abaa2024 building enclosure conference

Invisible Improvement: Air Tightening an Office in a Historic Pier

Jeff Speert

4EA Building Science

AIA Continuing Education Provider

abaa EDUCATION

Invisible Improvement

Air Tightening an Office in a Historic Timber Pier

Jeff is a Principal and Office Director at 4EA Building Science His passion for building sustainability and durability; and fascination with tectonics and construction methods, led him to a building science career.

Jeff is a building science generalist with an interest in elements that provide energy efficiency, including air barriers and thermal bridging. His technical depth in building science and foundation in architecture and design have helped build the 4EA culture—tackling the challenging task of harmonizing aesthetic vision with the high-performance demands of contemporary building enclosures.

Jeff Speert, AIA LEED AP
4EA Building Science
jeffs@team4ea.com

Invisible Improvement: Air Tightening an Office in a Historic Timber Pier

Historic structures provide a significant cultural value and in the case of the Seattle waterfront, link the maritime period around Seattle's founding to the current tourist and commercial center of the city. In addition to contributing to the local heritage and historic fabric, existing buildings generally also contribute disproportionately to the energy consumption of our building stock. Pier 56 was constructed in 1900 over Elliott Bay as a timber structure and for much of its history was a base for nautical transportation. Today, the lower floor of the building houses several retail and restaurant tenants. The upper floor, approximately 30,000 square feet, is leased by the architecture firm Mithun.

Mithun leased the space in 2000 and as part of a lease renewal in 2020, completed tenant improvements including air sealing. The goal of the air tightening measures was to reduce energy use and improve occupant comfort, which was a challenge for a vaulted exposed timber structure with no cooling and no perimeter heat distribution.

This session is a case study covering the pre-improvement multi-fan air barrier testing, diagnostics completed during testing to determine leak locations, remedial work completed during construction, and the final air barrier test. We will also include post-occupancy energy use comparison and occupant descriptions of comfort improvements.

Learning Objectives

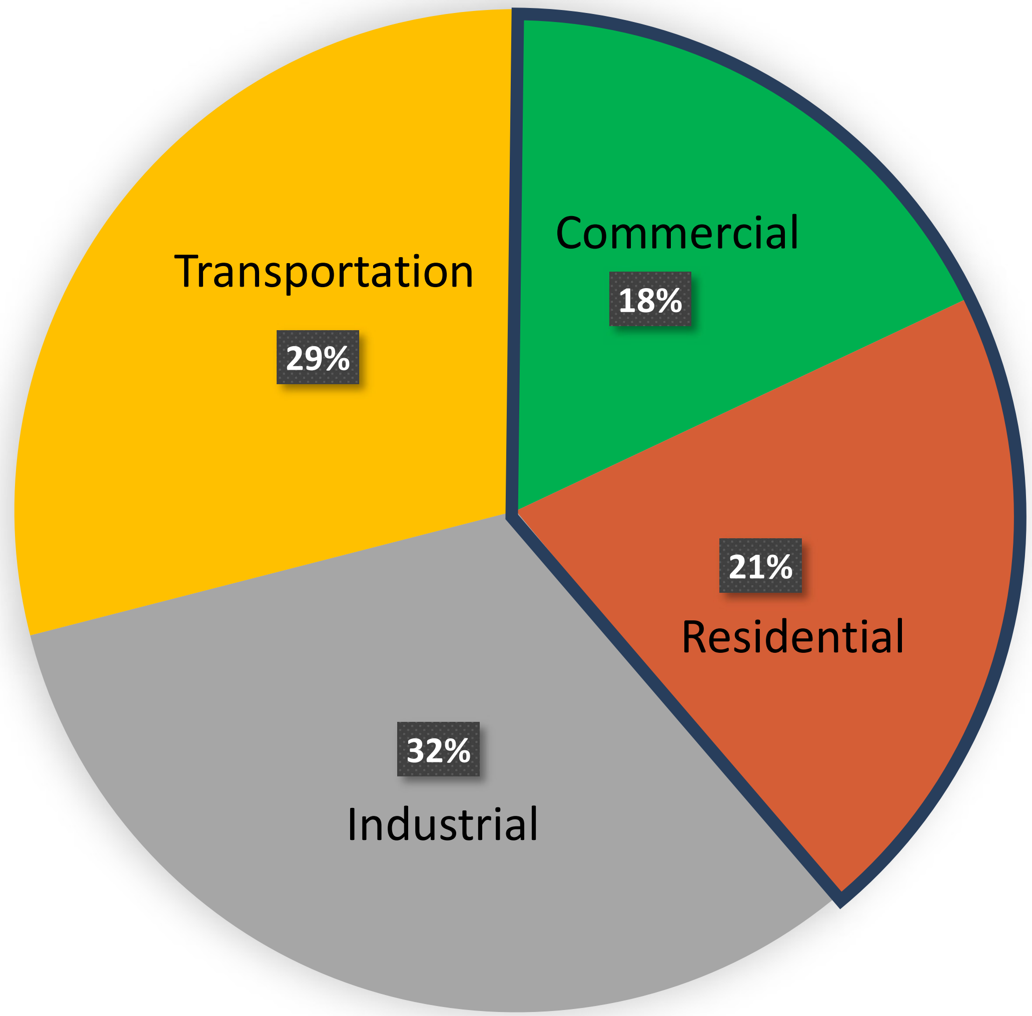
1. Identify at least three locations of air leakage in a historic timber framed structure.
2. Establish a methodology for determining, designing, and confirming air tightening measures in existing buildings.
3. Evaluate the value of different air sealing measures on occupant comfort.
4. Understand the methods used to validate performance improvements associated with air sealing old buildings.

Outline

- Energy use and air leakage in existing buildings
- Trends in Codes and Standards for existing buildings
- Case Study building background
- Case Study building testing, air sealing and post testing
- Conclusions

Energy Use by End-Use Sectors in the U.S.

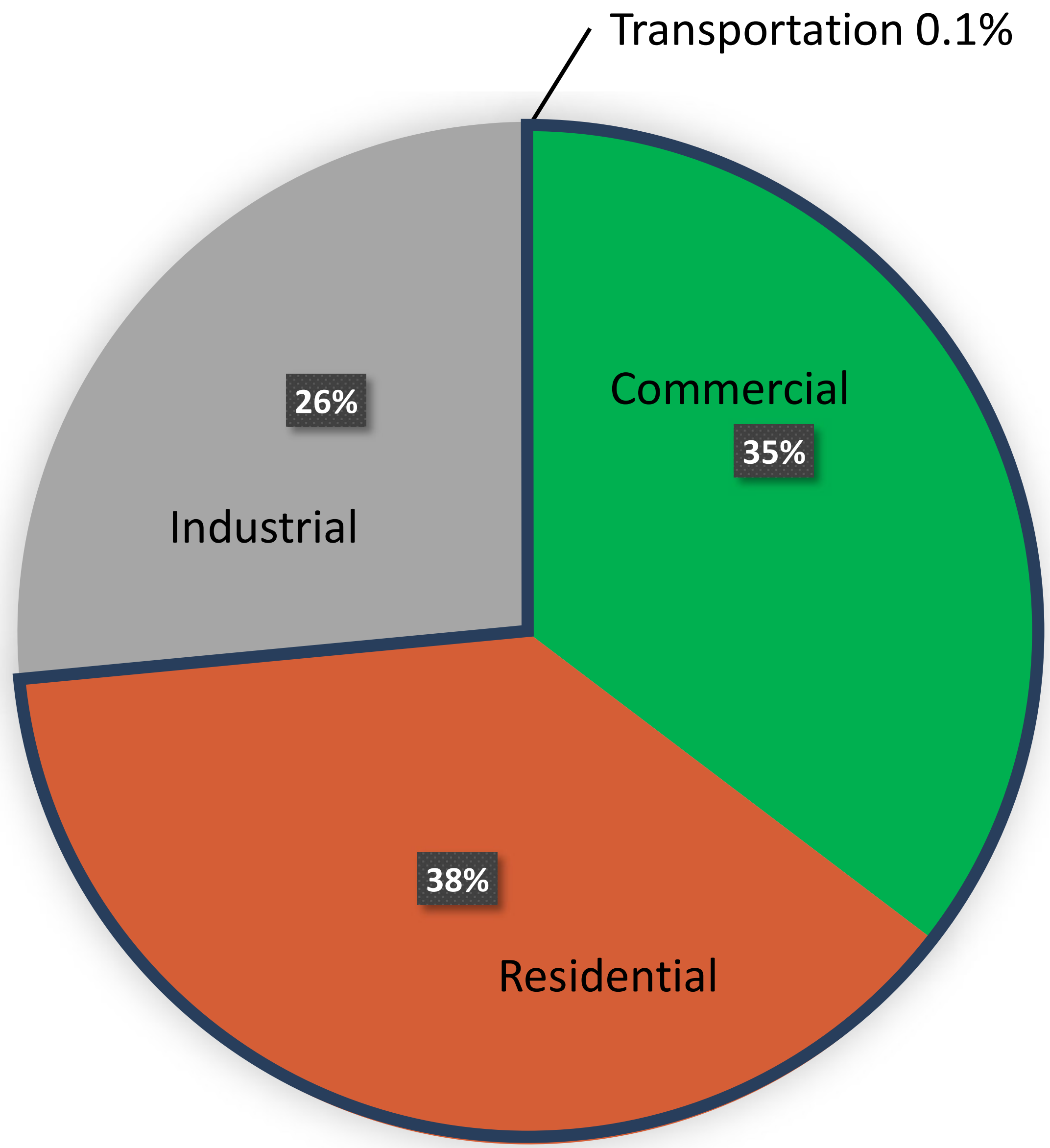
40% of total energy consumption is in buildings



Source: EIA, 2019

Electricity Use in the U.S.

75% of total U.S. electricity consumption is for buildings



Source: EIA, 2019

Building Stock in the U.S.

