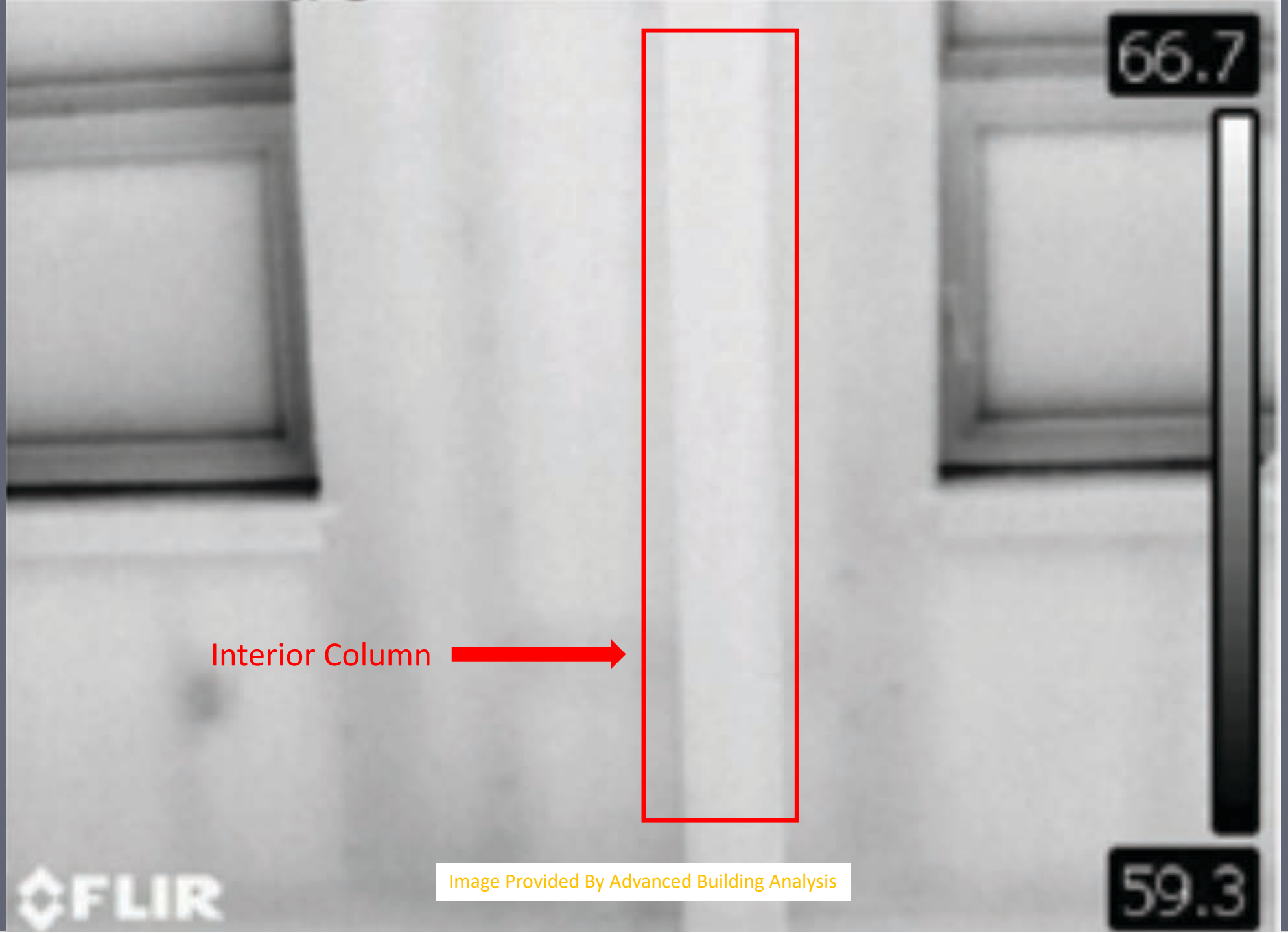
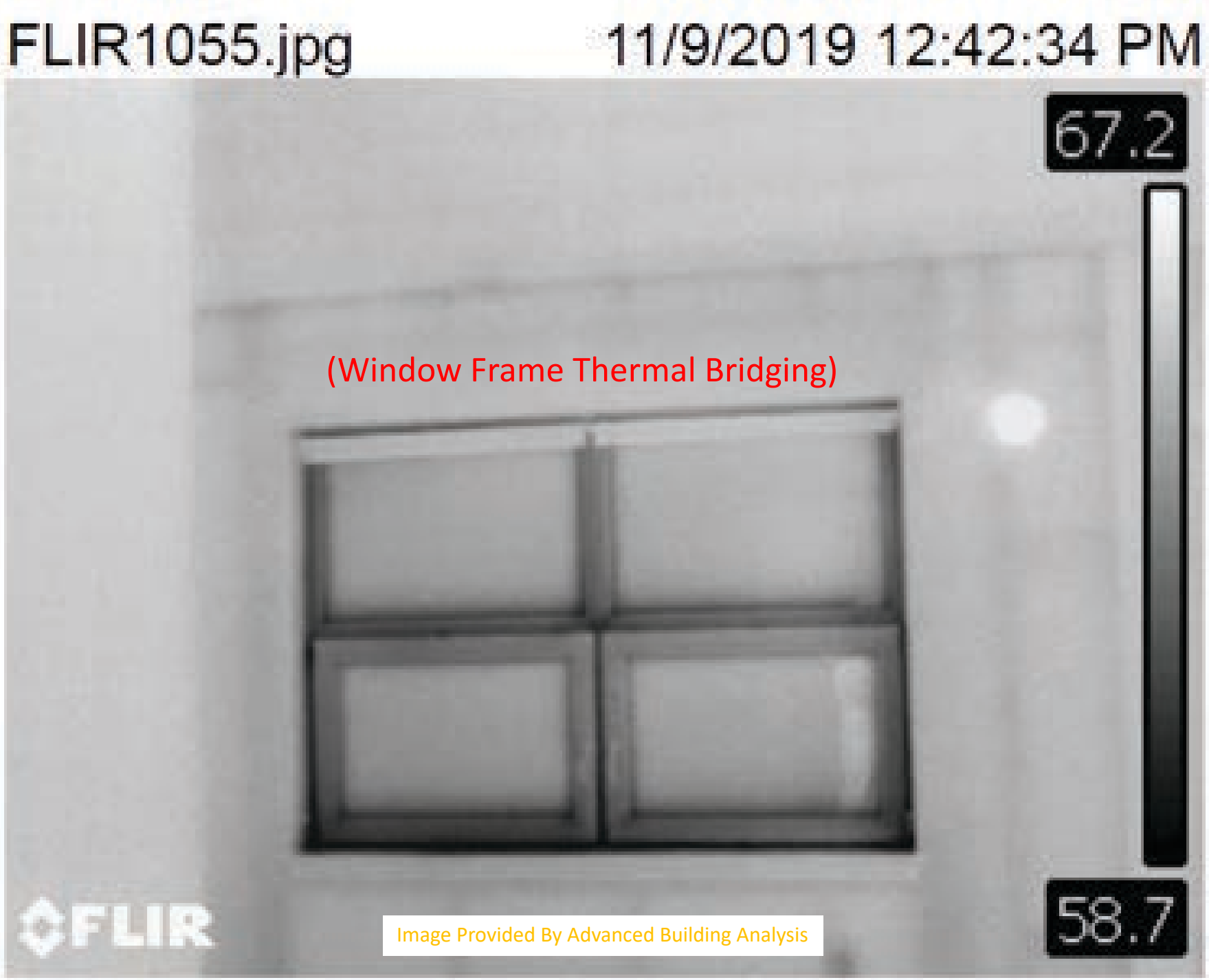
72.8
THERMAL IMAGING
65.5
FLIR


