



Retrofit with People in Place: Multi-Family High-Rise Affordable Case Study



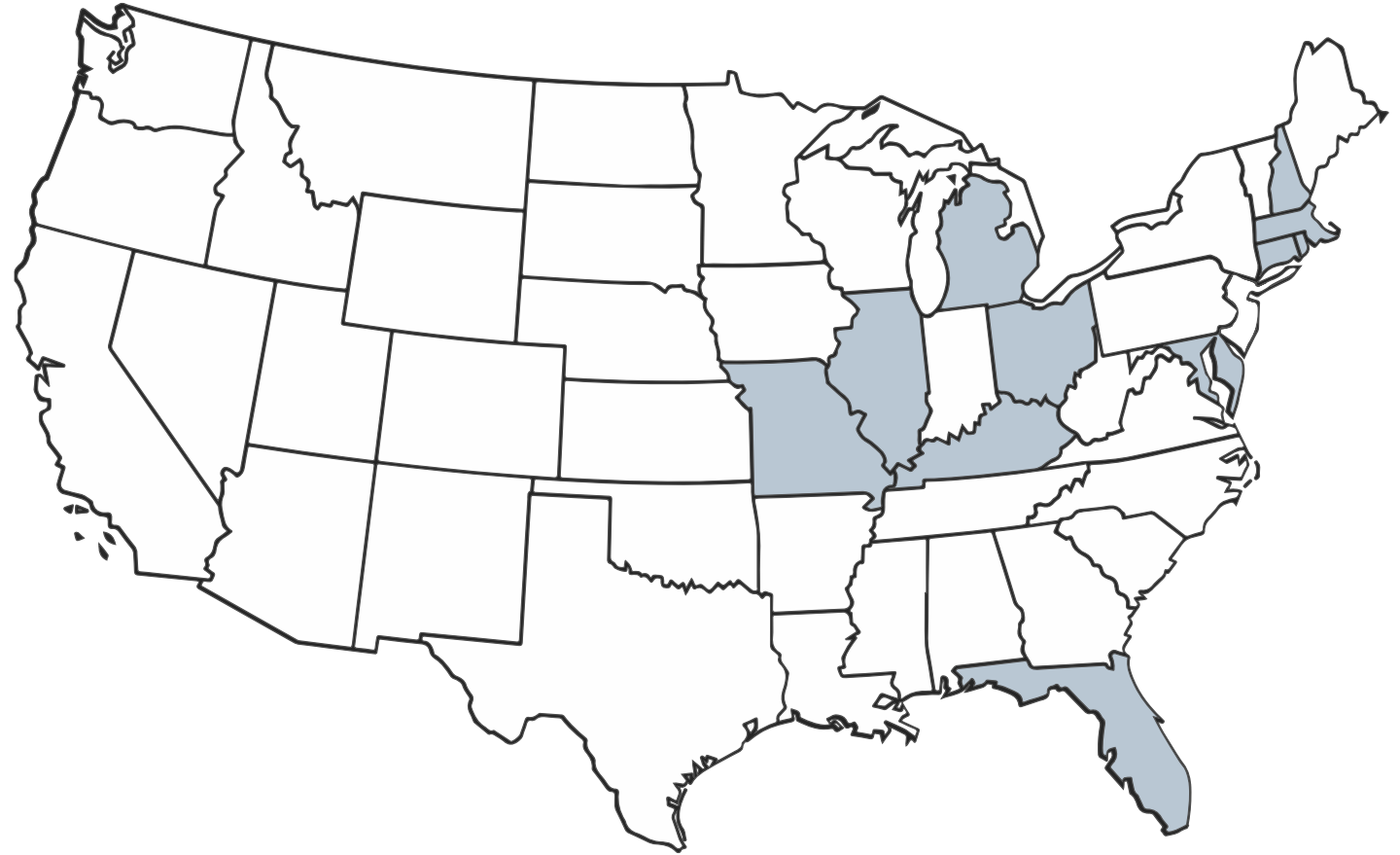
Preservation of
Affordable Housing

BUILDING EVOLUTION CORPORATION
Achieve Performance & Durability Through A Holistic Approach™

POAH's Properties

Affordable Multifamily Housing

Connecticut	257 units
Washington, D.C.	94 units
Florida	1,356 units
Illinois (1D)	2,155 units
Kentucky	41 units
Massachusetts	3,426 units
Maryland	100 units
Michigan	645 units
Missouri	1,538 units
New Hampshire	264 units
Ohio	1,104 units
Rhode Island	1,007 units
TOTAL	11,987 units



CORPORATE OFFICES: BOSTON | CHICAGO | KANSAS CITY | WASHINGTON, D.C.



Salem Heights, 281 Units Family, Salem, MA
Built: 1974

History and Facts:

POAH Purchased the Property in 2003

Family Community

Proceeds in 2003 were used to purchase site so
minimal upgrades were made at that time

90% Units leased at 60% AMI or Lower
(until June 2057)

Project and Tenant Based Vouchers

POAH Pays all Utilities

New Boiler and DHW Paid for by Utility Incentive

How did we pay for this:

Construction Loan

Seller Note

Federal LIHTC

CIPF

Deferred Developer Fee

Construction Period Income from Operations

Energy Incentives

= \$45,000,000 construction cost

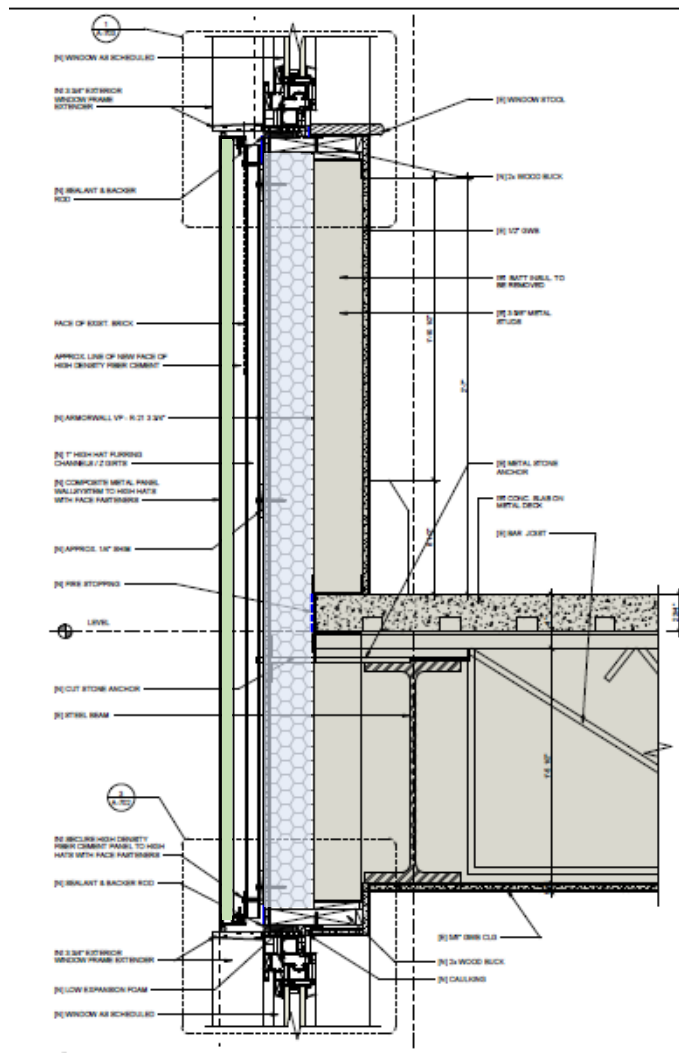


One One Bedroom and One Two Bedroom Hotel Suites on Each Floor



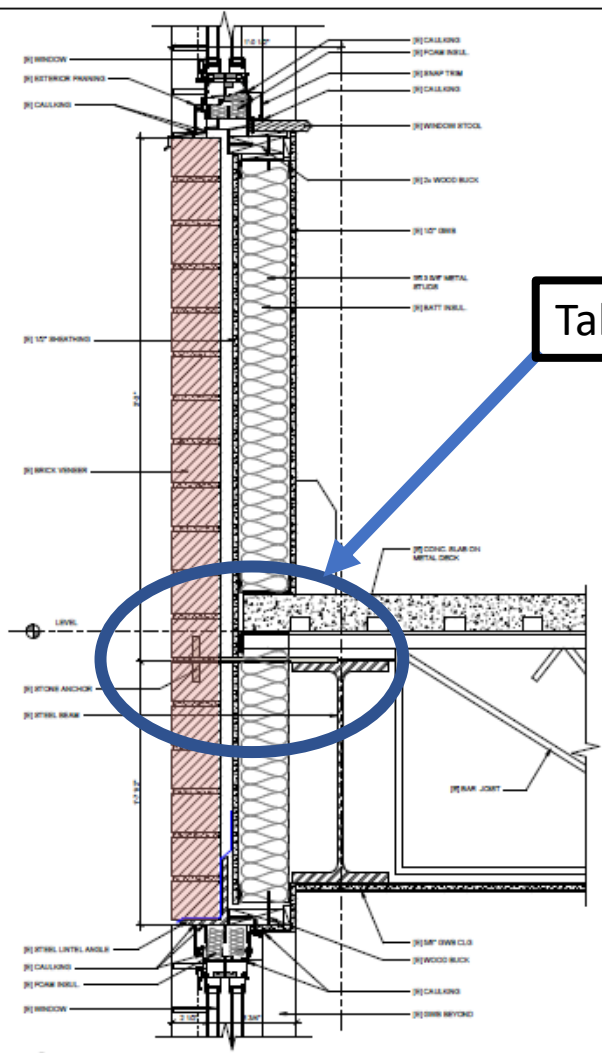


Existing Conditions: Masonry



4 PROPOSED WINDOW HEAD/SILL AT ACM
3/4" = 1'-0"

New Metal Panel Cladding
(with Armorwall)