Around 80% of the buildings we have today will exist in 2050

Retrofitting an existing building emits 50-75% less carbon than constructing a new building

Source: World Economic Forum

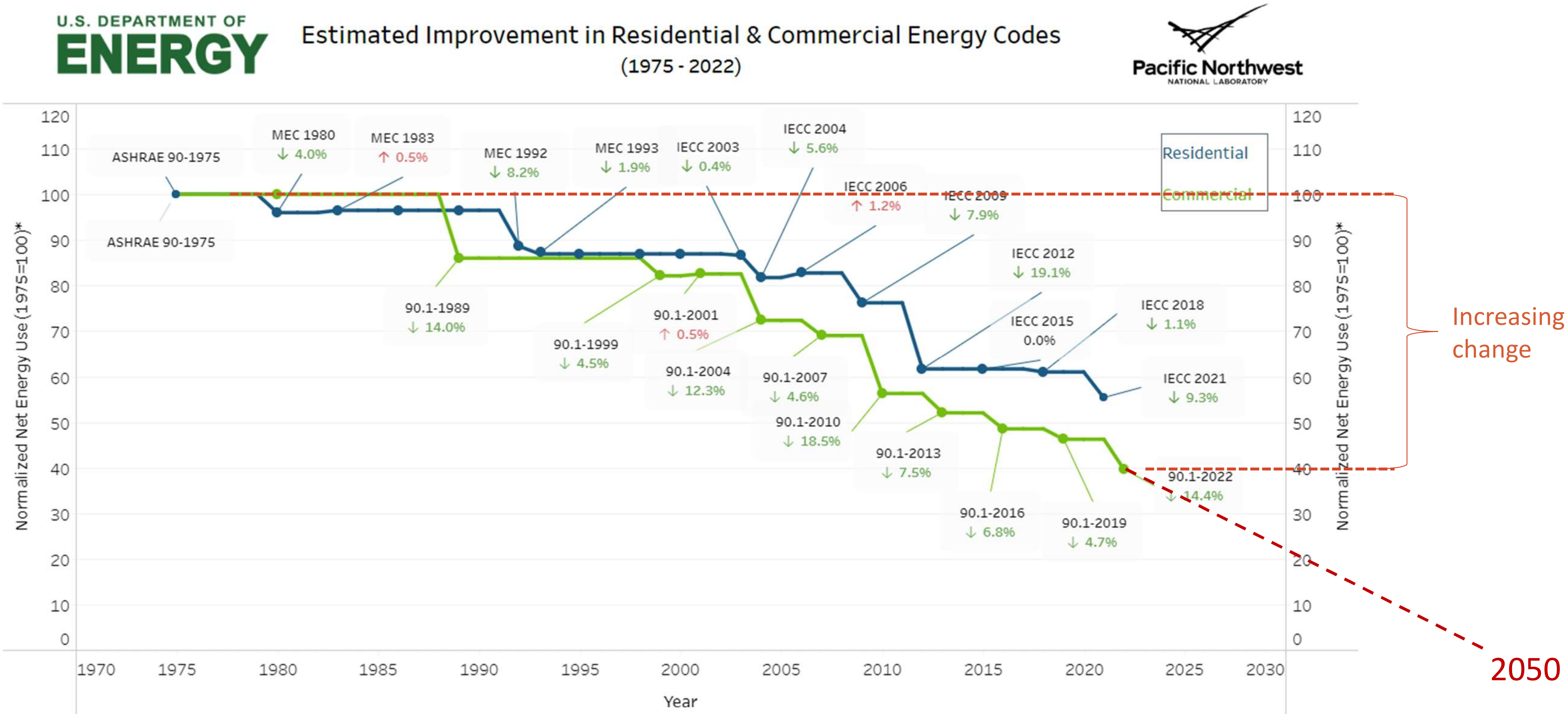
CITIES AND URBANIZATION

To create net-zero cities, we need to look hard at our older buildings

Nov 8, 2022

abaa building enclosure conference

Trajectory of Building Codes



*Net energy use includes the contribution of renewable energy generation

Need for updating existing buildings

Reports / Renovation of near 20% of existing building stock to zero-carbon-ready by 2030 is ambitious but necessary

Renovation of near 20% of existing building stock to zero-carbon-ready by 2030 is ambitious but necessary

Part of Technology and innovation pathways for zero-carbon-ready buildings by 2030

lea.org/reports

Renovating the existing building stock to a zero-carbon-ready level is a key priority for achieving the sector's decarbonisation targets for 2030 and 2050. However, the retrofitting of buildings is a significant challenge since at least 40% of buildings floor area in developed economies was built before 1980, when the first thermal regulations came into force. Retrofitting 20% of the existing building stock to a zero-carbon-ready level by 2030 is an ambitious but necessary milestone toward the Net Zero Emissions by 2050 Scenario (NZE Scenario). To achieve this goal, an annual deep renovation rate of over 2% is needed from now to 2030 and beyond.

Improving the performance of older buildings that have not integrated energy efficiency requirements since their construction is a critical priority. As a first step, it is necessary to implement passive measures to the building envelope to enhance its thermal performance to at least the minimum levels defined by the building energy codes to reduce the energy service demand for heating and cooling. High-efficiency HVAC and DHW equipment would complement the building renovation, further reducing the energy use that renewable or other clean energy sources would ultimately supply.

Enclosure vs. Mechanical Improvements

- First, decrease loads
- Then, construct to meet demands
- The enclosure stays with the building
- Mechanical systems must be replaced every 15-20 years

Historic Structures

National Historic Preservation Act (1966)

"Preservation of this irreplaceable heritage is in the public interest"

Buildings listed or eligible for the National Historic Register of Historic Places need not comply with IECC if compliance "would threaten, degrade or destroy the historic form, fabric or function of the building" (ICC 2018 C501.6)

Source: ICC 2108 C501.6

Trends to Improve Existing Buildings

LEED v5 (Existing Buildings – BETA Version)

- Assessment for Climate Resilience is a Prerequisite
- Air tightness improvement credit
  - <5k SF = 3 ACH 50
  - >5k SF = 0.4 CFM/SF at 75 Pa

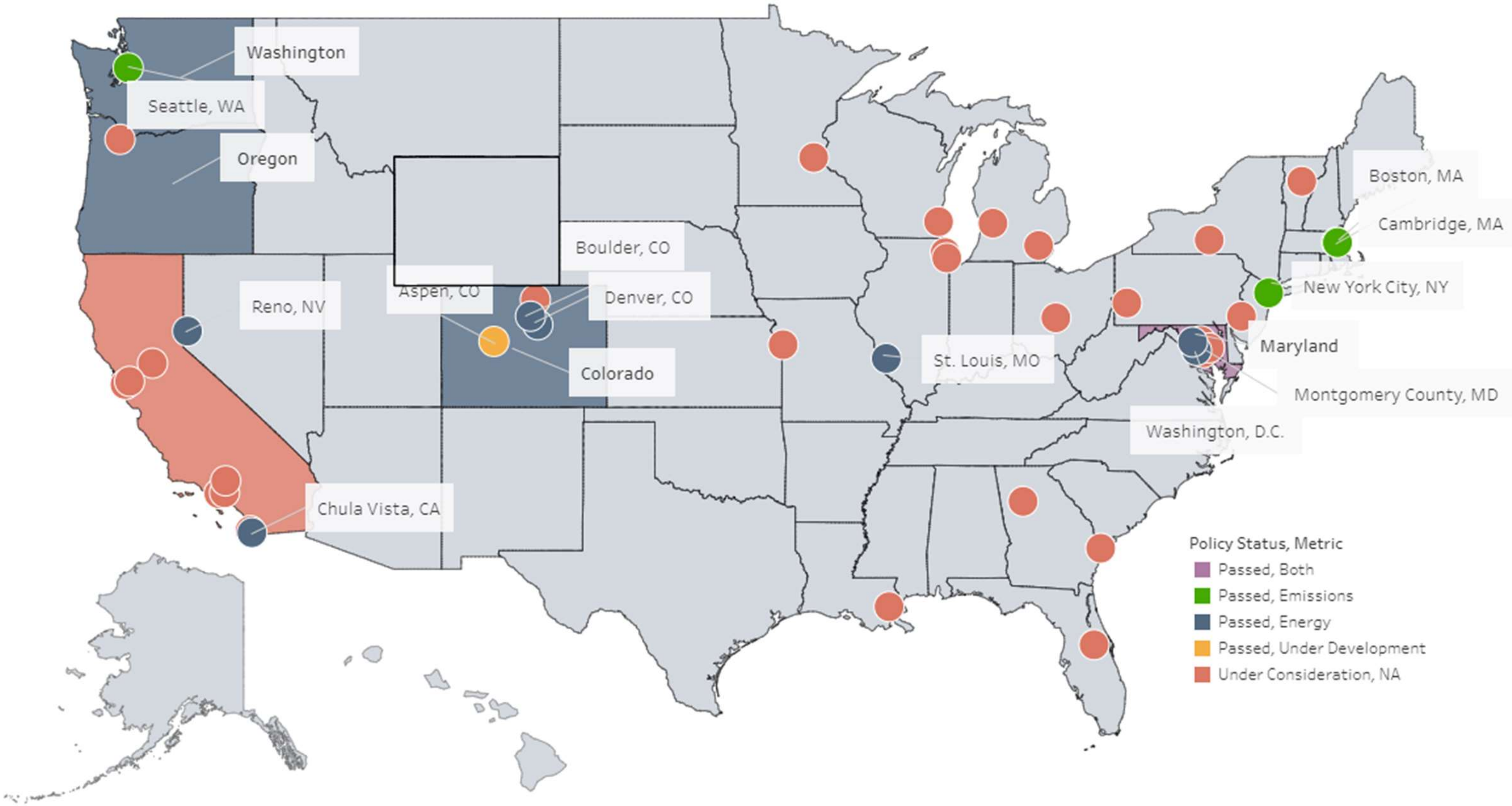
  or reduce leakage by 50%

Seattle Substantial Alterations

- Major improvements include requirement energy upgrades to within roughly 10% of current code