E60
83.9
62.5


66.7
Interior Column
FLIR
Image Provided By Advanced Building Analysis
59.3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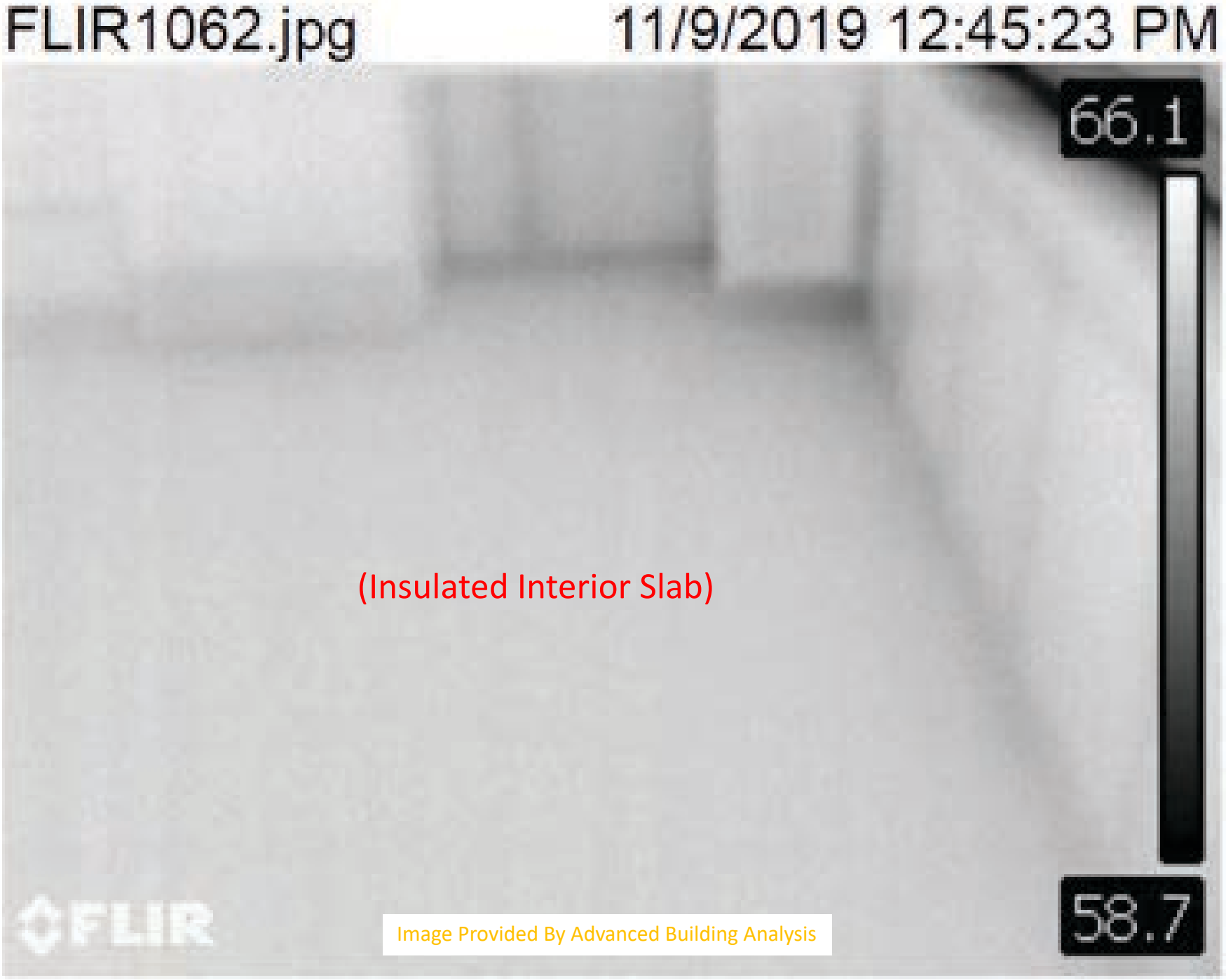
67.2
58.7
(Window Frame Thermal Bridging)
FLIR
Image Provided By Advanced Building Analysis


FLIR1062.jpg
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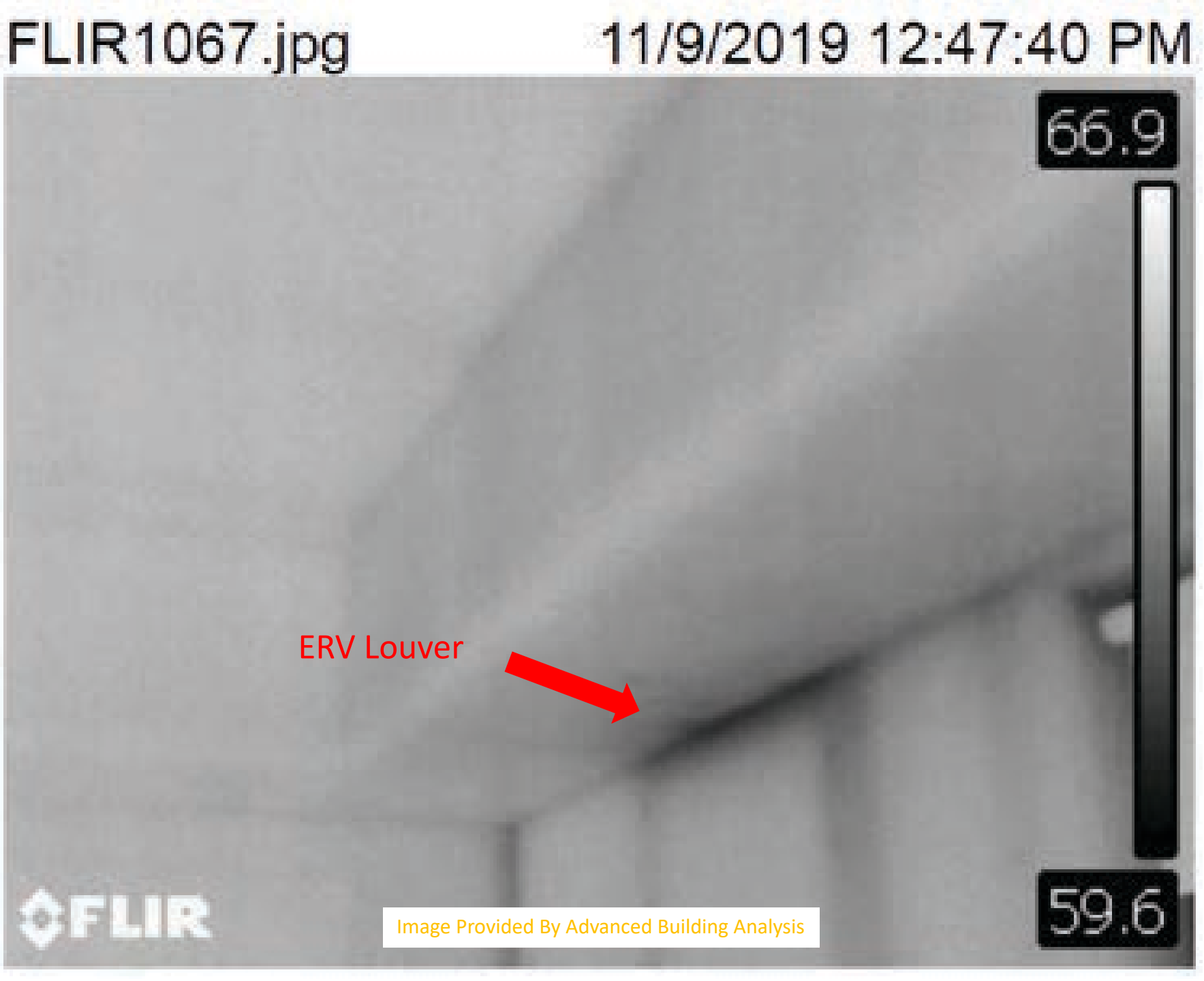
66.1
58.7
(Insulated Interior Slab)
FLIR
Image Provided By Advanced Building Analysis