2 EXISTING WINDOW HEAD/SILL DETAIL
3/4" = 1'-0"

Existing Brick Cladding

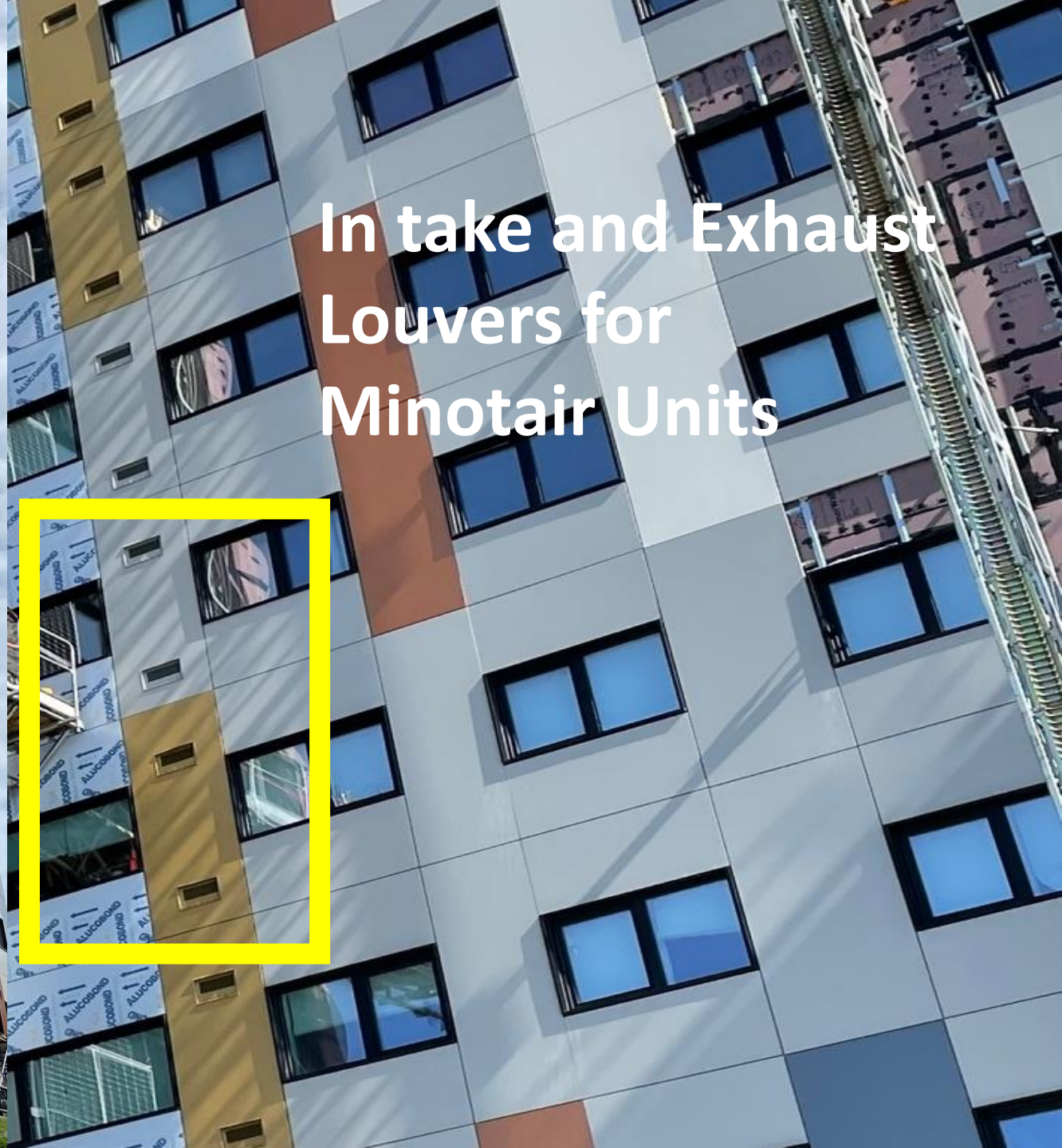
Tab and Pin

Exterior Wall Details



**Existing Windows:
Changed height to
match all others**

Armorwall Install

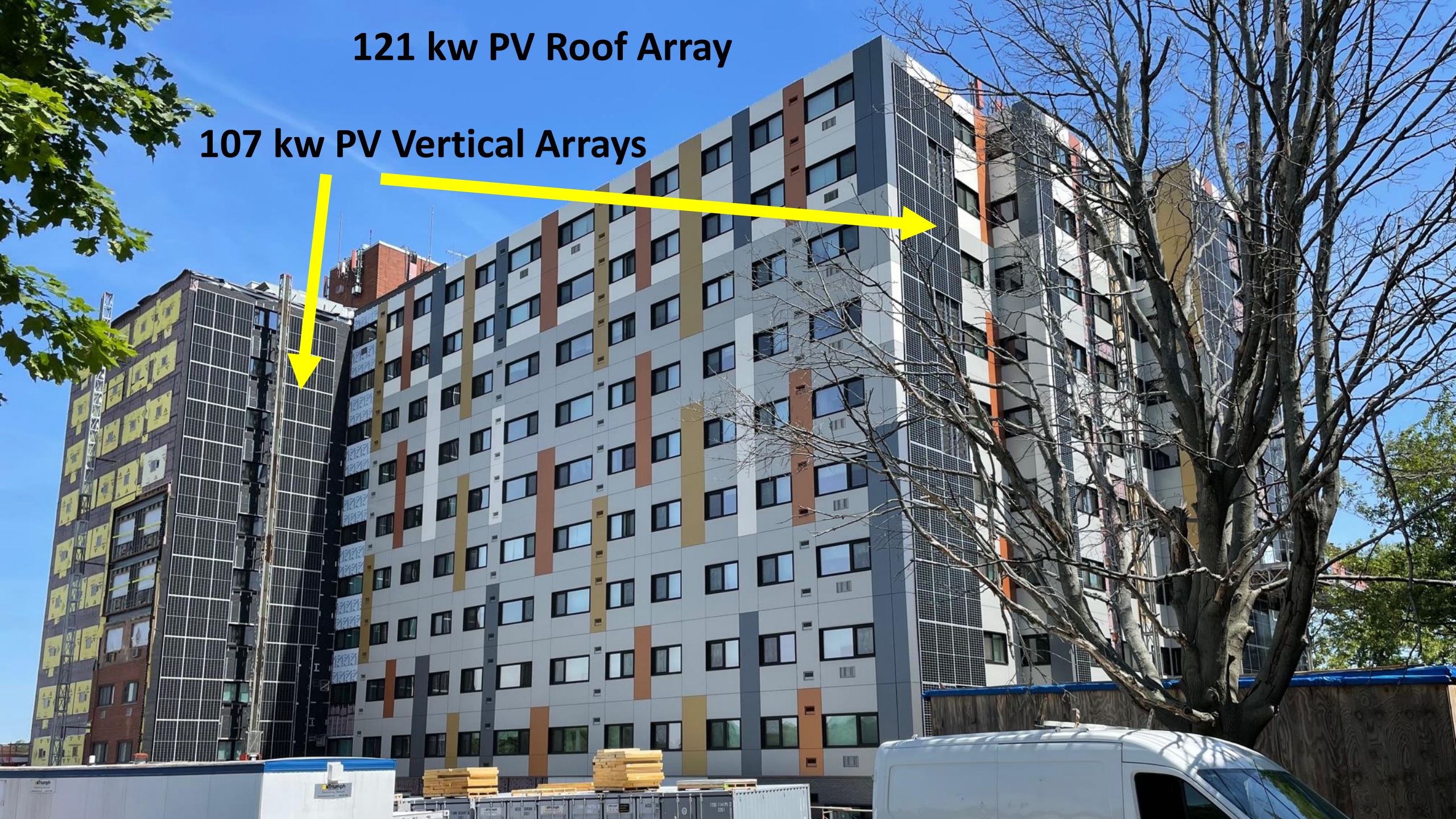


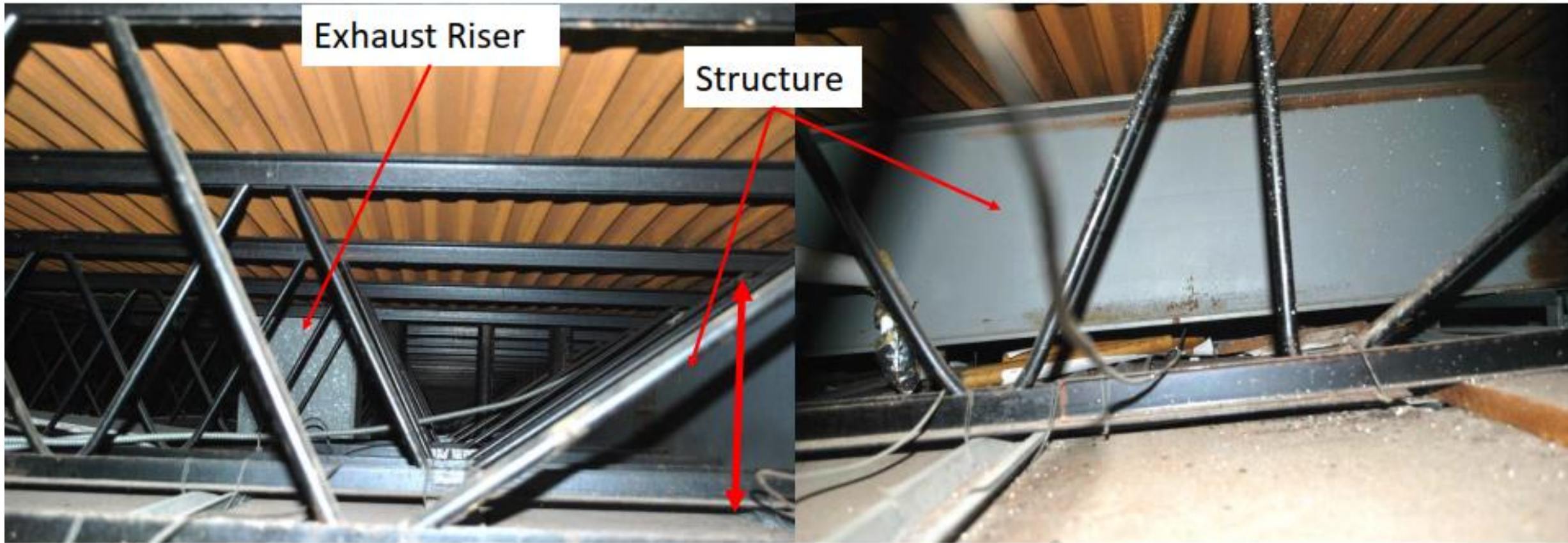
In take and Exhaust Louvers for Minotair Units