abaa building enclosure conference

State and Local Building Performance Standards



History of Weatherization

History of Weatherization

Seattle Waterfront

Pier 56

Seattle Waterfront

Railroad Avenue

Photo credit: Seattle Municipal Archives

Pier 56

Seattle Waterfront
1936

Photo credit: Seattle Municipal Archives

Pier 56

Seattle Waterfront
1936

Photo credit: Seattle Municipal Archives

Pier 56

Seattle Waterfront
1960's

Photo credit: Seattle Municipal Archives

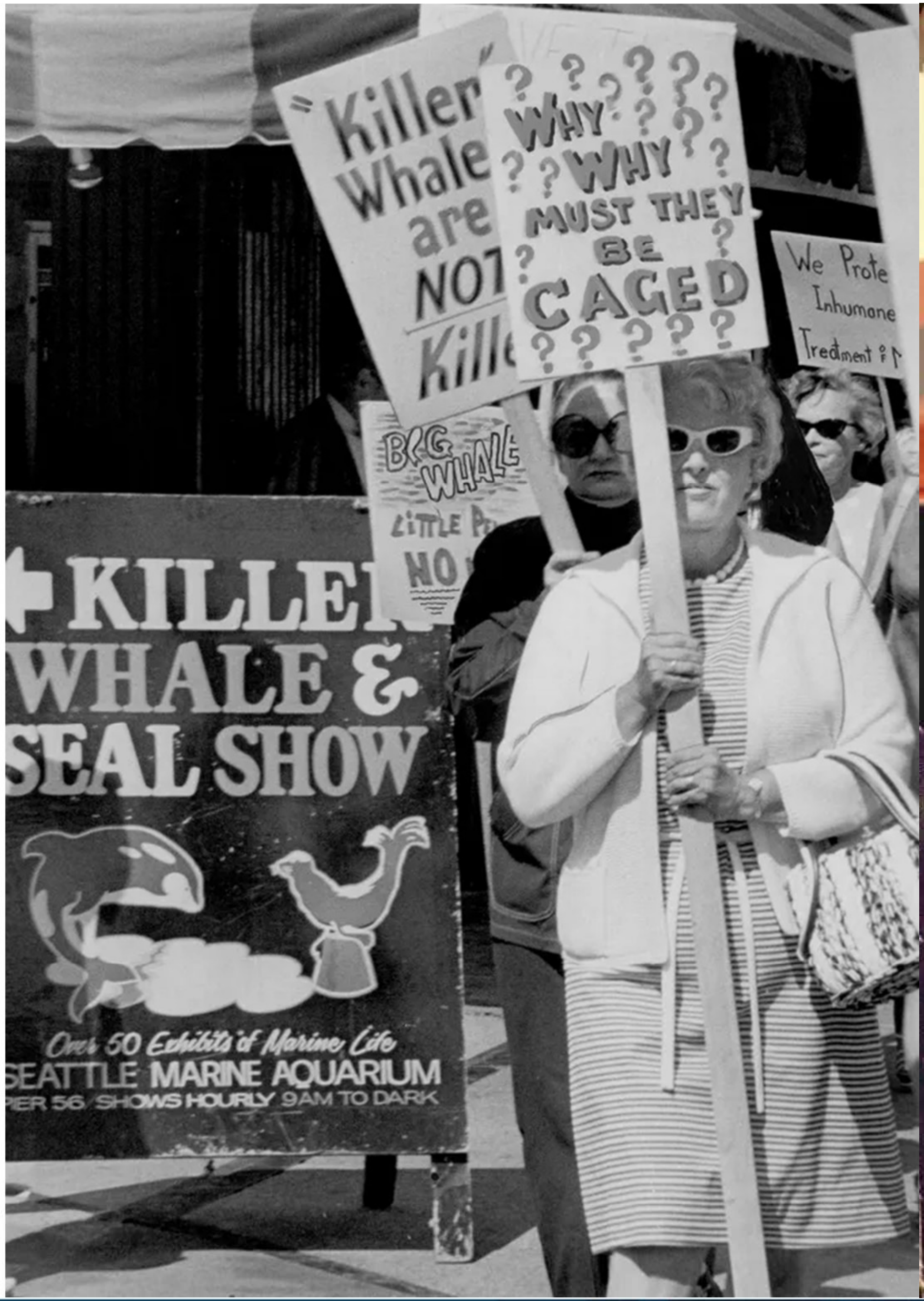
Pier 56

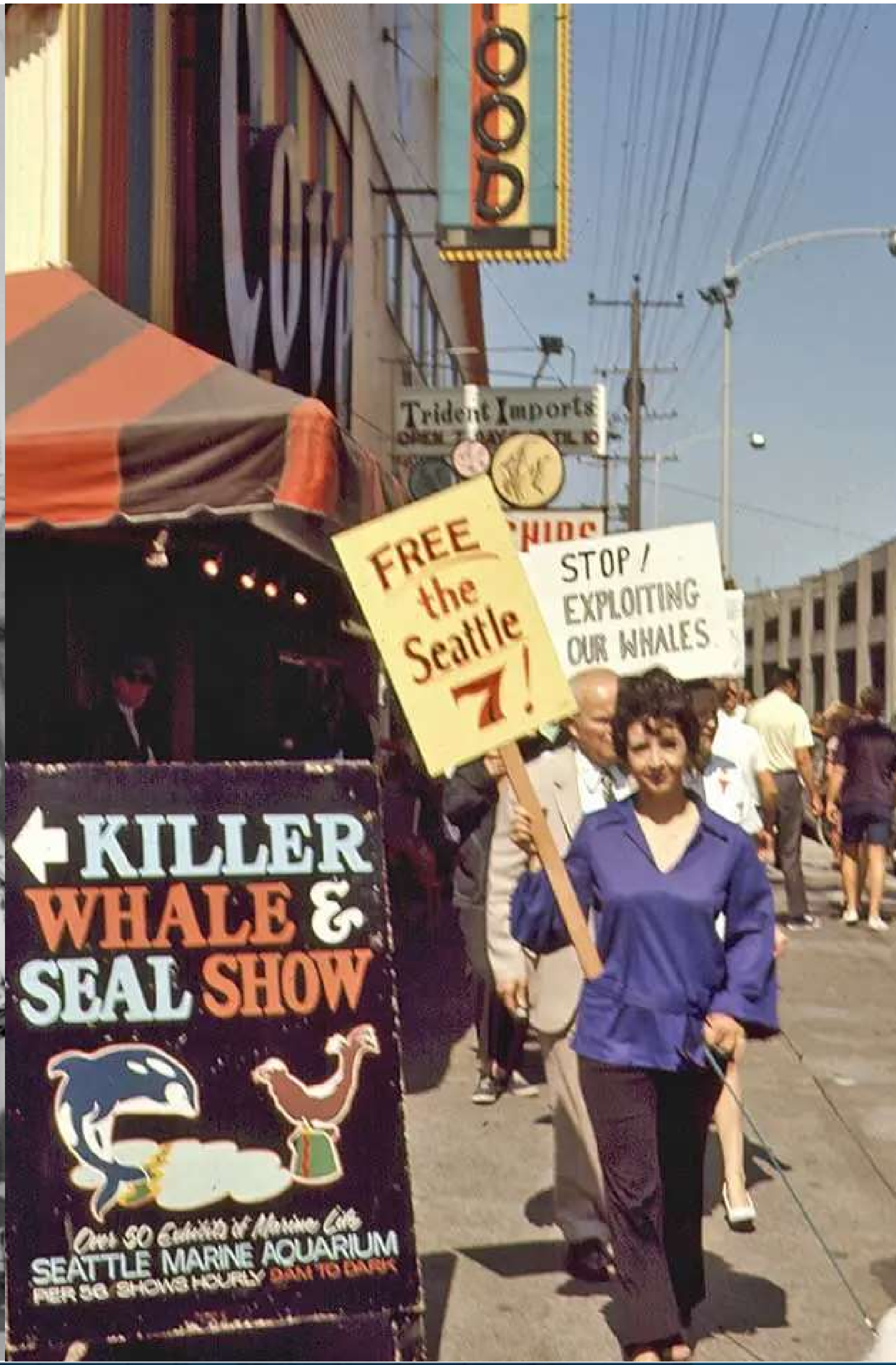
Seattle Marine Aquarium

1966

Namu

Pier 56





Seattle Marine Aquarium
May 1970

Pier 56

Mithun

Designing for Positive Change

Mithun

Goal for Remodel

- Space to be an expression of the firm values

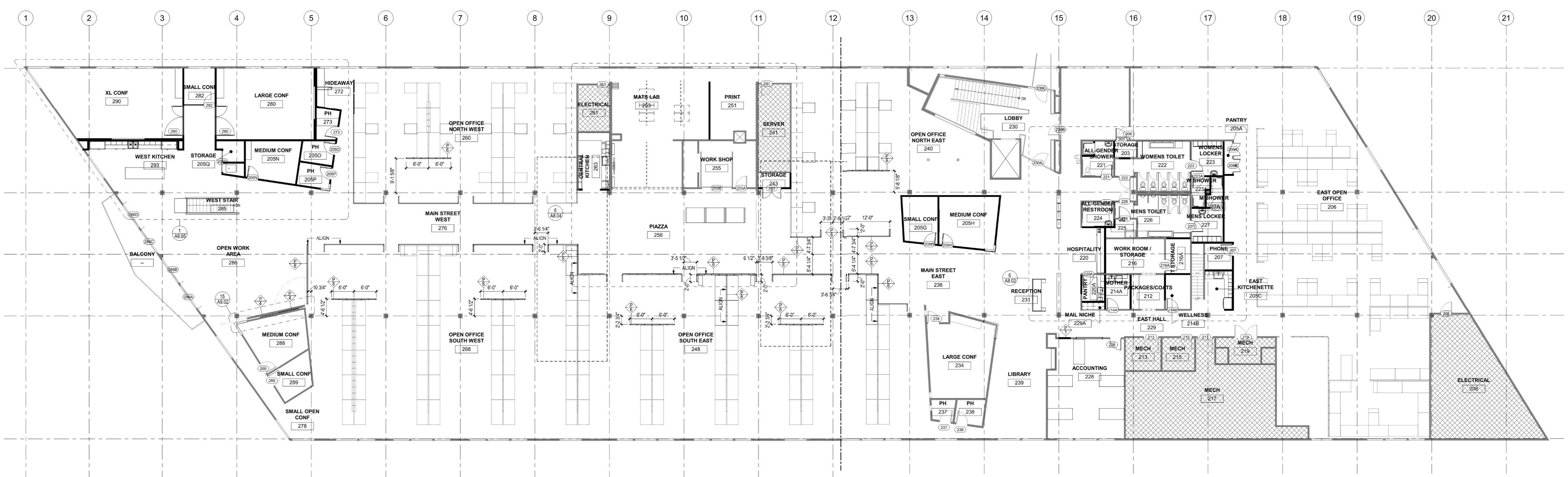
Fitwel

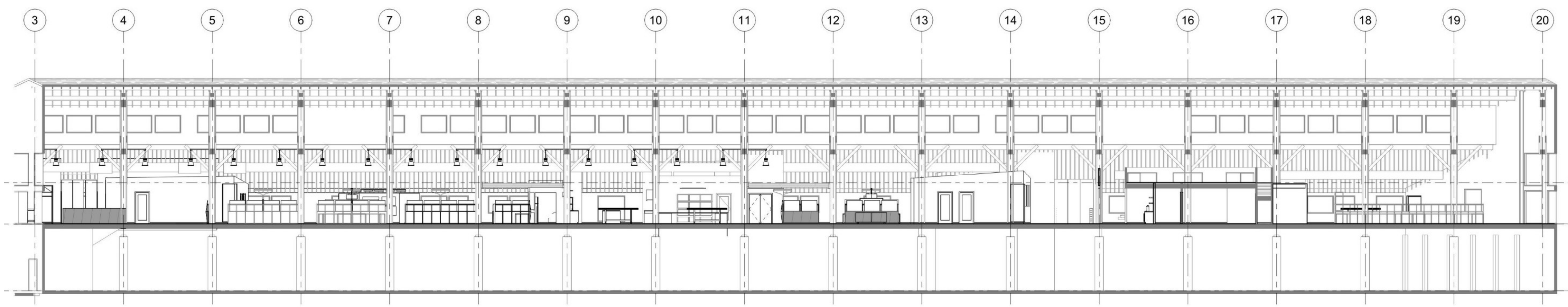