FLIR1067.jpg
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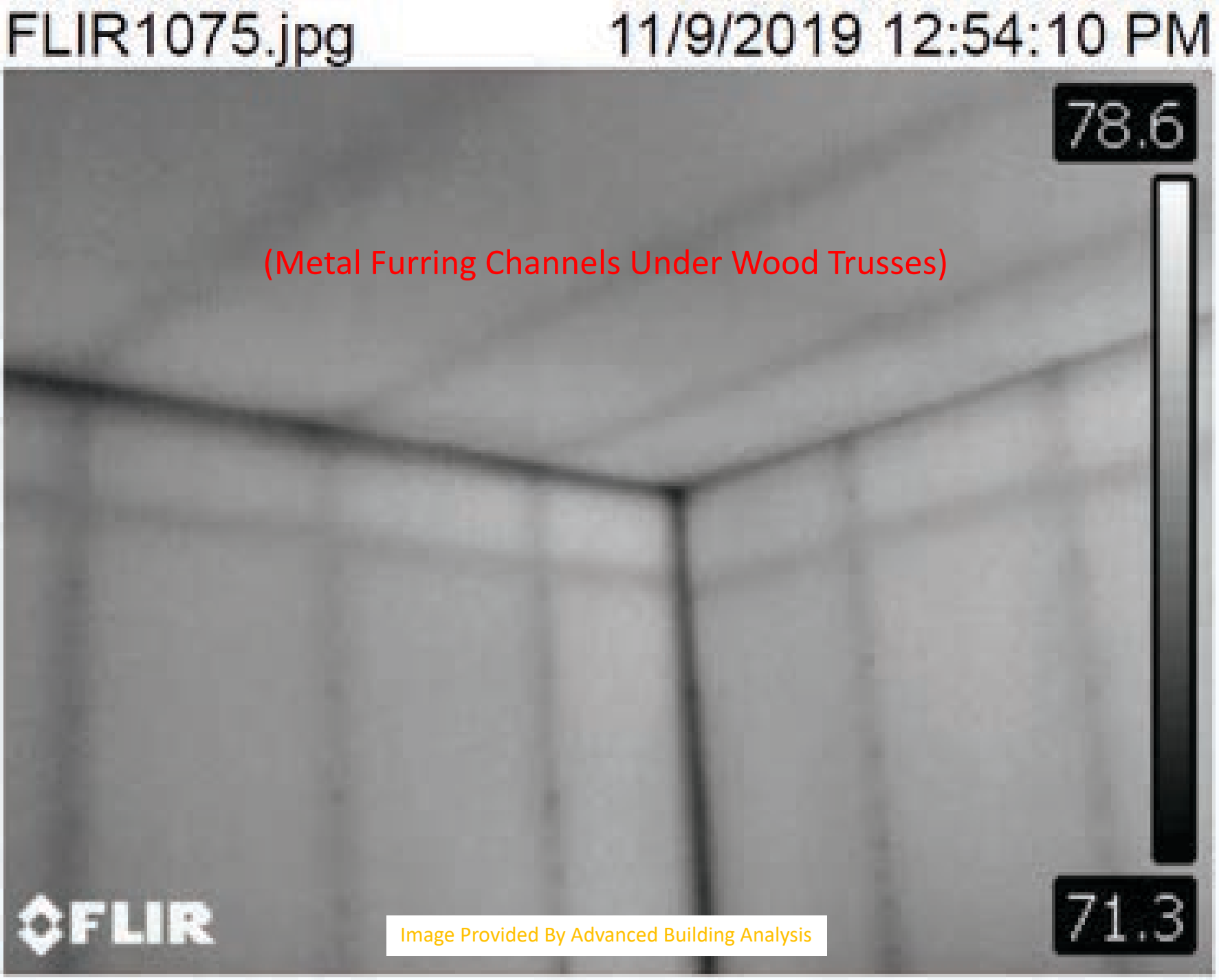
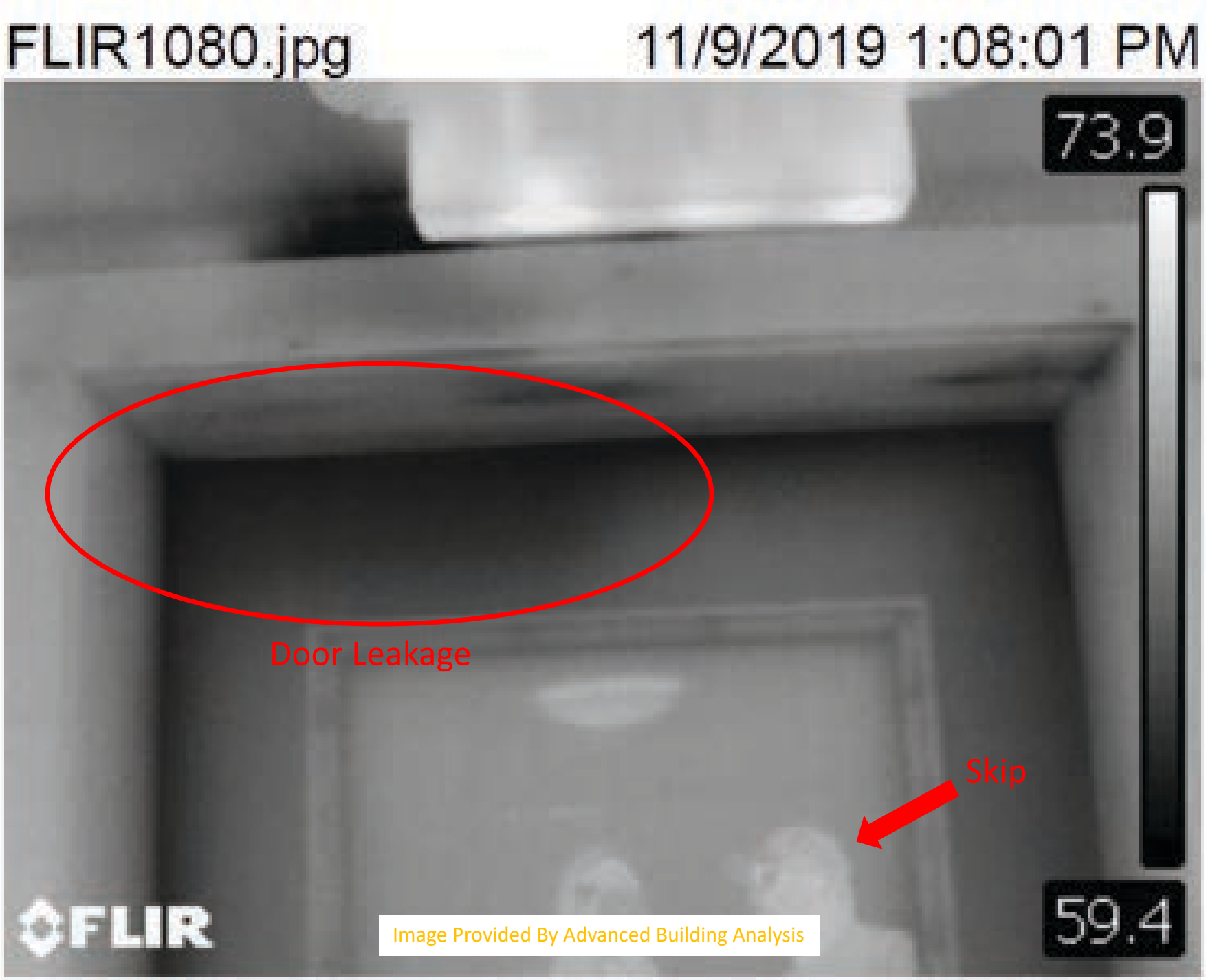