121 kw PV Roof Array

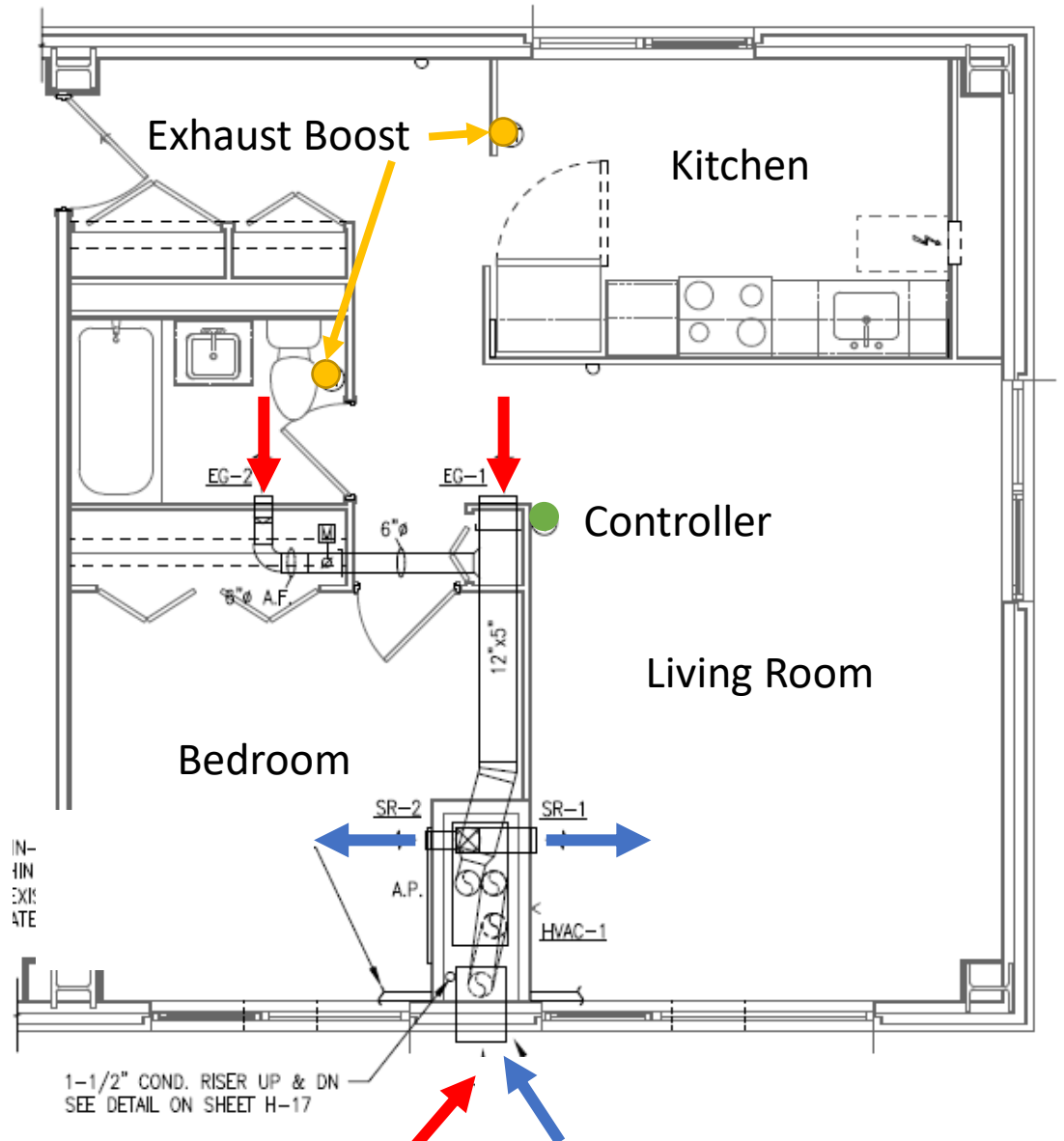
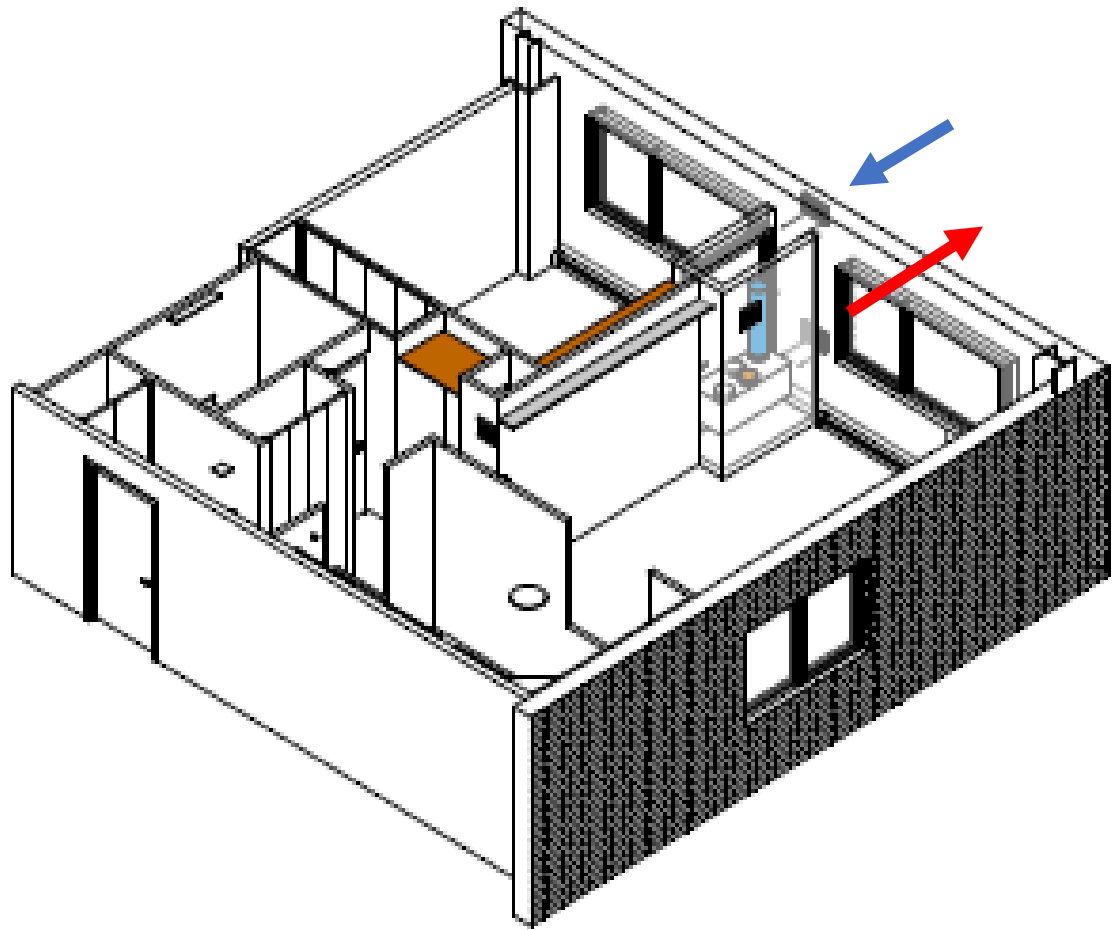
107 kw PV Vertical Arrays





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HVAC Considerations



18 x 12" Exhaust Louver Below Alternating each floor

18 x 12" Intake Louver Above Alternating each floor



Zone Valve Installed on Existing Baseboard and Connected to Minotair



Minotair Install

Passive House?



Why Not Passive House?

➤ Exterior Wall: R28

- R21 continuous Armorwall panel
- Existing fiberglass batt (~R-11) between 3 5/8" metal studs

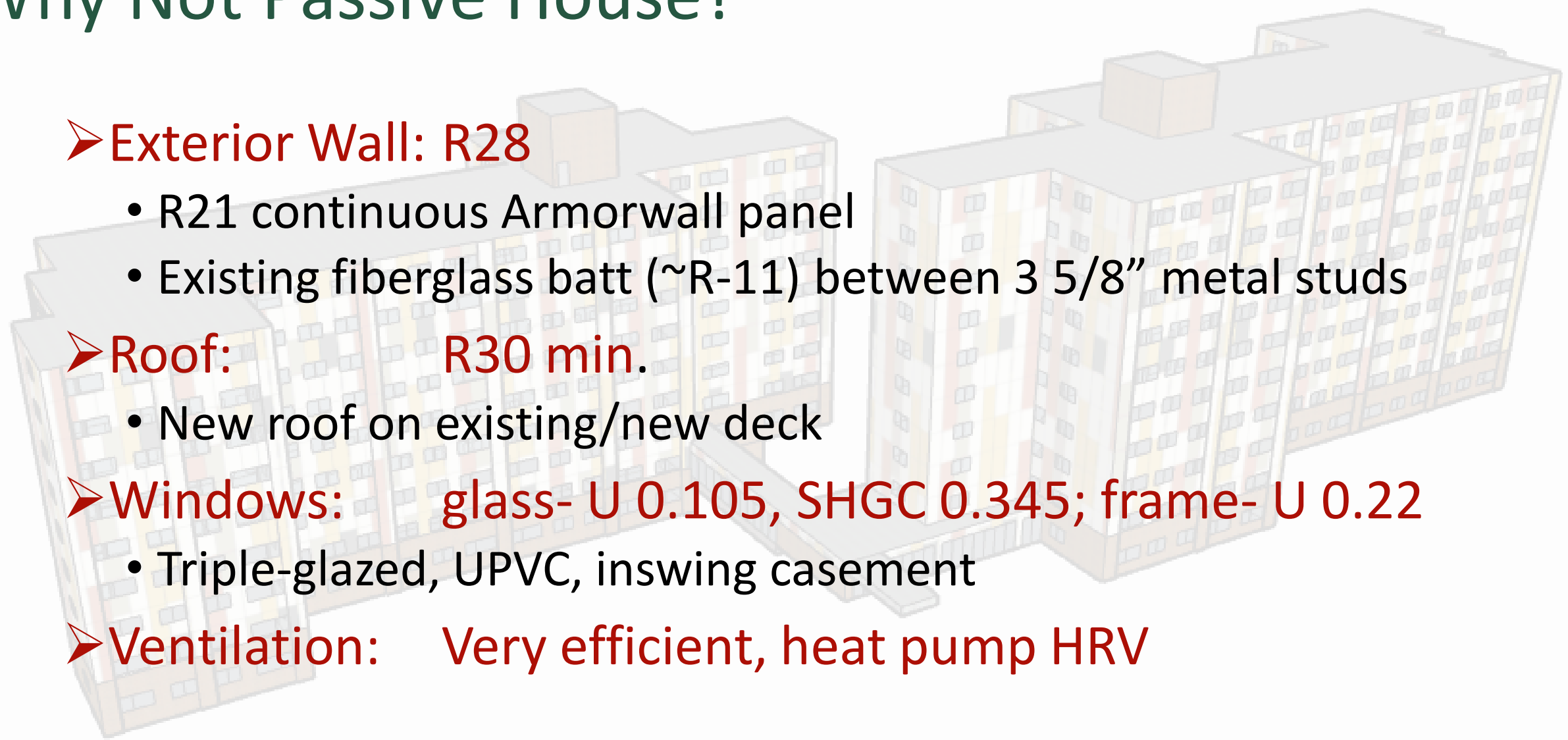
➤ Roof: R30 min.