- 2-star certification

ILFI

- Petal - Ready
  - Materials
  - Equity
  - beauty

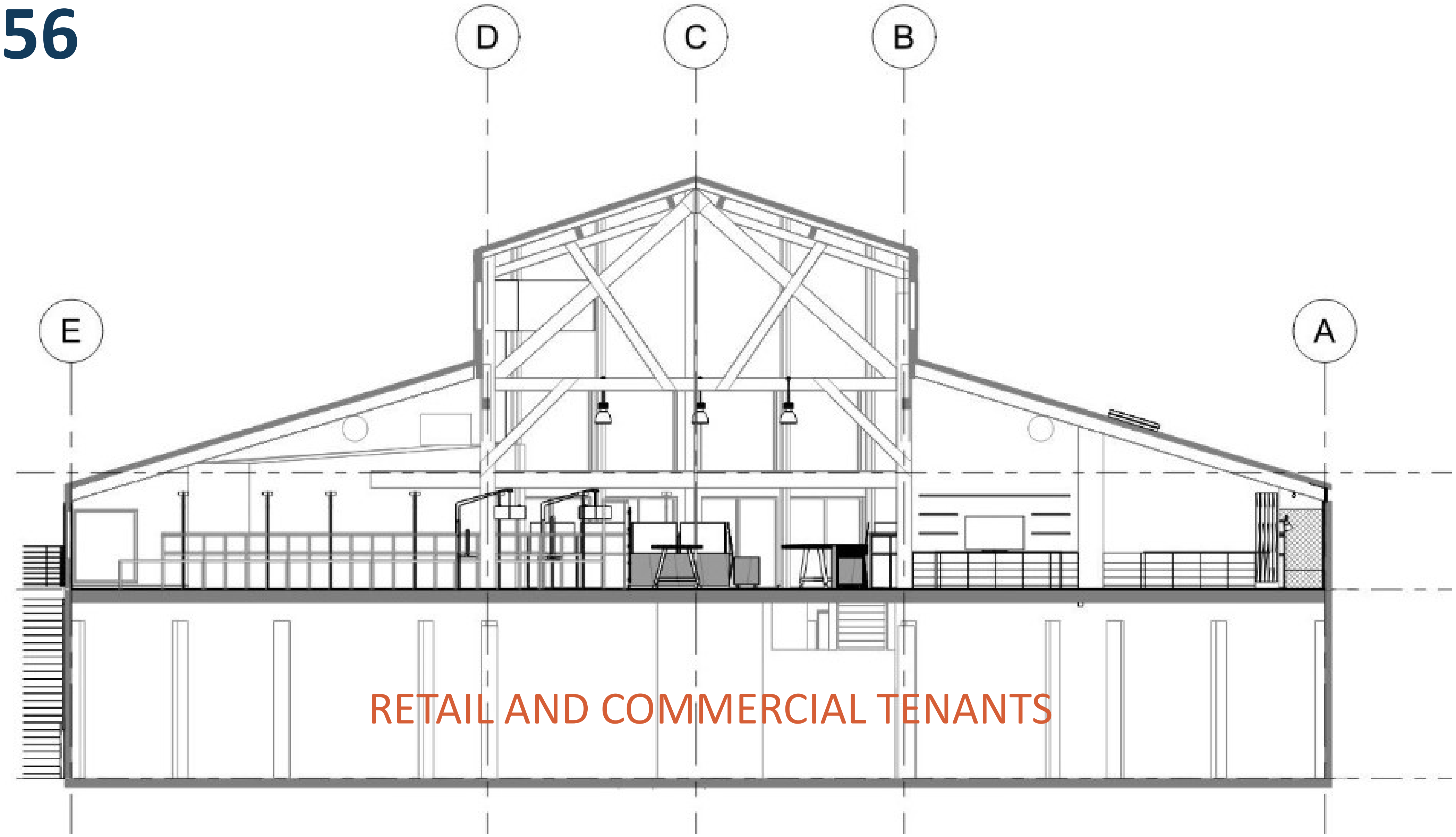
Pier 56





1 LONGITUDINAL BUILDING SECTION
1" = 10'-0"

Pier 56



Pier 56

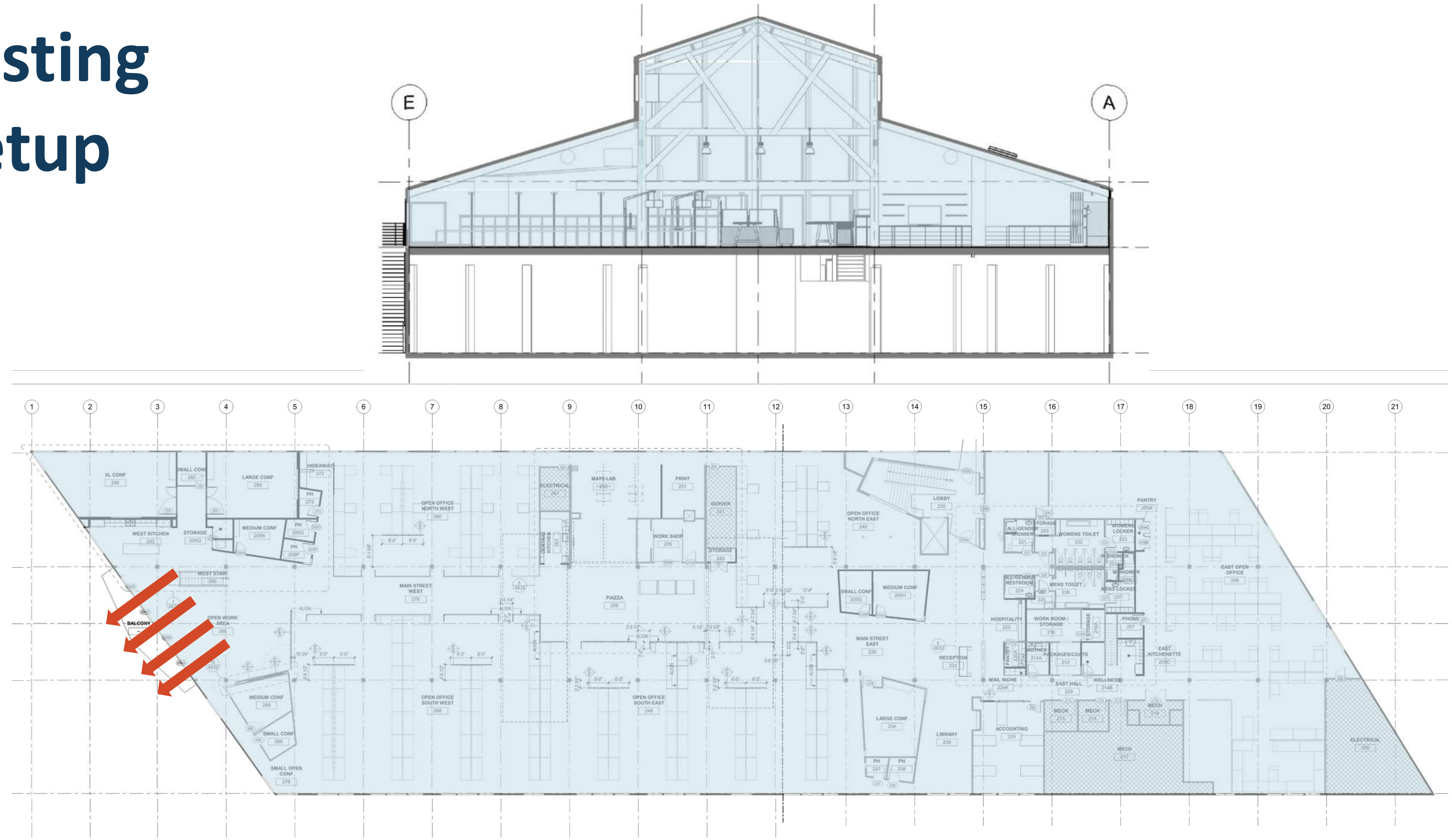
Pier 56

Pier 56

Air Sealing Goals

- Reduce energy use
- Reduce temperature variability at the perimeter
- Decrease drafts

Testing Setup



Testing Setup

Testing

Testing

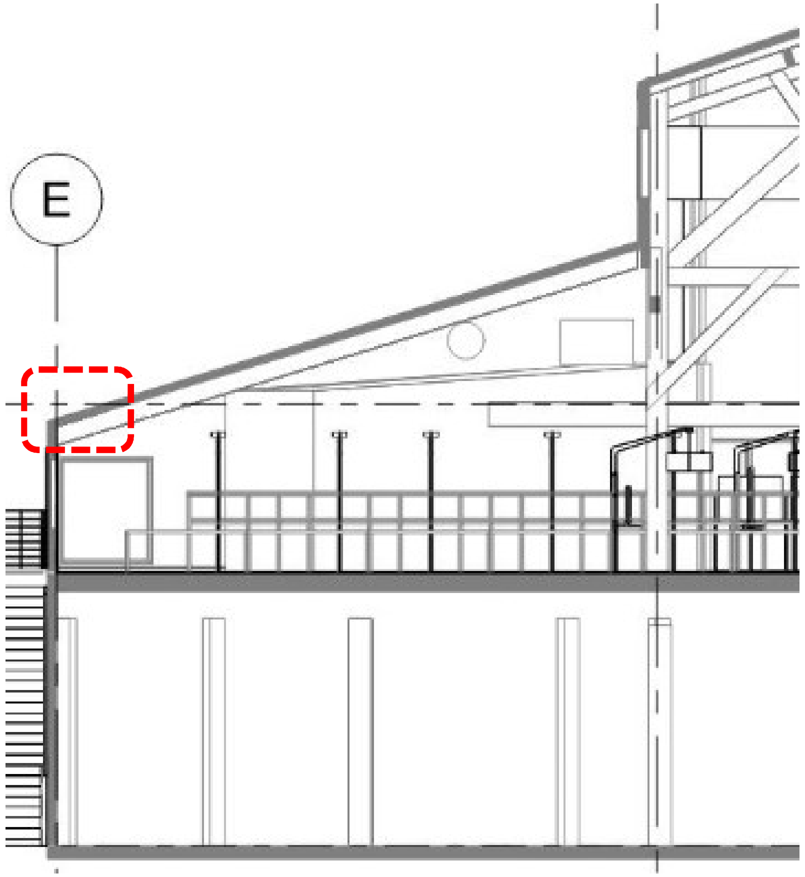
Testing and Diagnostics

- 87, 524SF of enclosure area
- 10 high-capacity blower door fans
- Masking and temporary sealing completed
- Could not be isolated from the lower level
- Tested in October 2020

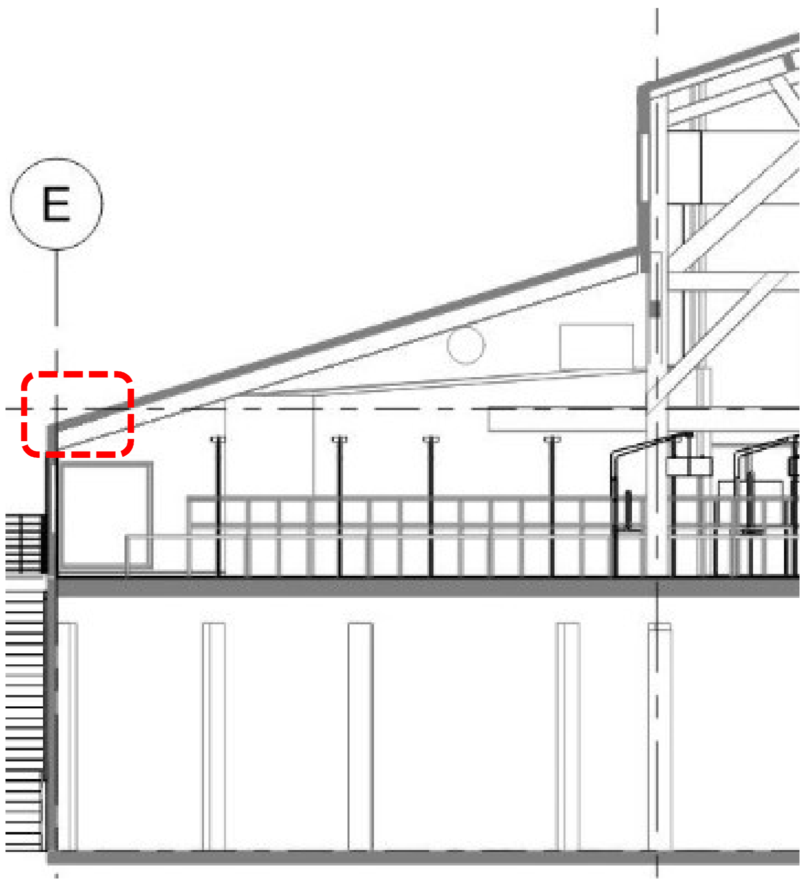
Initial Test

0.934 CFM/SF at 75 Pascals	Depressurization	5.915 ACH50
1.255 CFM/SF at 75 Pascals	Pressurization	8.134 ACH50
1.094 CFM/SF at 75 Pascals	**Average**	**7.02 ACH50**