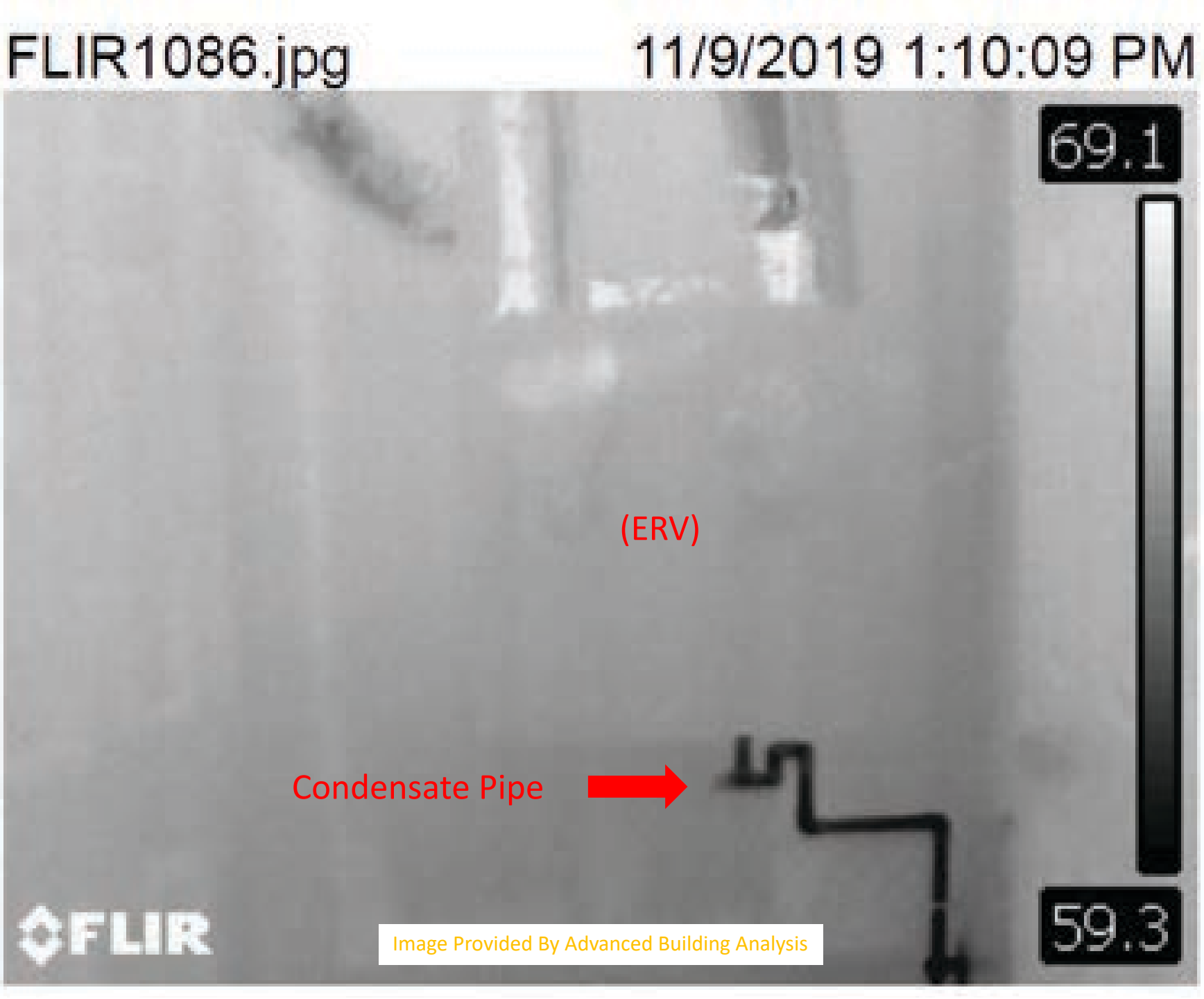
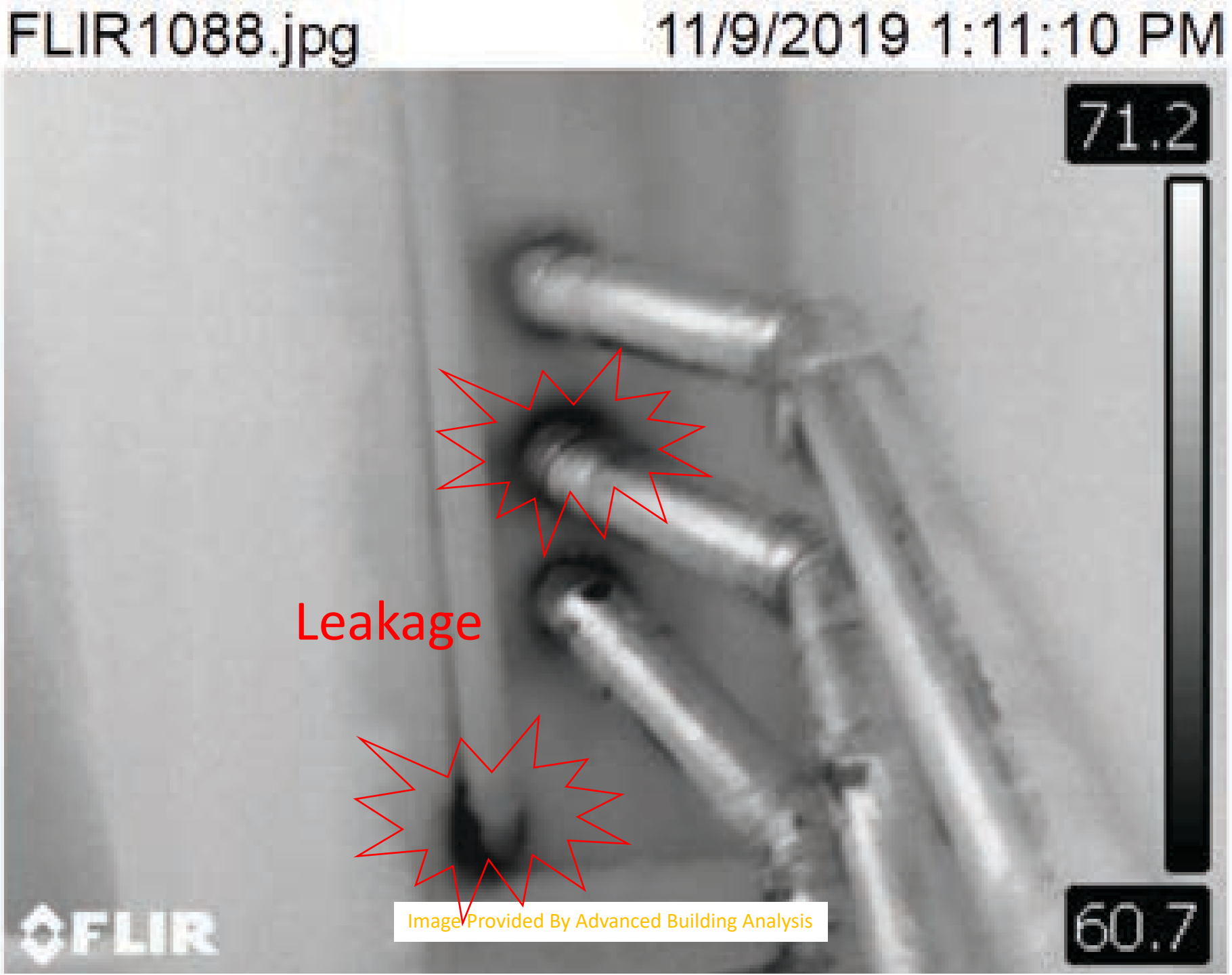
66.9
59.6
ERV Louver
FLIR
Image Provided By Advanced Building Analysis