- New roof on existing/new deck

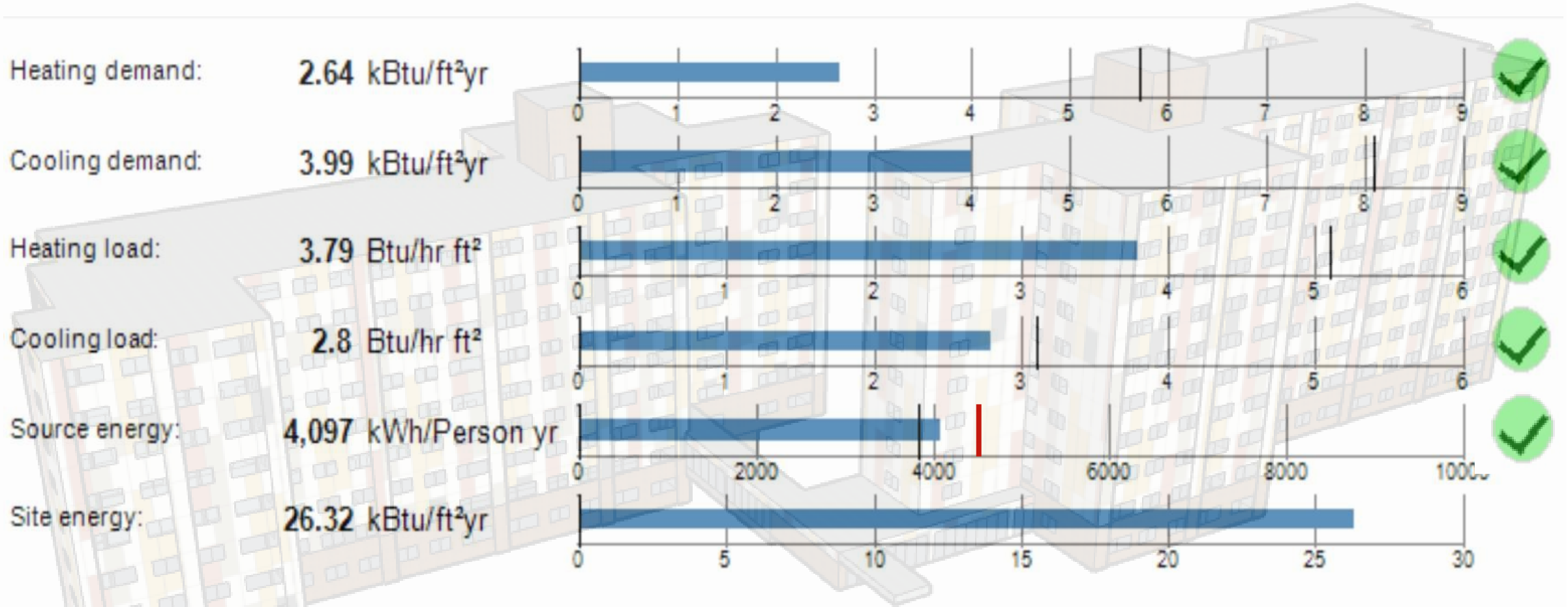
➤ Windows: glass- U 0.105, SHGC 0.345; frame- U 0.22

- Triple-glazed, UPVC, inswing casement

➤ Ventilation: Very efficient, heat pump HRV



Salem Heights – PH Performance Criteria



➤ Envelope airtightness at 50 Pa: 0.06 cfm/sf*

WUFI Energy Modeling Results

Passive House, Retrofits, and Possible Concerns

- Performance standards 
- Prescriptive standards 
 - PHIUS requirements
 - Co-requisites
 - Energy Star Multifamily New Construction
 - DOE Zero Energy Ready Home
 - EPA Indoor airPLUS



Evaluation of Prescriptive Requirements

- We evaluated 342 prescriptive checklist items
- These checklists come from
 - EPA Energy Star Multifamily New Construction program,
 - DOE Zero Energy Ready Home (ZERH) program,
 - EPA Indoor airPLUS program.
- ...plus PHIUS prescriptive requirements

Evaluation of Prescriptive Requirements

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Search...

File Automation Forms

Energy Star MF New Construction Checklist ☆ Share

Grid View Filter Off Arial 10 B I U

Checklist	Checklist Number Designation	Filter	Verification Item (insert copied cells here)	Applicability to Retrofit	Applicability to Salem	Explanation - Salem	
			required for projects in California)				
5	ES MFNC Rater Design Checklist	2	ALL	2. High-Performance Fenestration			
6	ES MFNC Rater Design Checklist	2.1	ALL	2.1 Dwelling units:			
7	ES MFNC Rater Design Checklist	2.1.1	PRESCRIPTIVE	2.1.1 Prescriptive Path: Specified fenestration meets or exceeds ENERGY STAR MF Reference Design requirements. ^5	Applicable, no problem	Applicable, no problem	
8	ES MFNC Rater Design Checklist	2.1.2	ERI, ASHRAE	2.1.2 ERI Path and ASHRAE Path: Specified fenestration meets or exceeds 2009 IECC residential requirements. ^5	Applicable, no problem	Applicable, no problem	
9	ES MFNC Rater Design Checklist	2.2	ALL	2.2 Common space: ^2			
10	ES MFNC Rater Design Checklist	2.2.1	ERI, PRESCRIPTIVE	2.2.1 ERI Path and Prescriptive Path: Specified fenestration meets or exceeds ENERGY STAR MF Reference Design requirements. ^5	Applicable but with challenges	Applicable but with challenges	
11	ES MFNC Rater Design Checklist	2.2.2	ASHRAE	2.2.2 ASHRAE Path: Specified fenestration meets or exceeds 2009 IECC commercial requirements. ^5	Applicable but with challenges	Applicable but with challenges	
12	ES MFNC Rater Design Checklist	3	ALL	3. High-Performance Insulation			
13	ES MFNC Rater Design Checklist	3.1	ALL	3.1 Dwelling unit:			
14	ES MFNC Rater Design Checklist	3.1.1	PRESCRIPTIVE	3.1.1: Prescriptive Path: Specified ceiling ^6, wall ^7, and slab-on-grade insulation levels meet or exceed ENERGY STAR MF Reference Design requirements. ^8, ^9, ^10	Not applicable/Not appropriate to retrofit	Applicable but with challenges	The original foundation (changes) is R-0.3 with no insulation with R-10 for 24" below. The proposed floor s when it needs to be a minimum R-1 minimum of 2 feet in: The proposed roof is minimum R-47.6 (for The proposed floor s when it needs to be a minimum R-1 minimum of 2 feet in: The proposed walls when it needs to be a minimum R-15
15	ES MFNC Rater Design Checklist	3.1.2	ERI, ASHRAE	3.1.2: ERI Path and ASHRAE Path: Specified ceiling ^6, wall ^7, floor, and slab-on-grade insulation levels meet or exceed values from the "Group R" column in the 2009 IECC Commercial chapter. ^8, ^9, ^10	Applicable but with challenges	Applicable but with challenges	The original foundation with no insulation with R-10 for 24" below. The proposed floor s when it needs to be a

Prescriptive Requirements

Evaluation of Prescriptive Requirements

- We found that:

- 184 checklist items will be readily met by this project
- 43 checklist items may be a challenge for retrofit projects
- 102 checklist items may be possible for this project but need clarification
- 2 checklist items can not be field-verified
- 9 checklist items are not applicable to retrofit projects

Checklist	Checklist Number Variation	Verification Item	Applicability to Retrofit	Special Circumstances for Salem	Explanation
Heating & Cooling Loads					
ES National HVAC Design Report	3.1	Loads calculated using <input type="checkbox"/> Unabridged ACCA Manual J v8 <input type="checkbox"/> 2013/2017 ASHRAE Fundamentals <input type="checkbox"/> Other per AHJ	Possibly / Need clarification		
ES National HVAC Design Report	3.2	Check one box only to indicate whether the Dwelling Unit Loads is unit-specific or represents the design of more than one unit: <input type="checkbox"/> Unit-specific design <input type="checkbox"/> Group design <input type="checkbox"/> Worst case design	Applicable, no problem	Unit-type specific for Salem Heights. Ventilation rates are consistent but duct design may vary depending on unit type.	
ES National HVAC Design Report	3.3	Indoor design temperatures used in loads are 70F for heating and 75F for cooling.	Applicable, no problem		
ES National HVAC Design Report	3.4	Outdoor design temperatures used in loads (see Footnote 24 and www.energystar.gov/hvacdesigntemps)	Applicable, no problem		
ES National HVAC Design Report	3.5-3.18	Listing the unit plan for which loads were calculated	Possibly / Need clarification	Do we have this information for Salem Heights?	