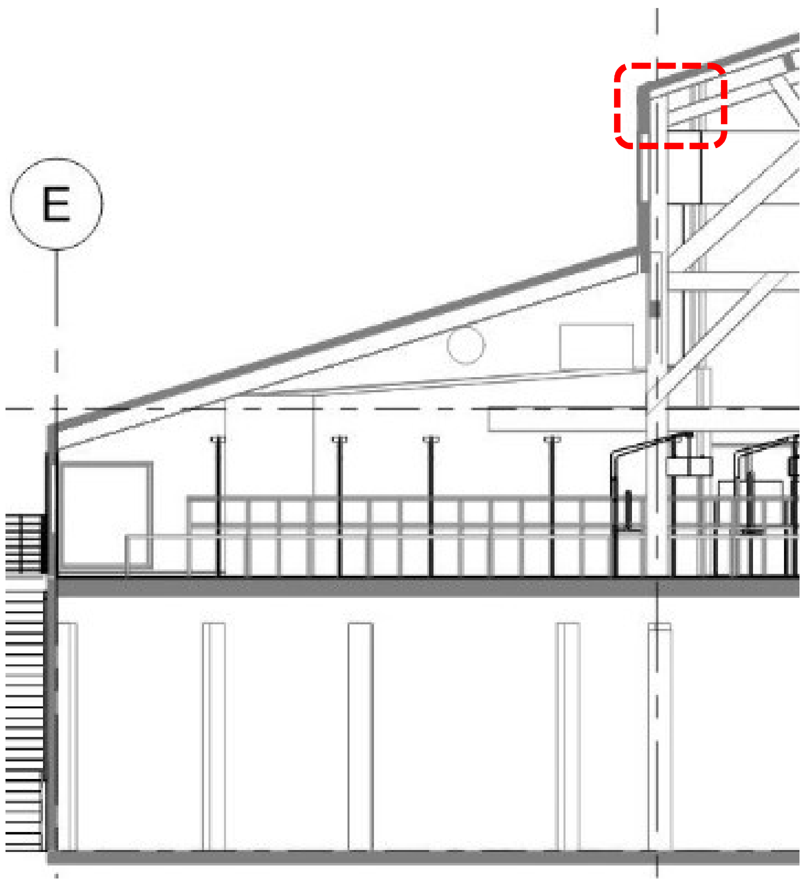
Testing and Diagnostics

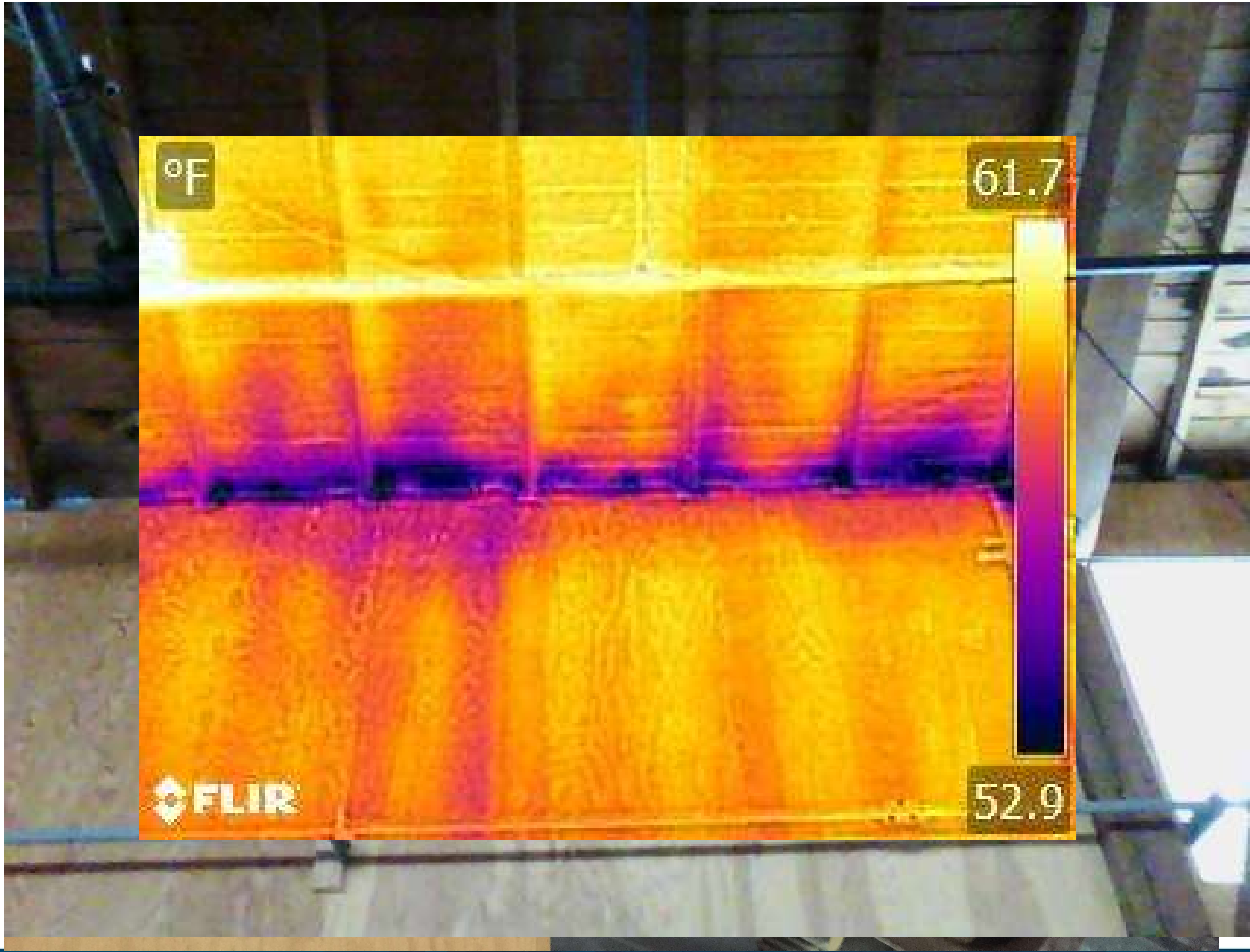


Testing and Diagnostics

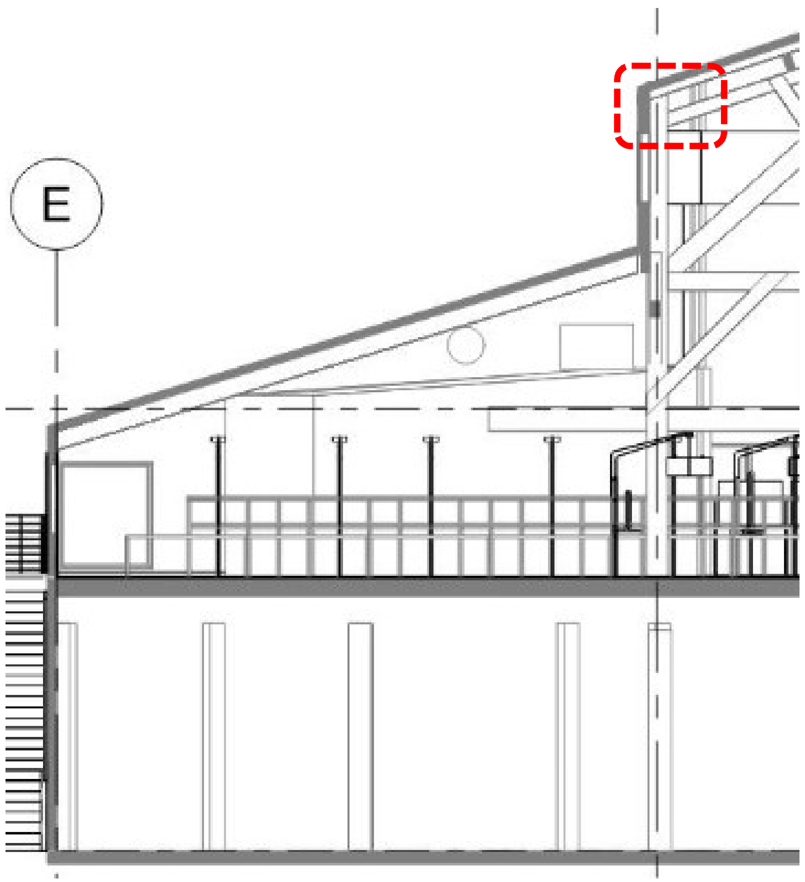


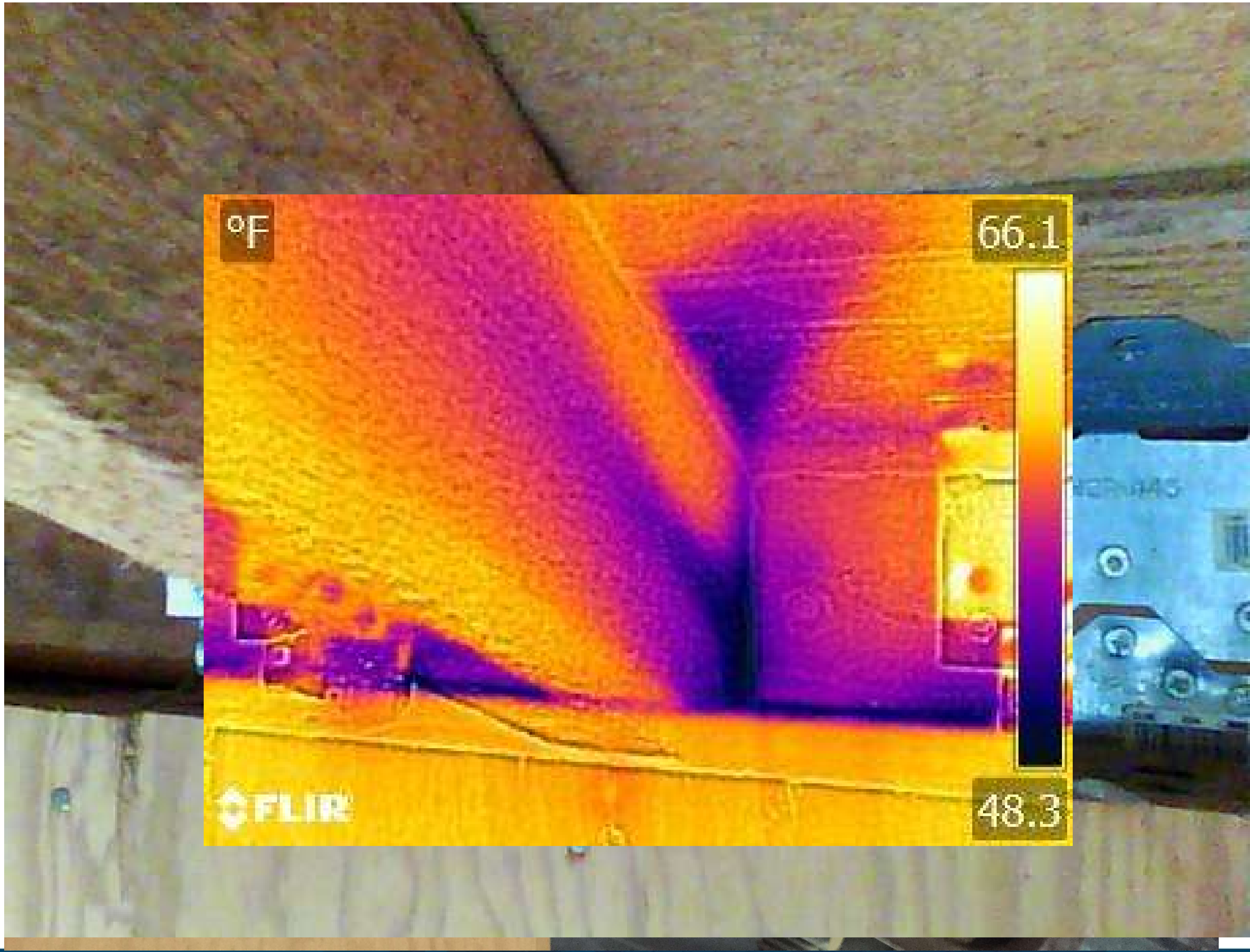