FLIR1075.jpg
11/9/2019 12:54:10 PM
78.6
(Metal Furring Channels Under Wood Trusses)
FLIR
Image Provided By Advanced Building Analysis
71.3


FLIR1080.jpg
11/9/2019 1:08:01 PM
73.9
Door Leakage
Skip
FLIR
Image Provided By Advanced Building Analysis
59.4


FLIR1086.jpg
11/9/2019 1:10:09 PM
69.1
(ERV)
Condensate Pipe
59.3
FLIR
Image Provided By Advanced Building Analysis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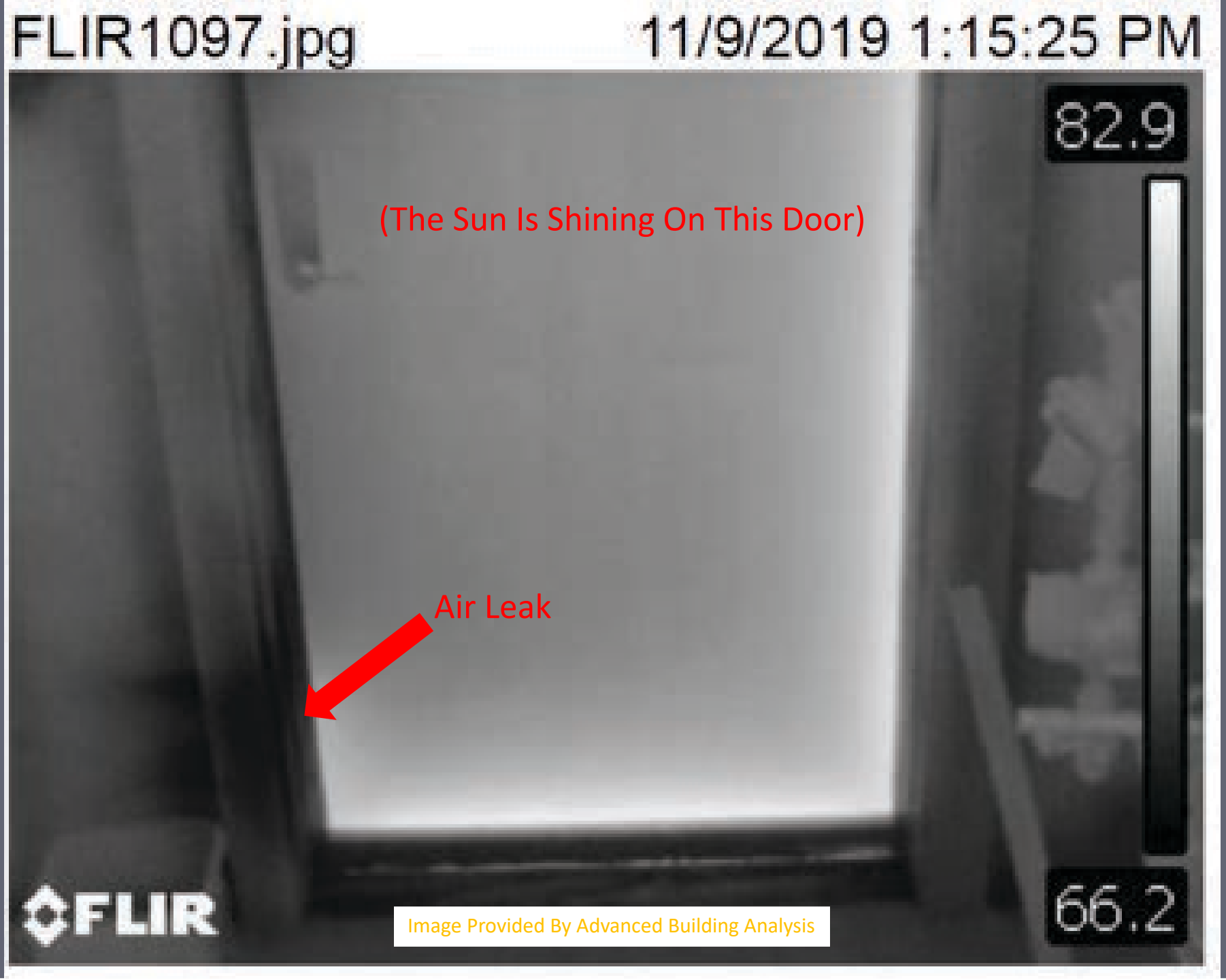
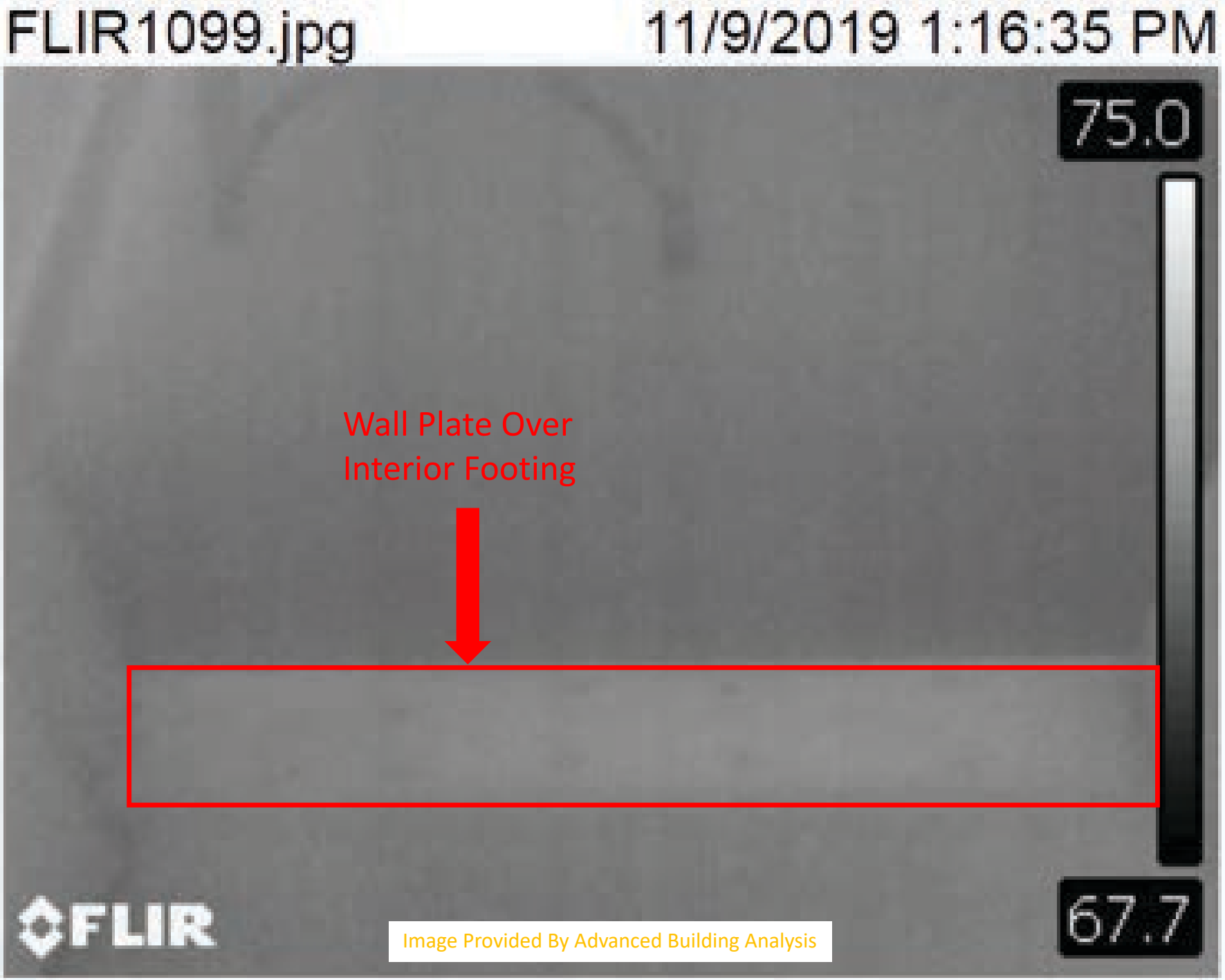
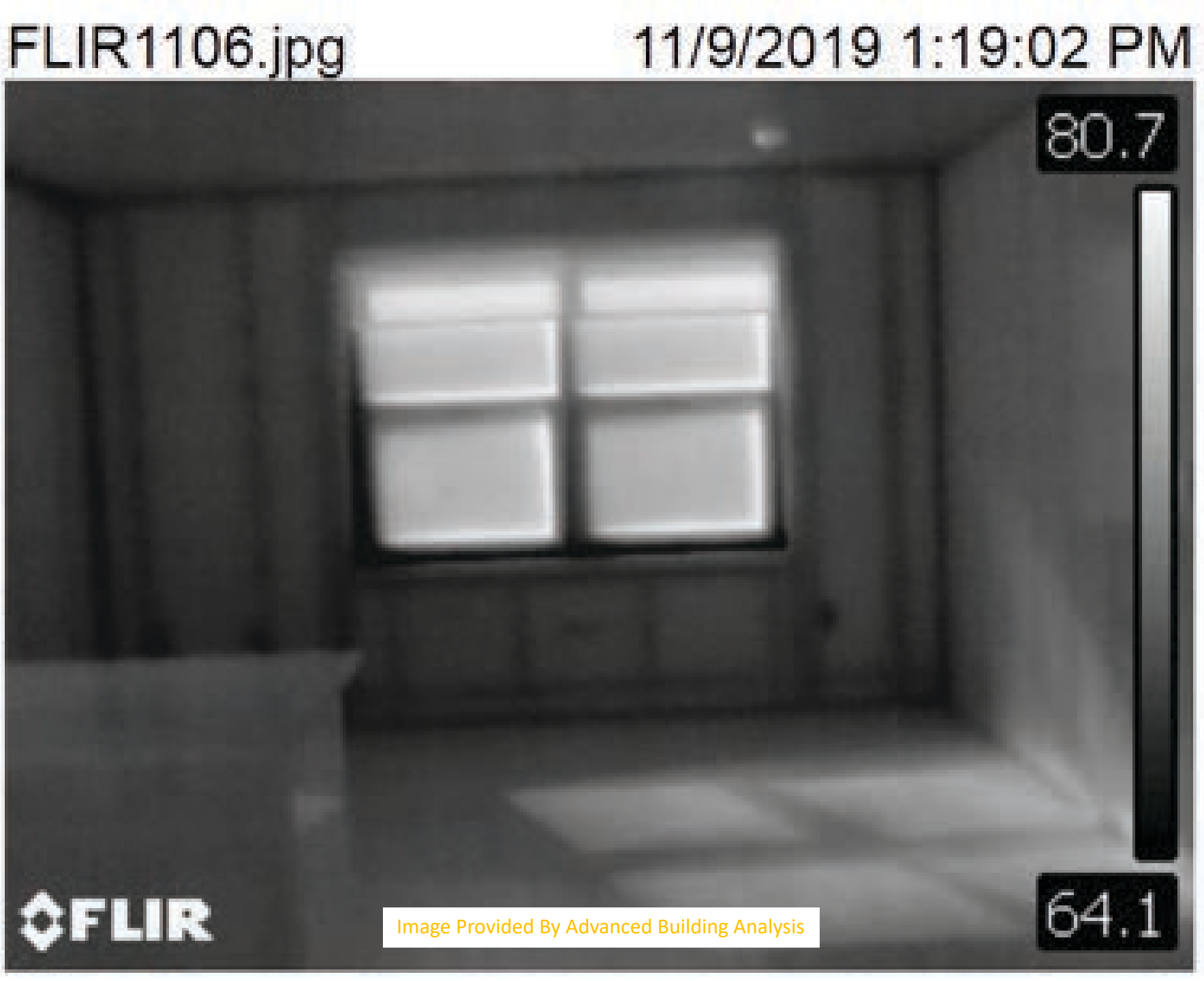
71.2
60.7
Leakage
FLIR
Image Provided By Advanced Building Analysis