Prescriptive Challenges for Salem Heights

1. Airtightness
2. Salem Heights-specific issues
3. General retrofit issues

Airtightness: Exterior Wall



Airtightness: Exterior Wall



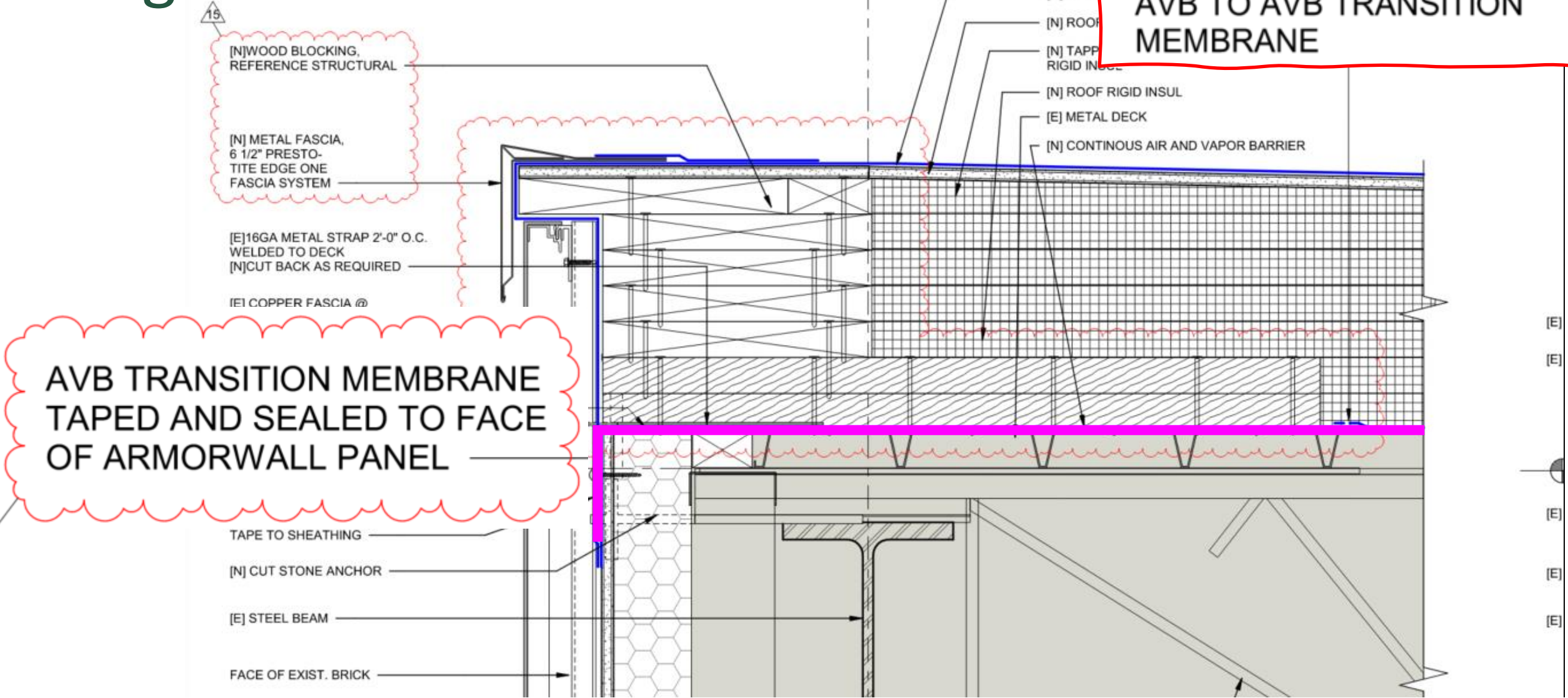
Prescriptive Challenge - Airtightness

Airtightness: Roof-to-Wall



Prescriptive Challenge - Airtightness

Airtightness: Roof-to-Wall



Prescriptive Challenge - Airtightness

Airtightness: Wall-to-Foundation



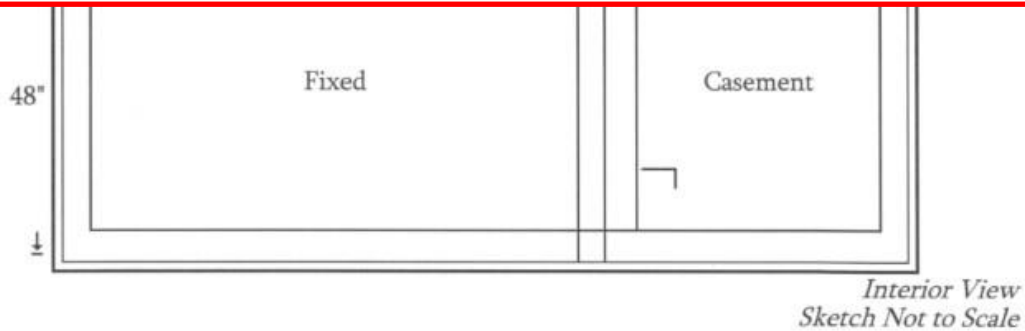
Prescriptive Challenge - Airtightness

Airtightness: Windows

III. TEST RESULTS, continued



Calculated Air Infiltration	0.01 cfm per square foot
Allowable Air Infiltration	0.02 cfm per square foot



- AIR INFILTRATION @ 1.57 PSF — TIME: 2:30 PM
Weather: 48°F; cloudy Wind: 9 mph north-northeast
Measured Air Leakage (Reading 1) 4.00 cfm
Measured Air Leakage (Reading 2) 4.25 cfm
Calculated Air Infiltration 0.01 cfm per square foot
Allowable Air Infiltration 0.02 cfm per square foot
See Photographs 1 and 2.



Airtightness: What Else?

0.06 cfm50/sf X lots of surface area = lots of cfm50

➤ Minotair louvers

- A lot of louvers!
- Exterior wall louver box, ducts, damper

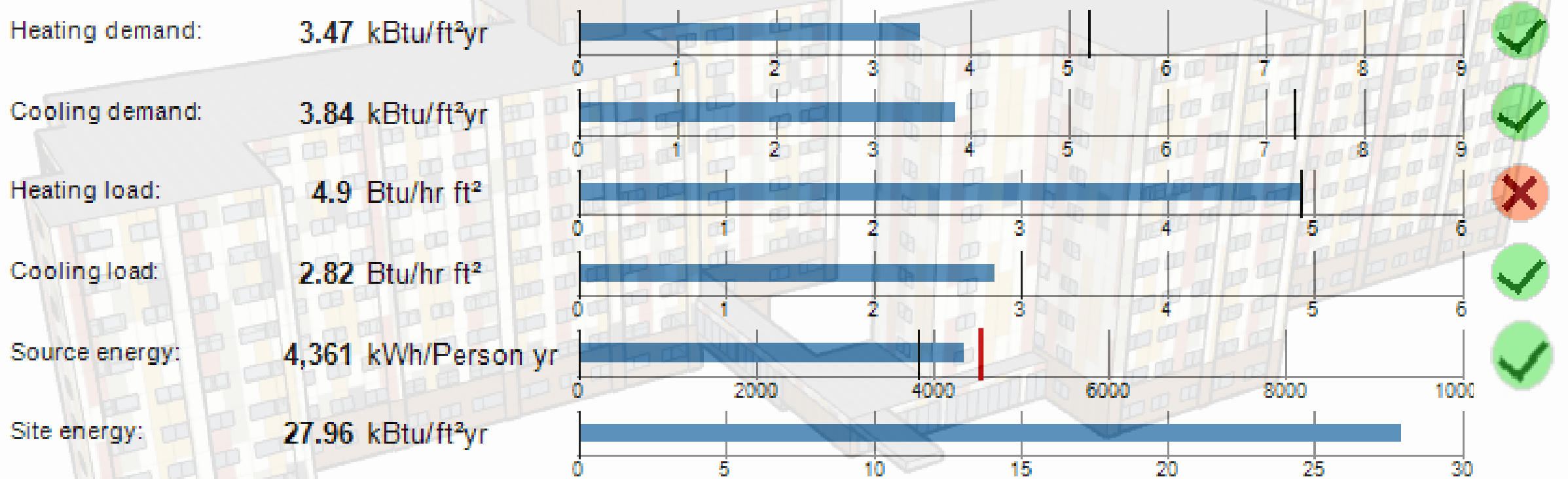
➤ Trash compactor rooms and chutes

Limited interior scope:

-  • Trash compactor room inside boundary

Airtightness: Performance vs. Prescriptive

➤ Envelope airtightness at 50 Pa: 0.23 cfm/sf (starts to fail)