Testing and Diagnostics



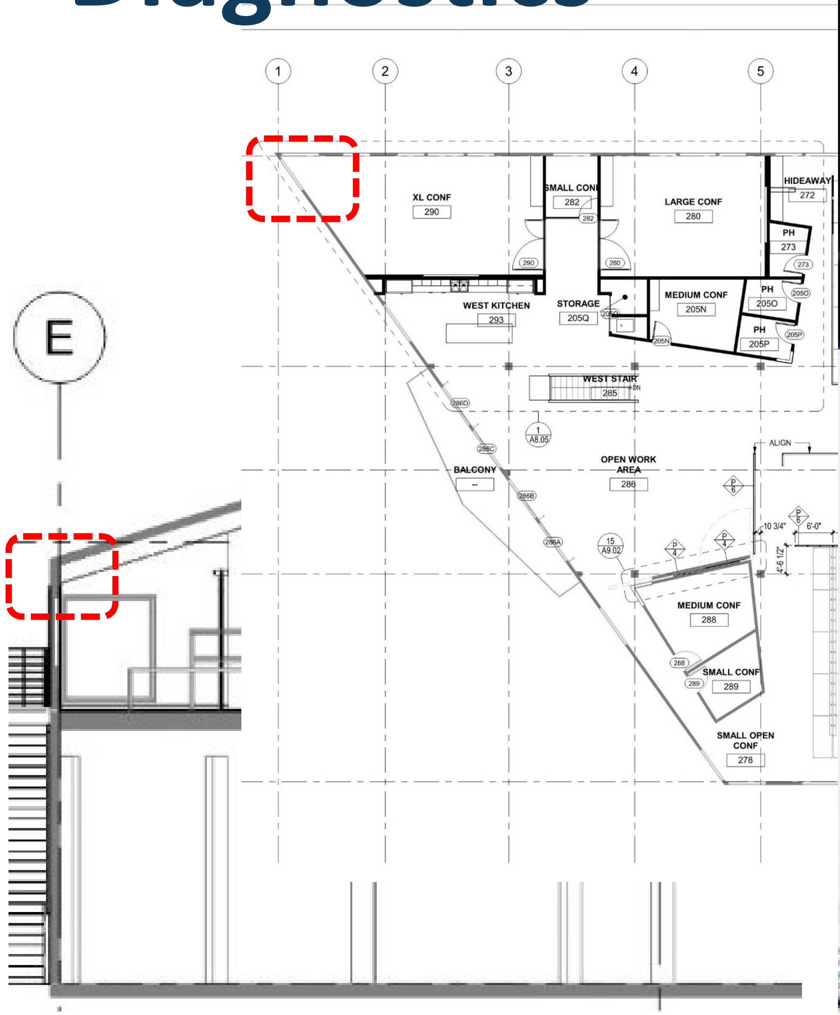


Testing and Diagnostics

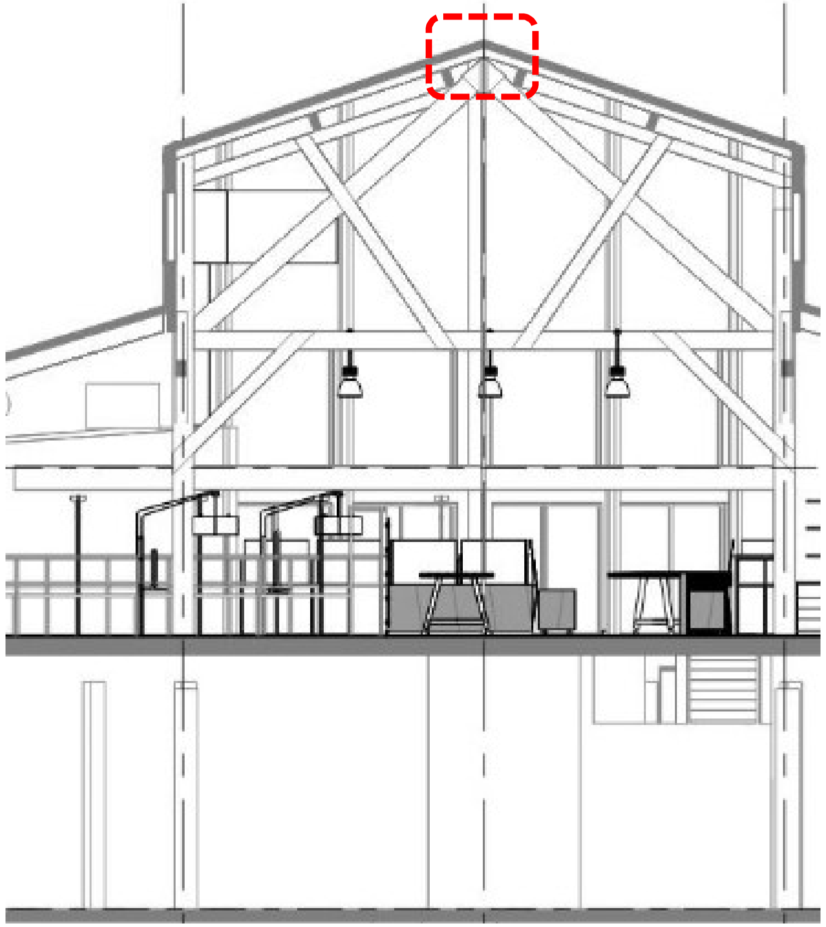


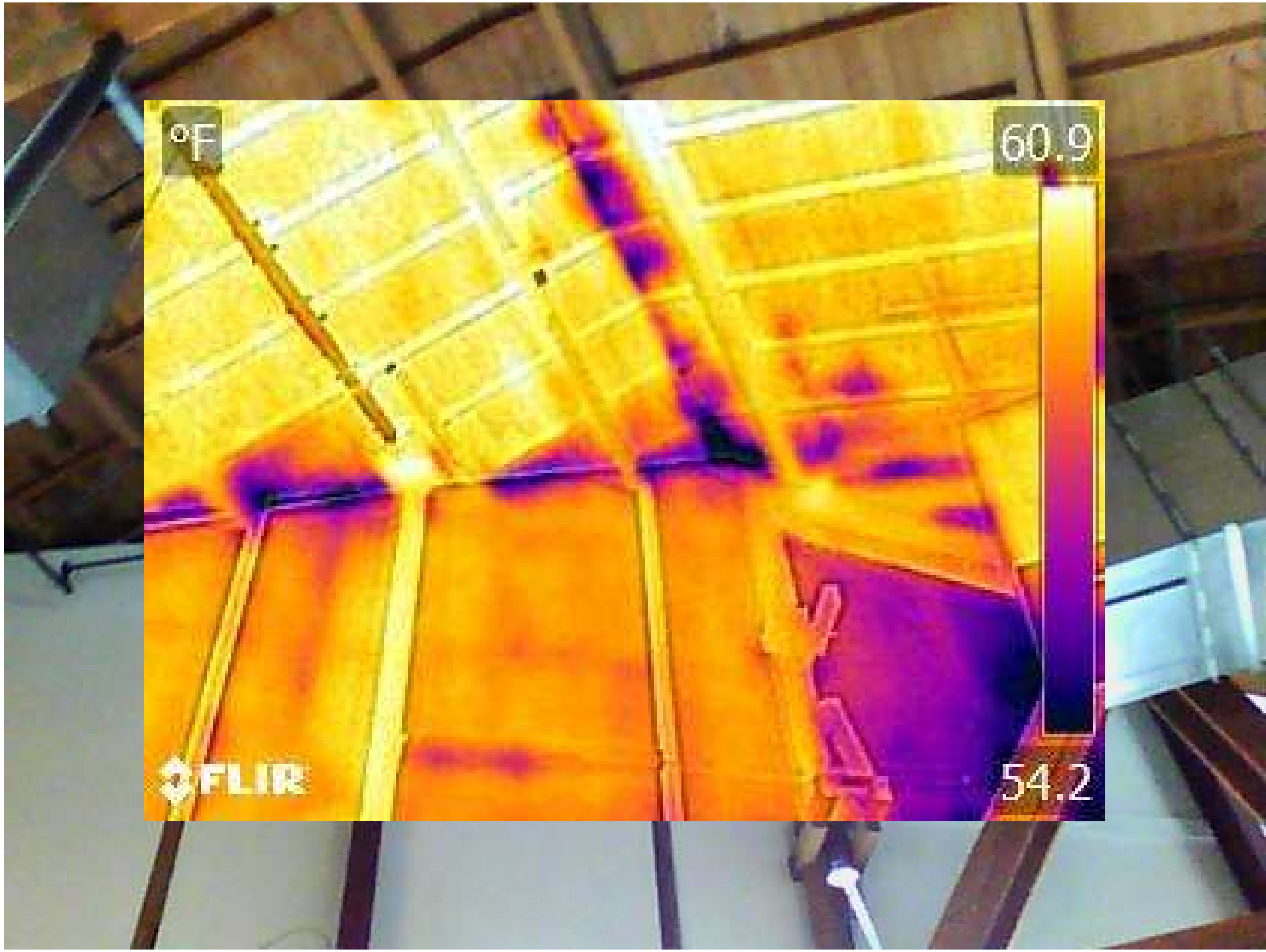


Testing and Diagnostics

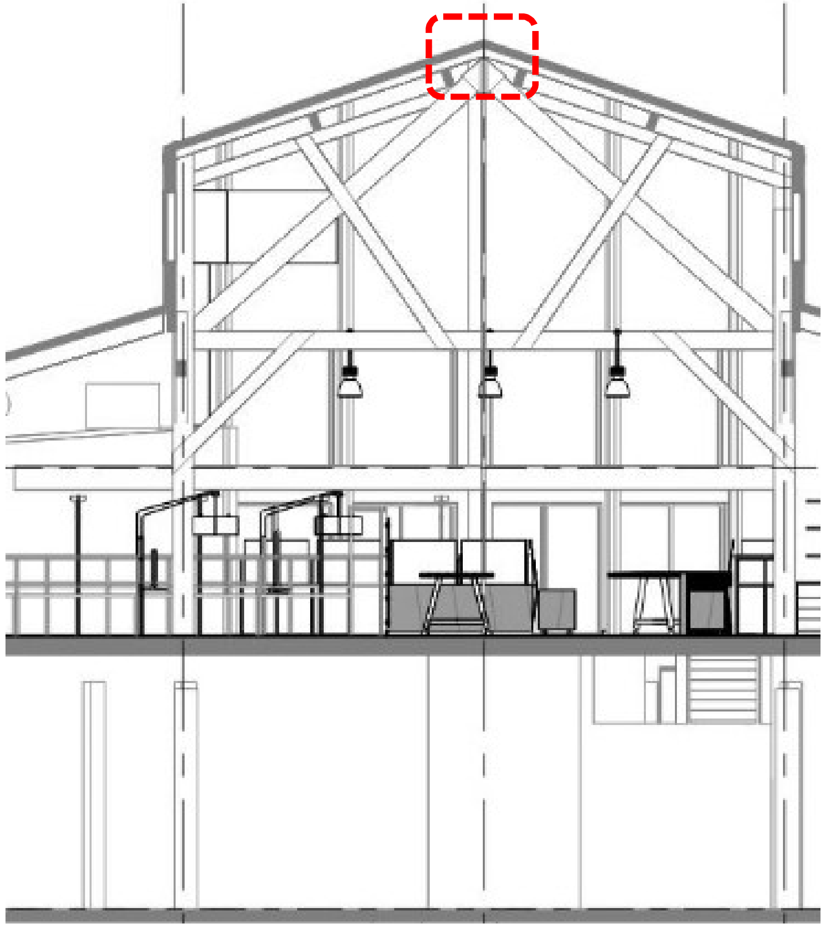