FLIR1097.jpg
11/9/2019 1:15:25 PM
82.9
(The Sun Is Shining On This Door)
Air Leak
FLIR
66.2
Image Provided By Advanced Building Analysis


FLIR1099.jpg
11/9/2019 1:16:35 PM
75.0
Wall Plate Over
Interior Footing
FLIR
Image Provided By Advanced Building Analysis
67.7

Images Provided By Advanced Building Analysis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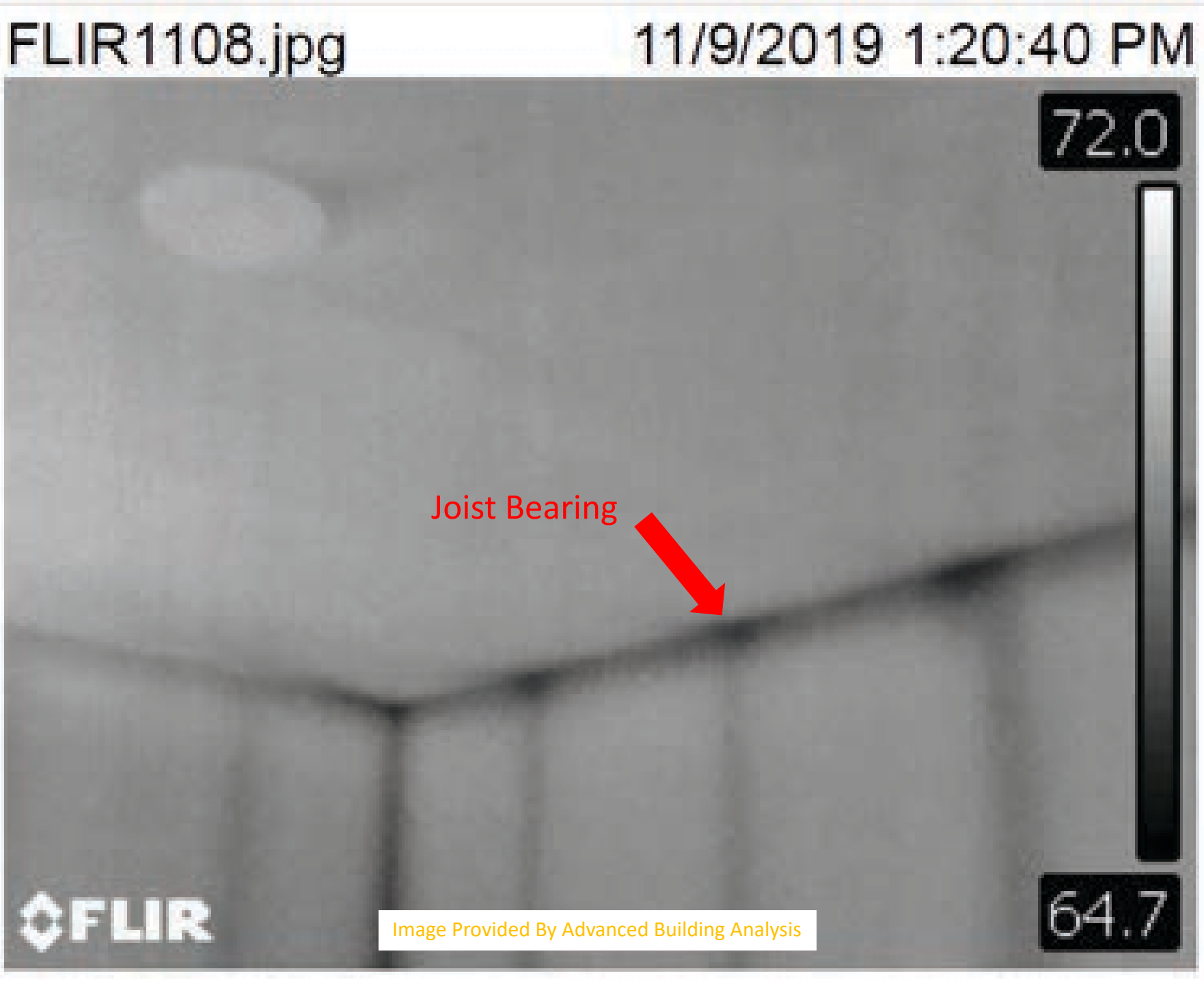
80.7
64.1
FLIR
Image Provided By Advanced Building Analysis