Salem Heights Prescriptive Challenge: Garage Ceiling

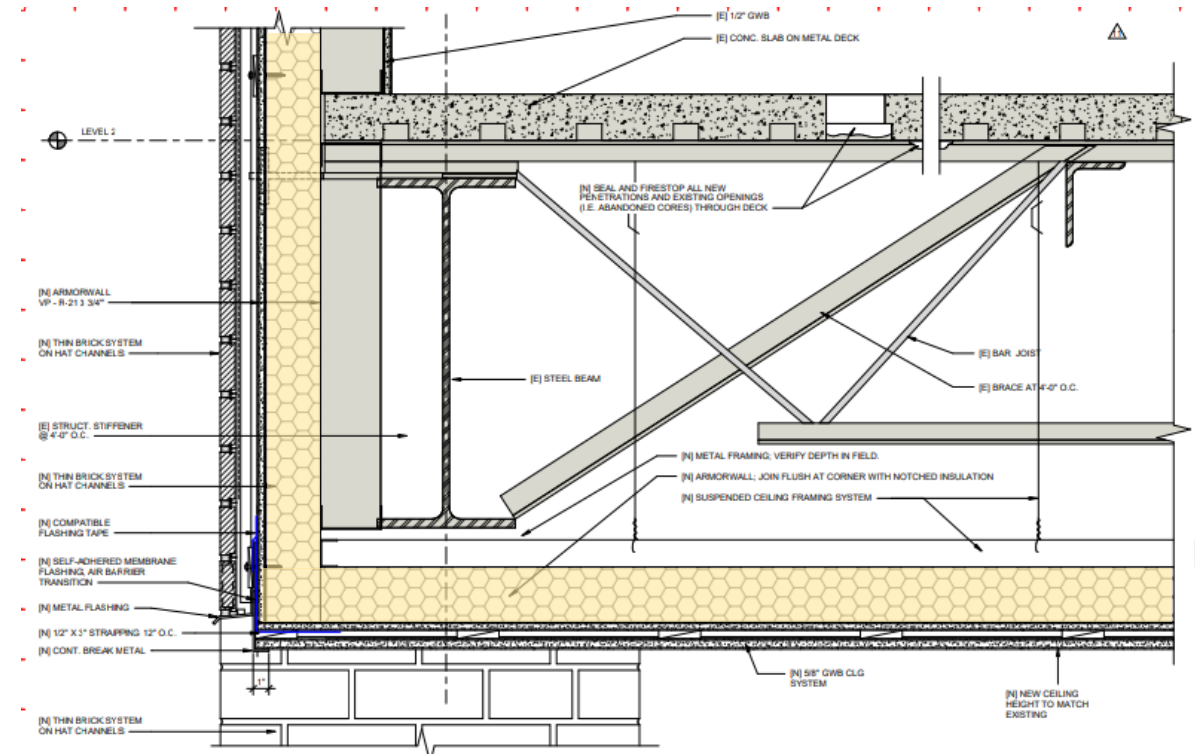
- R24.7 garage ceiling modeled:
 - R21 continuous 3 ¾" Armorwall



Good enough for WUFI



Good enough for Energy Star



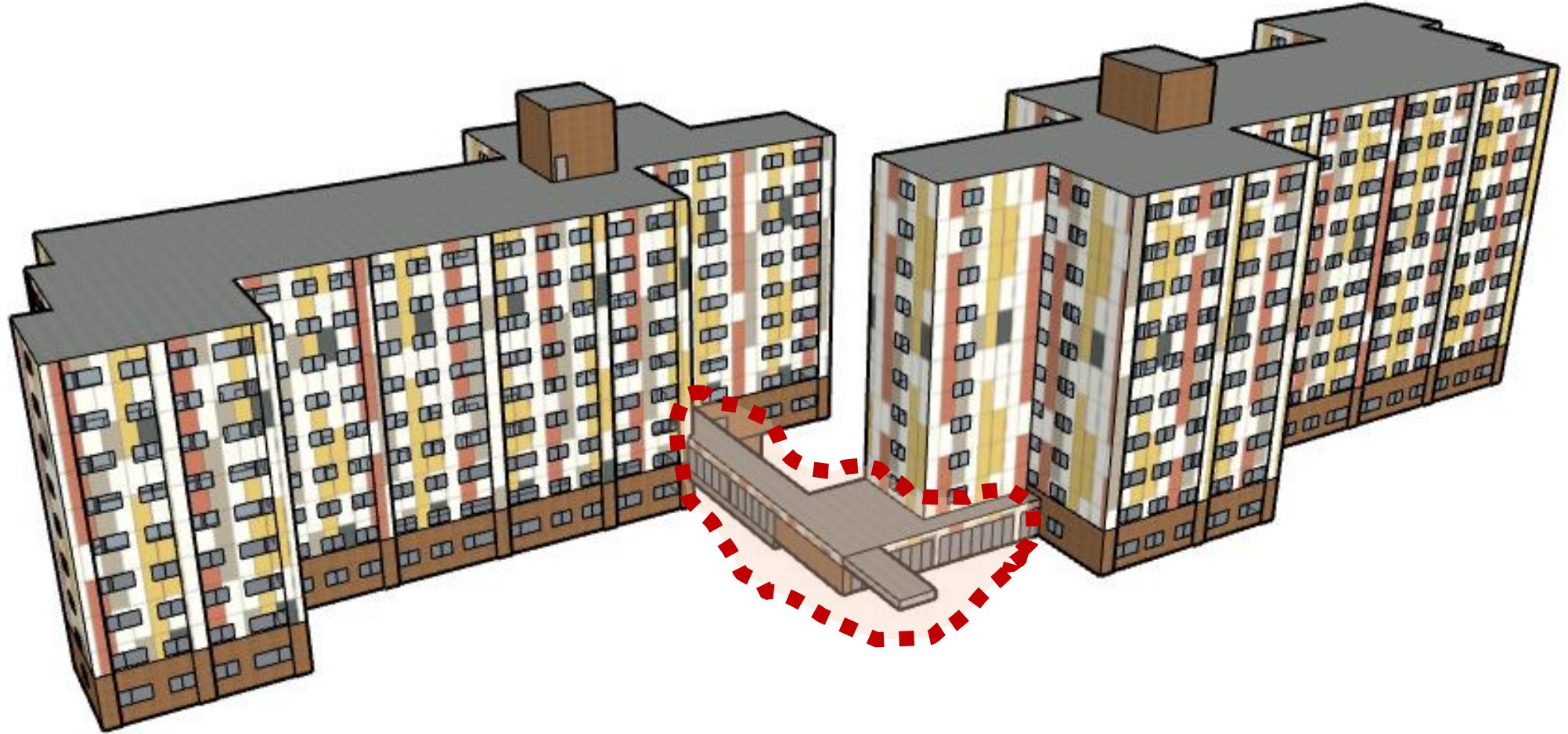
Salem Heights Prescriptive Challenge: Slab Edge

✓ We have a detail!