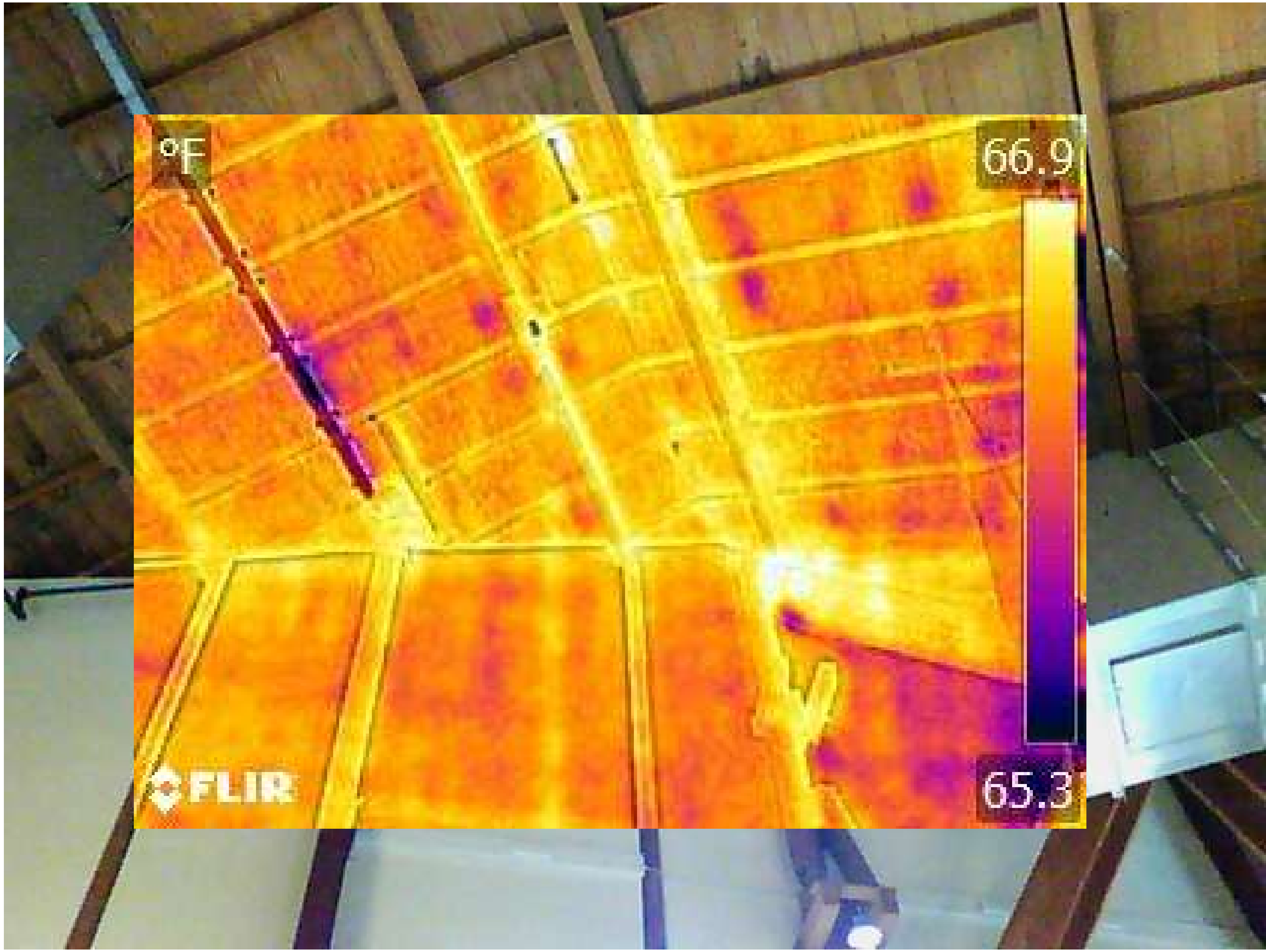
Testing and Diagnostics



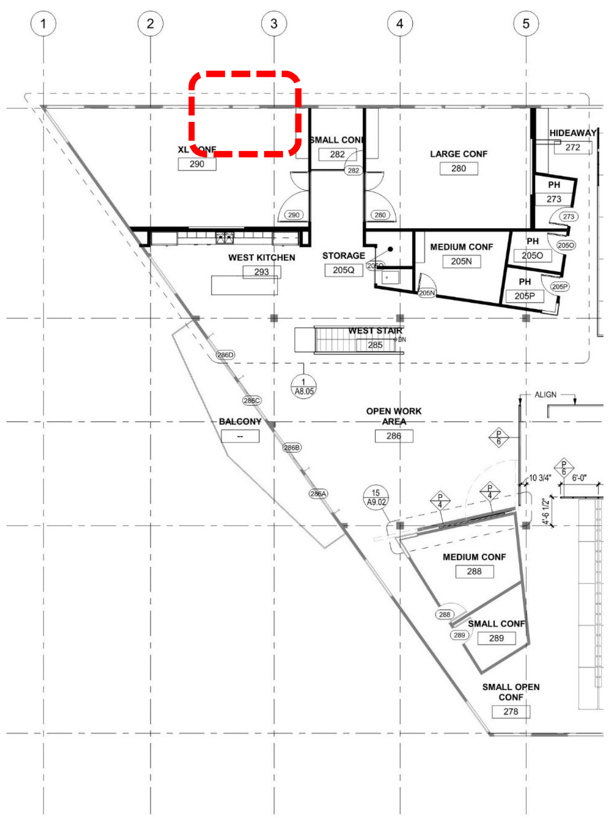


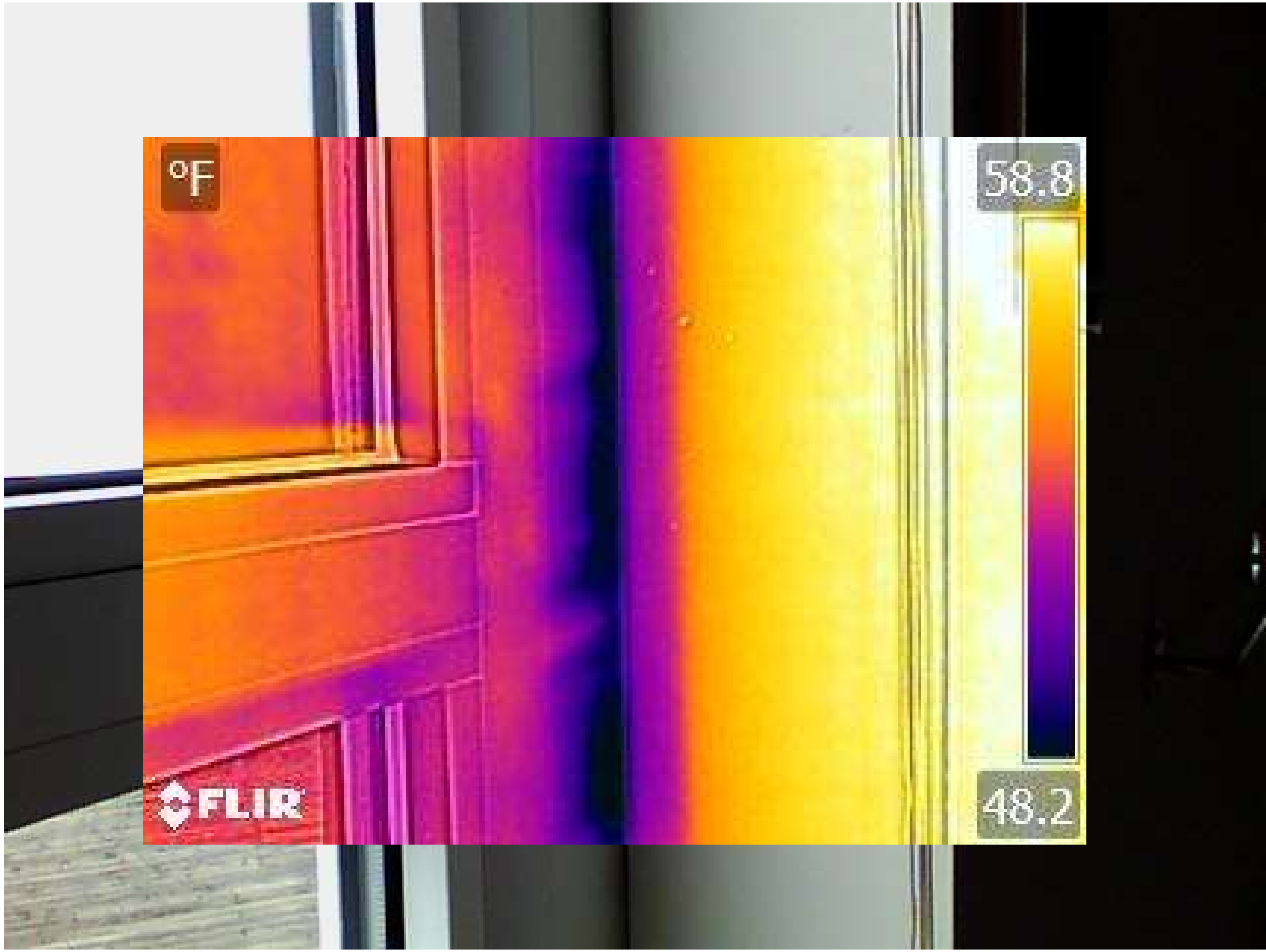
Testing and Diagnostics



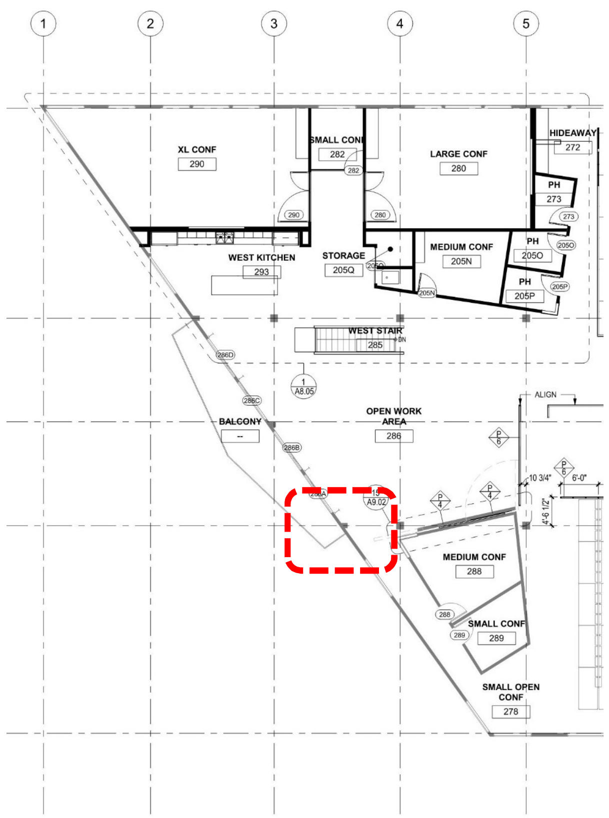