FLIR1108.jpg
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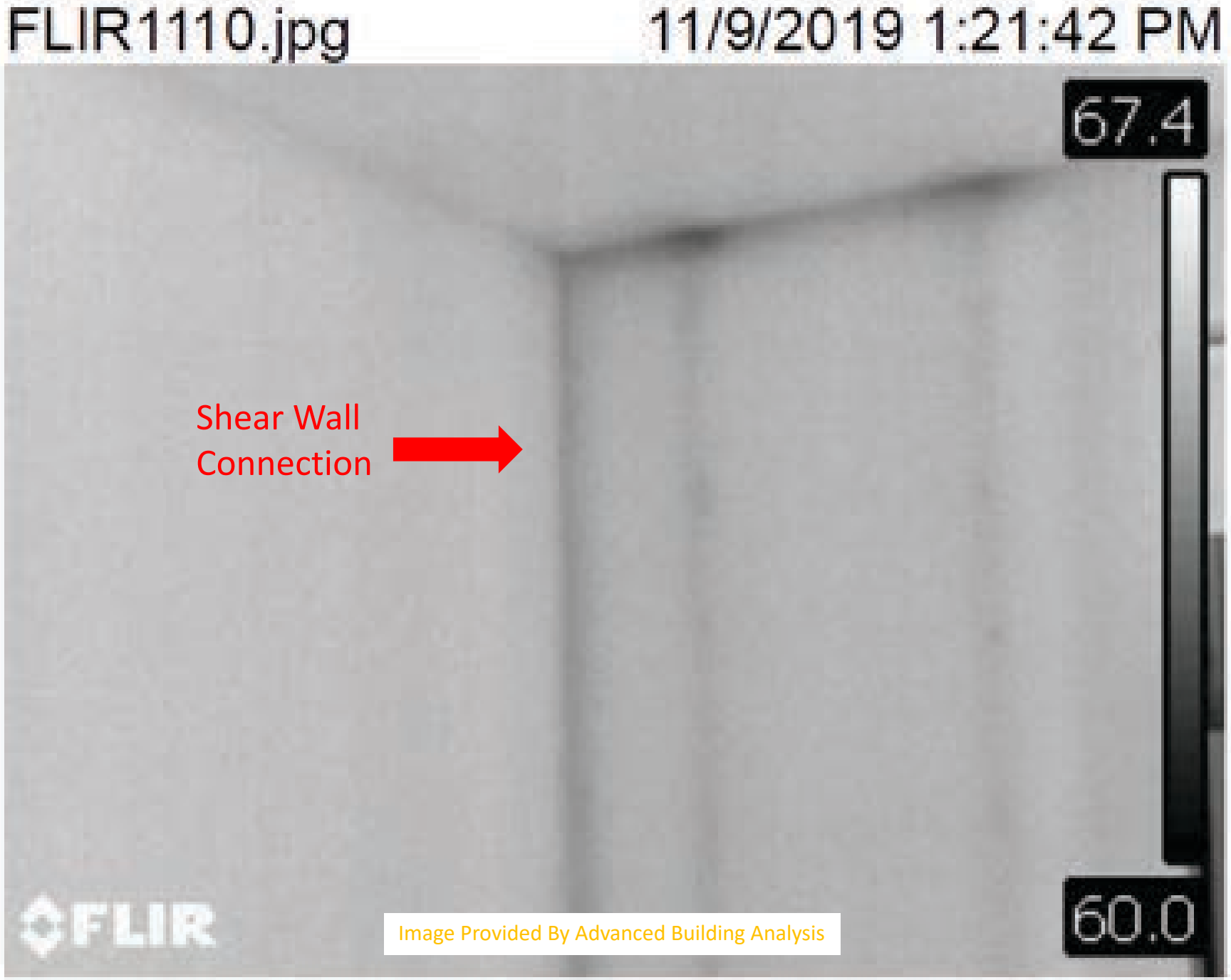
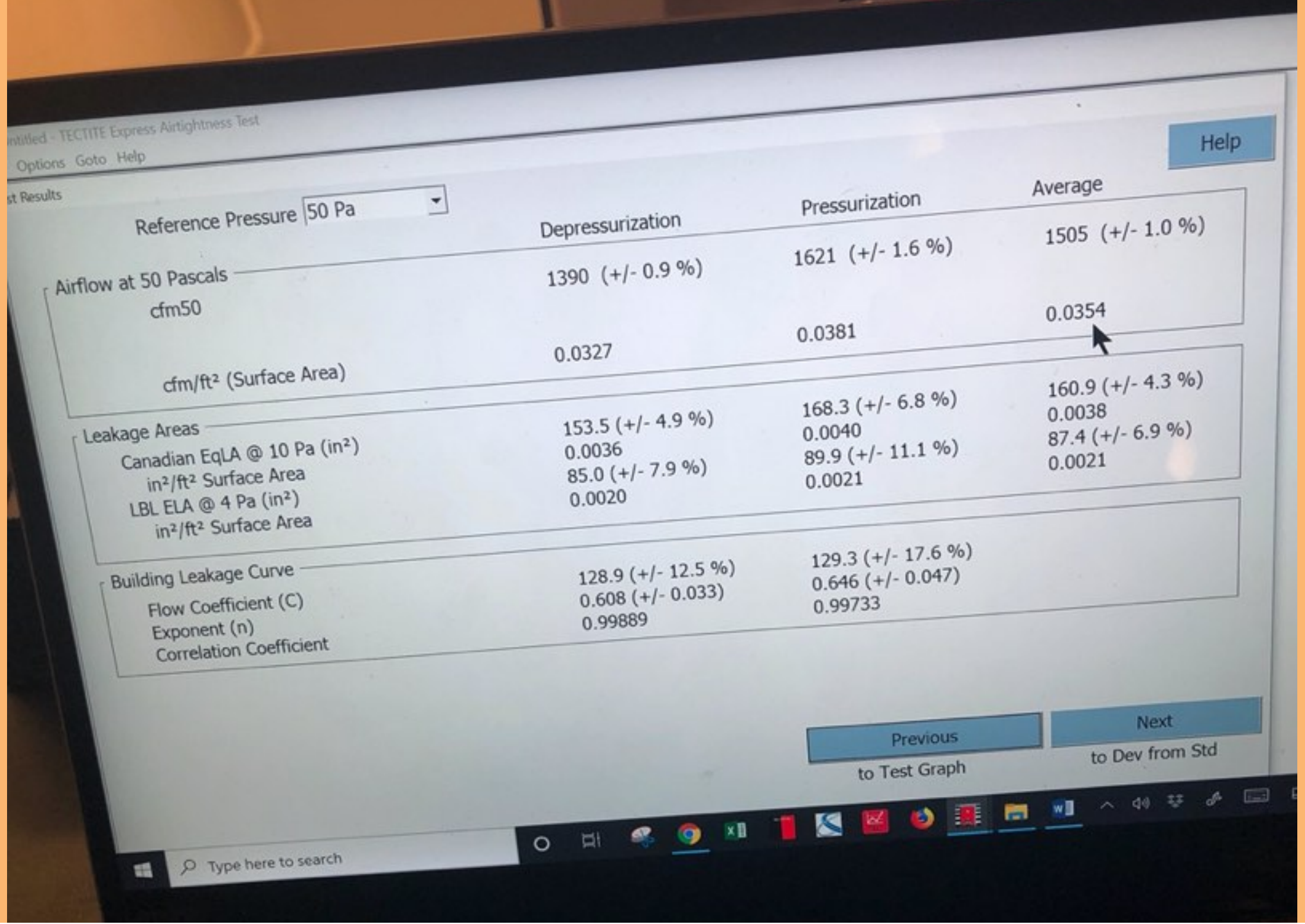
72.0
64.7
Joist Bearing
FLIR
Image Provided By Advanced Building Analysis