☹️ But, we haven't used it
Will be applied where
excavation needed



Salem Heights Prescriptive Challenge: Connector



Salem Heights Prescriptive Challenge: Connector

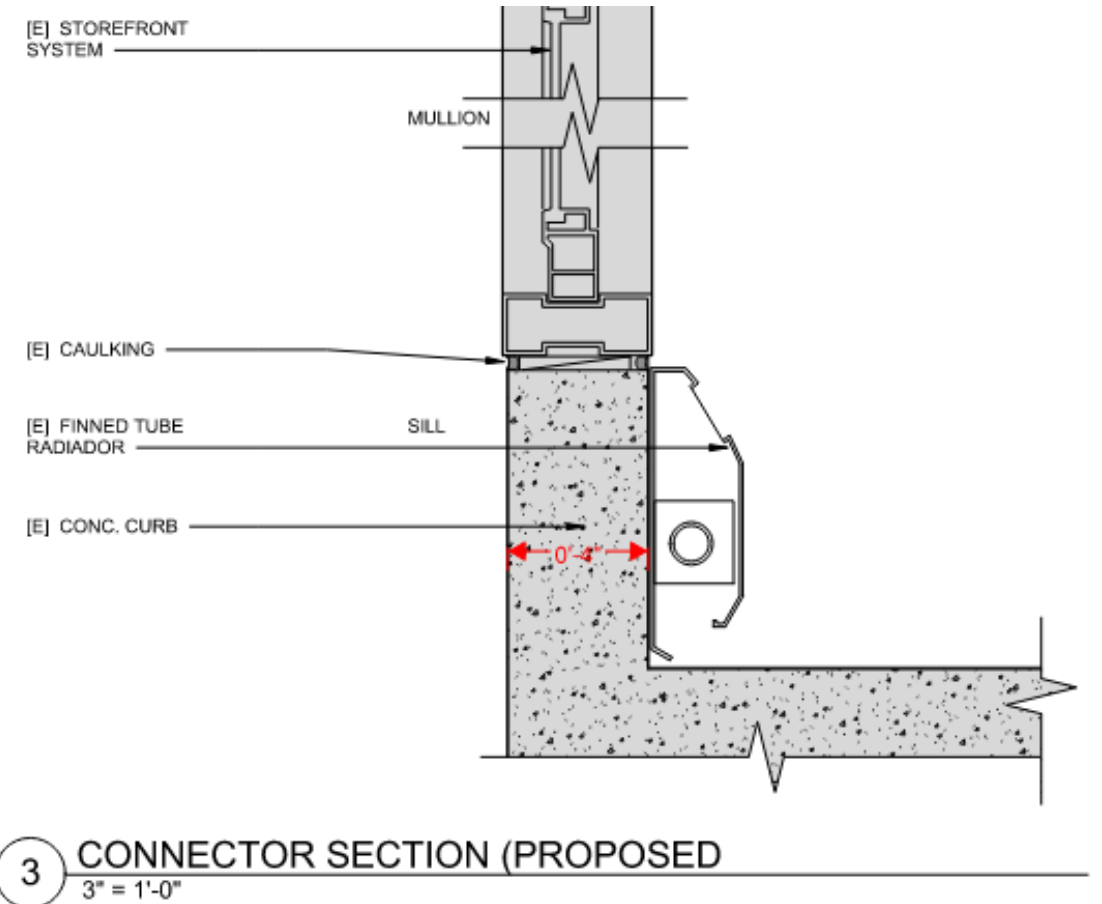


Salem Heights Prescriptive Challenge: Connector

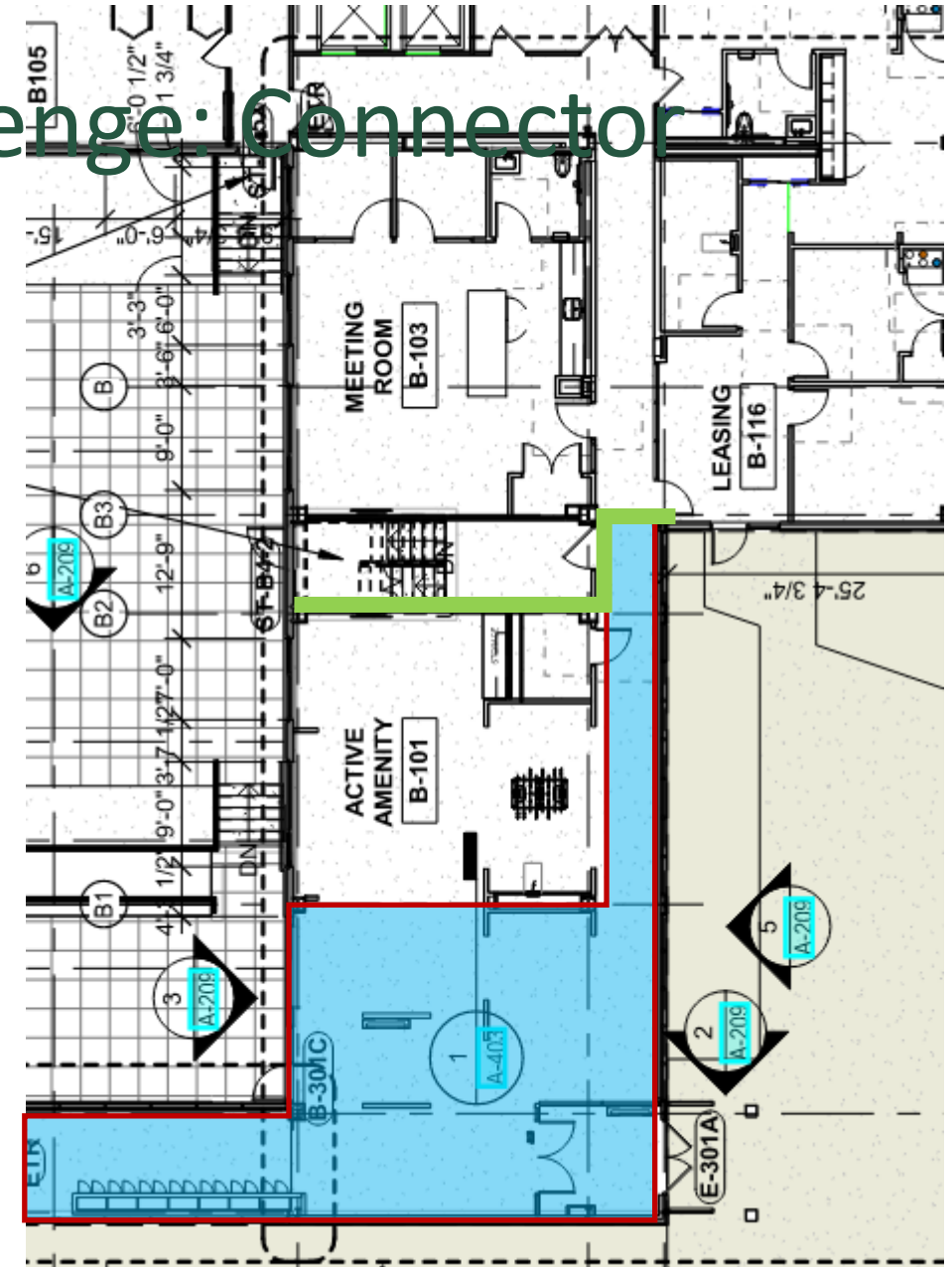
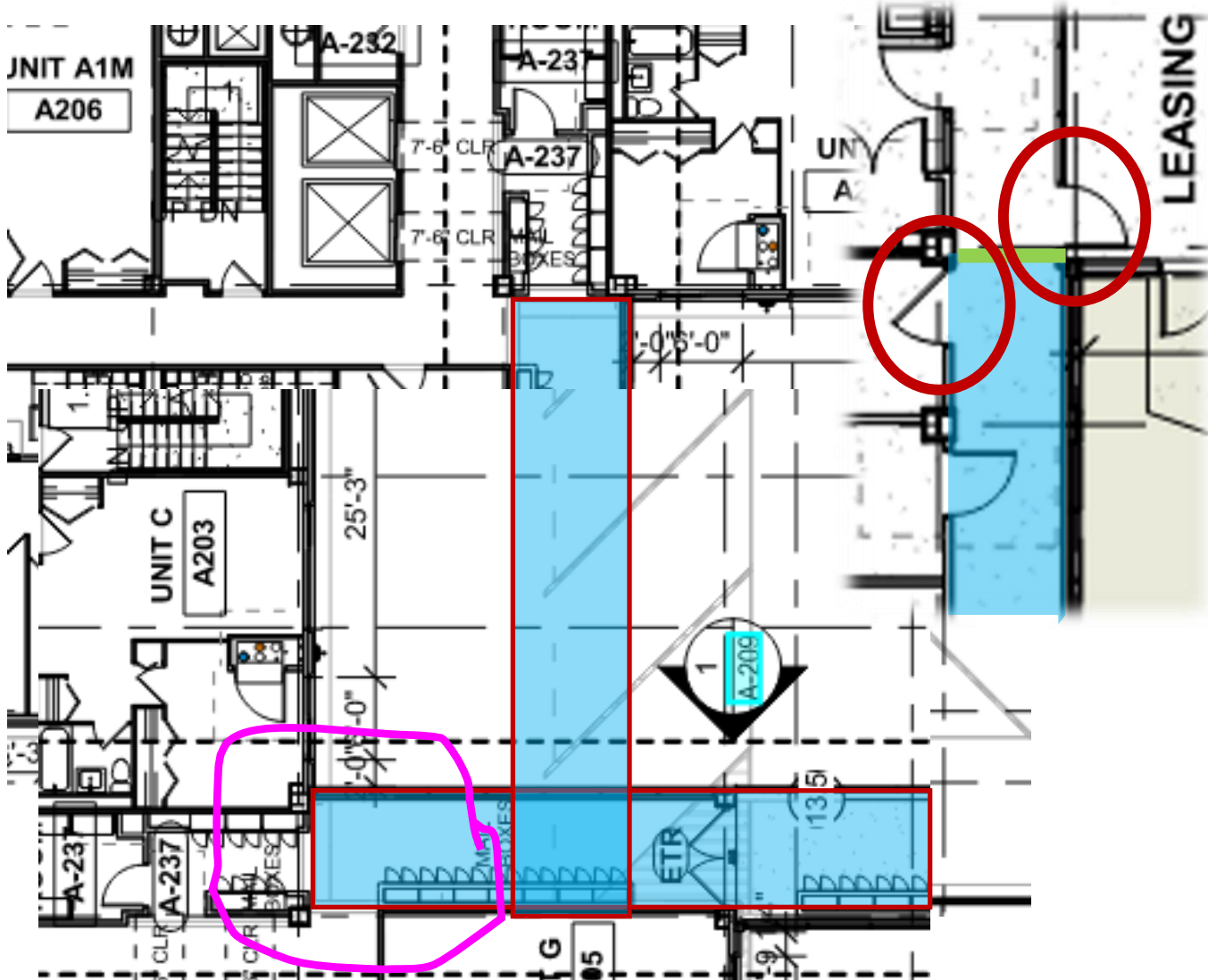


Salem Heights Prescriptive Challenge: Connector

- ☹️ ➤ Existing-to-remain storefronts
- ☹️ ➤ Uninsulated concrete at base of wall and floor



Salem Heights Prescriptive Challenge: Connector



Prescriptive Challenges: Project-Specific

Salem Heights Prescriptive Challenge: Connector

➤ It's too late for separating the non-compliant connector



➤ Why would we do this?

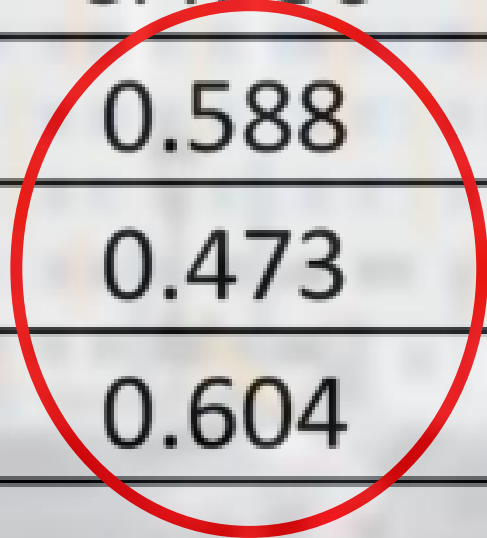
Typical Retrofit Prescriptive Challenge: Compartmentalization

- Energy Star requirement: 0.3 cfm 50 / sf enclosure
- Why else?
 - Ventilation and compartmentalization as minimum sanitary requirements for multi-unit housing

Salem Heights Compartmentalization

Pre-Construction testing results:

Unit ID	Flow (CFM)	CFM50
701	1,462	0.588
801	1,176	0.473
901	1,502	0.604



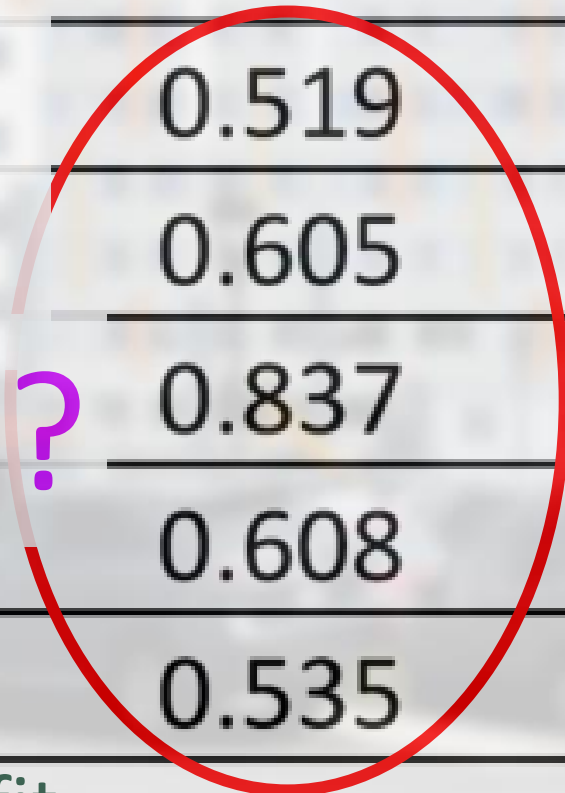
Salem Heights Compartmentalization

Post-Construction testing results:

Unit ID	Flow (CFM)	CFM50
212	1,477	0.519
902	1,755	0.605
904	2,033	0.837
1002	1,765	0.608
1004	1,300	0.535

WDTF?!

Where Did This Fail?



Salem Heights Compartmentalization

- Get some happy blower door operators
- Get some painter's tape
- Get after it



Salem Heights Compartmentalization

➤ Electrical Penetrations



Prescriptive Challenge: Typical Retrofit

Salem Heights Compartmentalization

➤ Plumbing Penetrations



Prescriptive Challenge: Typical Retrofit

Salem Heights Compartmentalization

➤ Plumbing Penetrations



Salem Heights Compartmentalization

➤ Plumbing Penetrations



Prescriptive Challenge: Typical Retrofit

Salem Heights Compartmentalization

➤ Plumbing Penetrations



Prescriptive Challenge: Typical Retrofit

Salem Heights Compartmentalization

➤ Register Boots



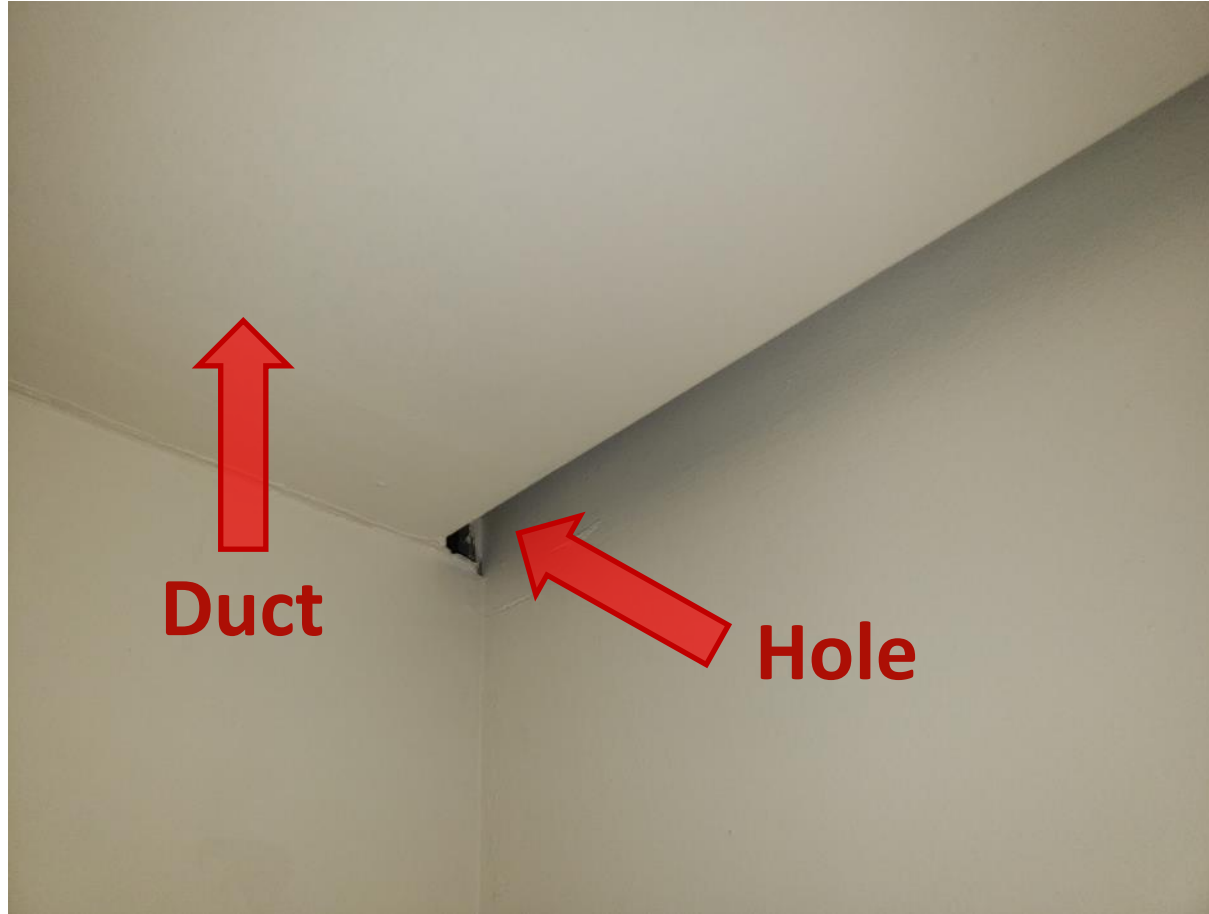
Salem Heights Compartmentalization

➤ Register Boots



Salem Heights Compartmentalization

➤ Duct Penetrations



Salem Heights Compartmentalization

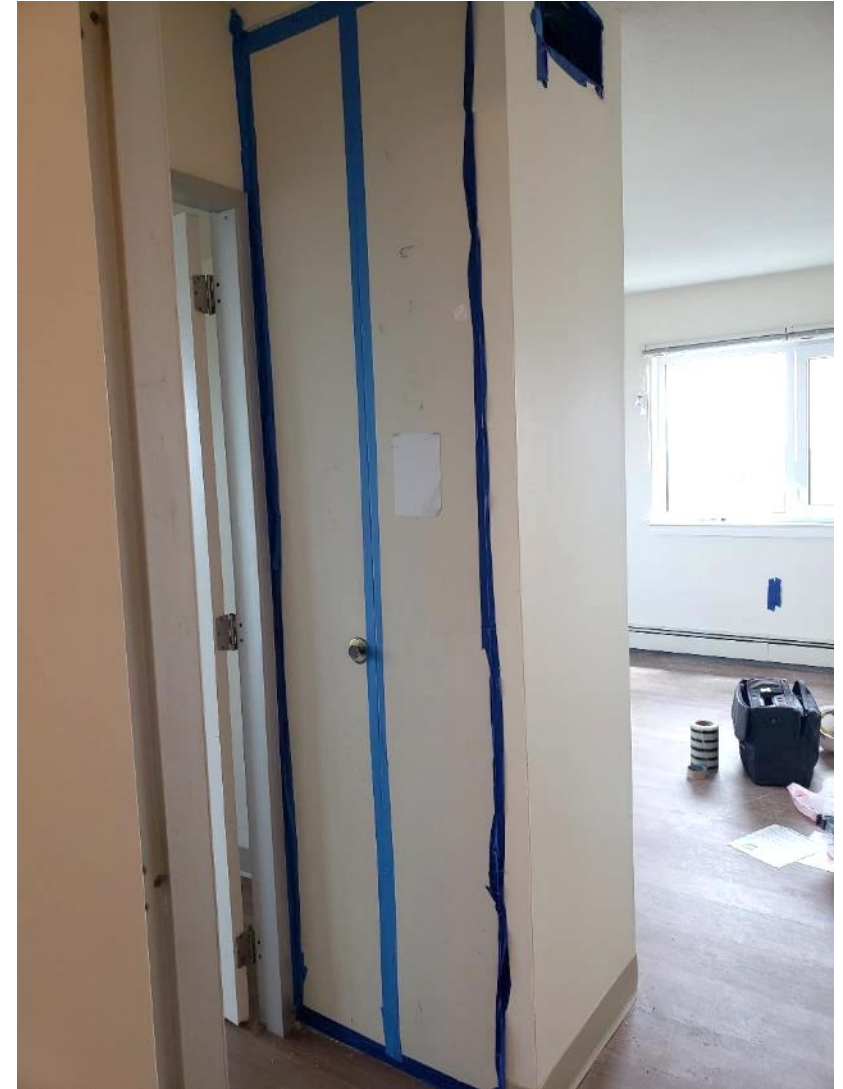
➤ Duct Penetrations



Prescriptive Challenge: Typical Retrofit

Salem Heights Compartmentalization

➤ Duct Penetrations



Prescriptive Challenge: Typical Retrofit

Salem Heights Compartmentalization

➤ Baseboard Radiators



Salem Heights Compartmentalization

➤ Baseboard Radiators



Salem Heights Compartmentalization

➤ Wall to Floor



Salem Heights Compartmentalization

How did we do?

Iterative Scenario	Unnormalized		Normalized
	CFM at 50 Pa	Change in CFM	CFM50/SF
Start (As Built)	1,540 ←	-	0.678
Electric	1,507	33	0.663
Plumbing	1,484	23	0.653
Register Boots	1,468	13	0.646
Duct Penetrations	1,305	163	0.574
Baseboard Radiators	1,066	204	0.469
Wall/Floor Gaps	1,003	63	0.442
Sealed Grilles (for Minotair Leakage)	838 ←	165	0.369

Prescriptive Challenge: Typical Retrofit

Salem Heights Compartmentalization

We could get there at unit turns!

- Painting/caulking
- Kitchen rehab: cabinet and appliance replacement
- Replacement of fin tube cover

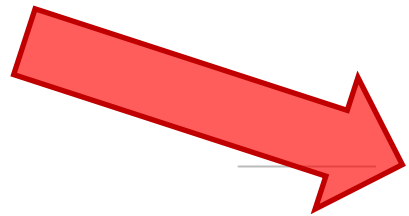
...And with proper implementation of scope

- Seal duct penetrations
- Seal register boot to drywall
- Tight ducts
- Verify dampers seal

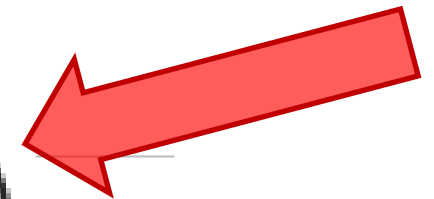
POAH Basis of Design



COMPARTMENTALIZATION: OPPORTUNITIES IN NEW CONSTRUCTION, UNIT TURNS OR REHABS



[DOWNLOAD THIS SECTION AS A PDF](#)



Passive House?

- Where does the airtightness end up?**
- Not full insulation at slab perimeter, is this a problem?**
- Can we exclude the connector from “Passive House” when it is still part of building?**
- Timeframe: some compartmentalization to happen later**



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