FLIR1110.jpg
11/9/2019 1:21:42 PM
67.4
Shear Wall
Connection
60.0
FLIR
Image Provided By Advanced Building Analysis

BLOWER DOOR TEST


ETEC
Network Configuration
MODE
Off
Ethernet
USB
A
B
Minneapolis Blower Door Model 3
ETEC
Control
The Energy Conservatory
Made in Minneapolis, MN USA
100–130 V
50/60 Hz
13 A Max
0–Max V


ntitled - TECTITE Express Airtightness Test
Options Goto Help
st Results
Help
Reference Pressure 50 Pa
Depressurization
Pressurization
Average
Airflow at 50 Pascals
cfm50
1390 (+/- 0.9 %)
1621 (+/- 1.6 %)
1505 (+/- 1.0 %)
cfm/ft² (Surface Area)
0.0327
0.0381
0.0354
Leakage Areas
Canadian EqLA @ 10 Pa (in²)
153.5 (+/- 4.9 %)
168.3 (+/- 6.8 %)
160.9 (+/- 4.3 %)
in²/ft² Surface Area
0.0036
0.0040
0.0038
LBL ELA @ 4 Pa (in²)
85.0 (+/- 7.9 %)
89.9 (+/- 11.1 %)
87.4 (+/- 6.9 %)
in²/ft² Surface Area
0.0020
0.0021
0.0021
Building Leakage Curve
Flow Coefficient (C)
128.9 (+/- 12.5 %)
129.3 (+/- 17.6 %)
Exponent (n)
0.608 (+/- 0.033)
0.646 (+/- 0.047)
Correlation Coefficient
0.99889
0.99733
Previous
to Test Graph
Next
to Dev from Std
Type here to search


FIRE
CAUTION

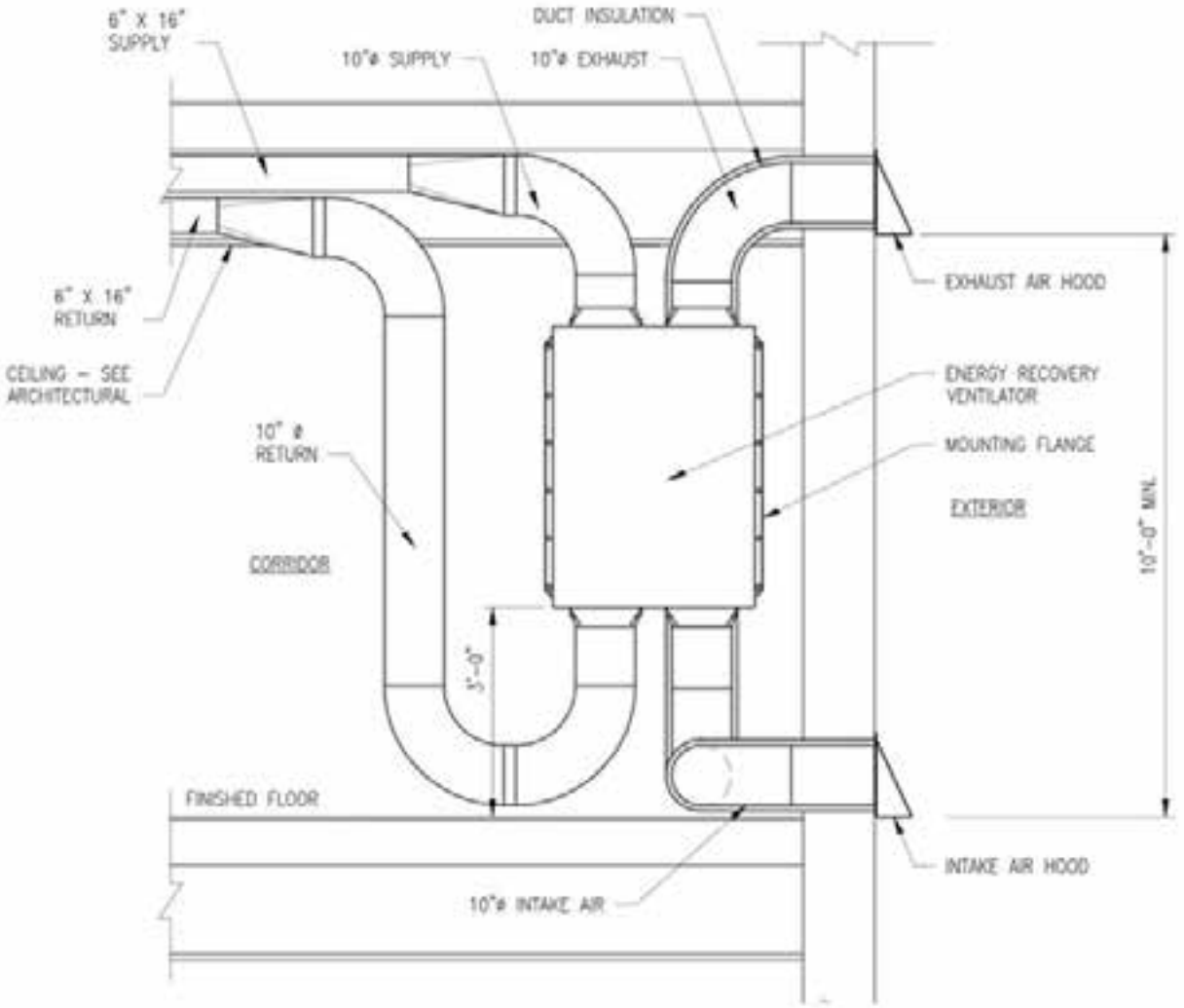
Trouble-Shooting

- Screws & Plugs For Exterior PVC Trim
- Air Barrier Connection Tapes
- Vapor Control Layer Termination
- Multiple Sheathing Layers & Over-Nailing

Things To Consider For Passive House

- “Air-Tight” Windows – Not Really New But Not Always A Quick Sell – Does It Meet All The Needs
- Heat Pump Clothes Dryers – Are They The Right Option For The Project
- Generators – What Needs Backup?
- “Air-Tight” & ADA Compliant Exterior Doors – Not Readily Available In Commercial Construction
- 3/8” PEX Domestic Water Piping – It’s Out There, Use It – Caution! No Fittings
- Air-Tight Electrical Boxes – Variety Works

Images Provided By Kaplan-Thompson Architects



4 / M500 UPPER FLOOR ERV MOUNTING DETAIL

SCALE: 1/2" = 1'-0"

NOTES:

1. DETAIL REFLECTS SECOND AND FOURTH FLOOR CONDITIONS. DUCTWORK AND ERV MOUNTING IS REVERSED ON THIRD FLOOR.
2. PROVIDE MANUFACTURER'S RECOMMENDED MAINTENANCE CLEARANCE.

Mastic Duct-Sealing – 1 Option For Duct Tightness

Central Boiler Plant – 1 Option For Domestic Hot Water

Images Provided By Kaplan-Thompson Architects

Conclusion

- Cost is manageable.
- Details need to be constructable
- Schedule impact is minimal.
- Education is key.
- Better buildings are very achievable.

Acknowledgements

QUESTIONS?

This concludes The American Institute of Architects Continuing Education Systems Course

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