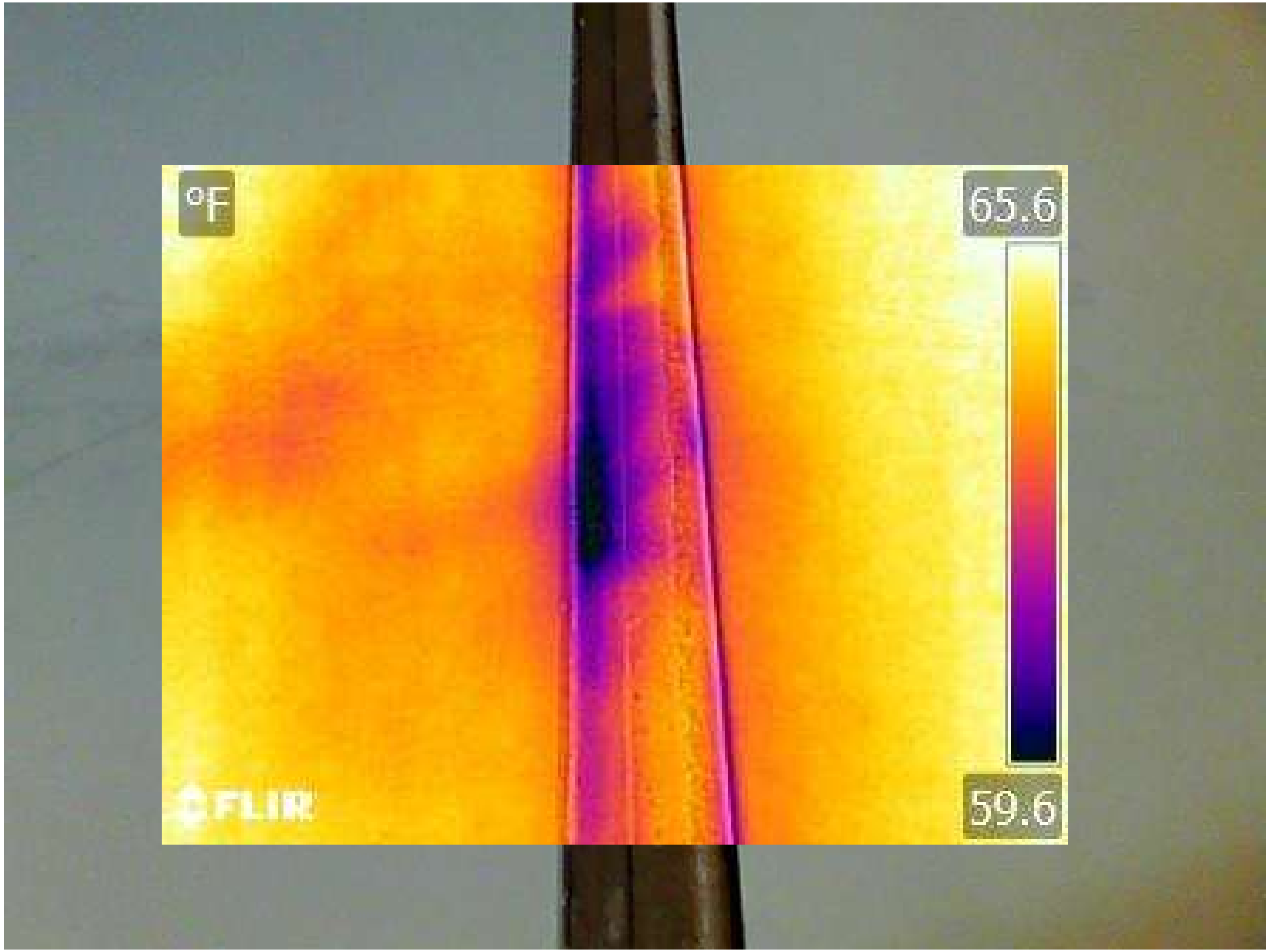
Testing and Diagnostics





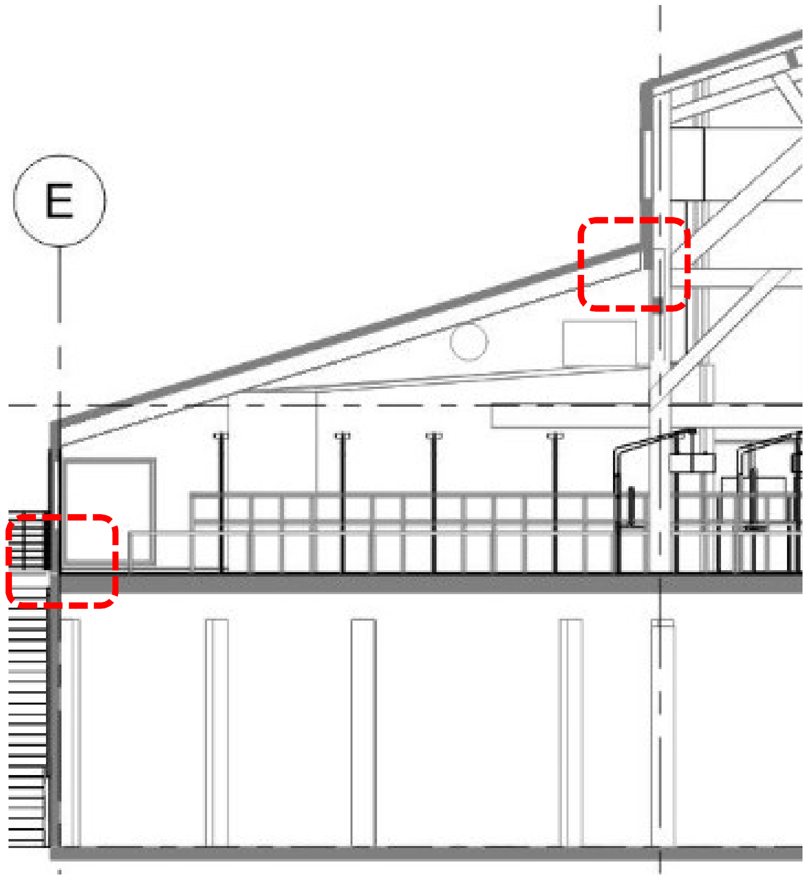
Testing and Diagnostics



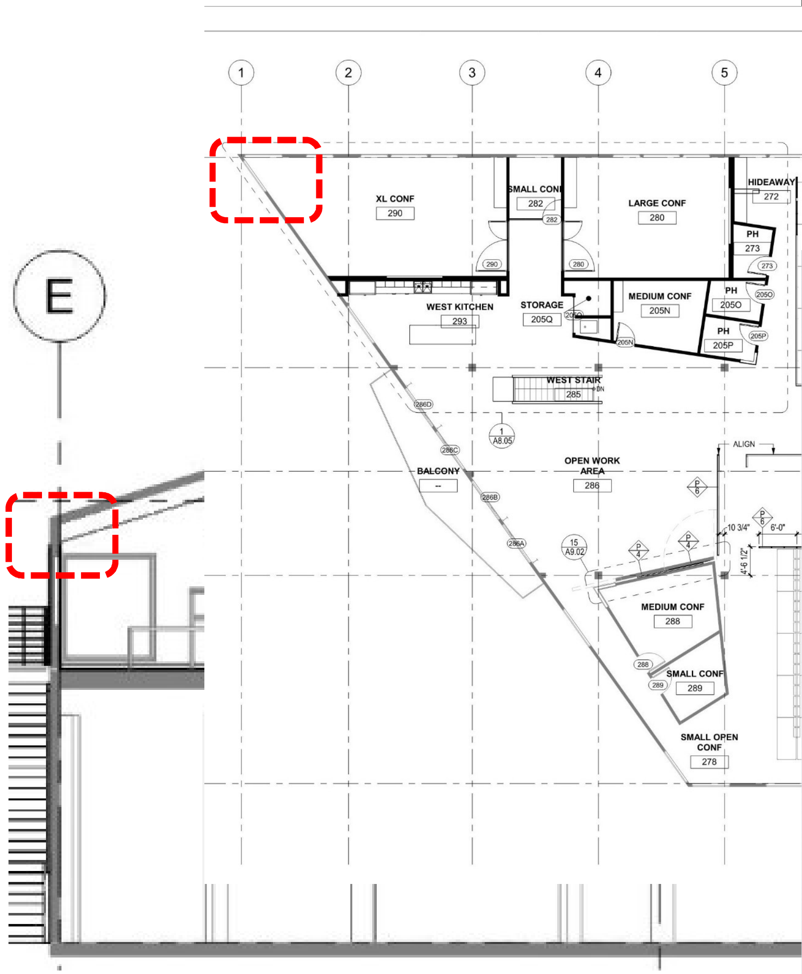


abaa building enclosure conference

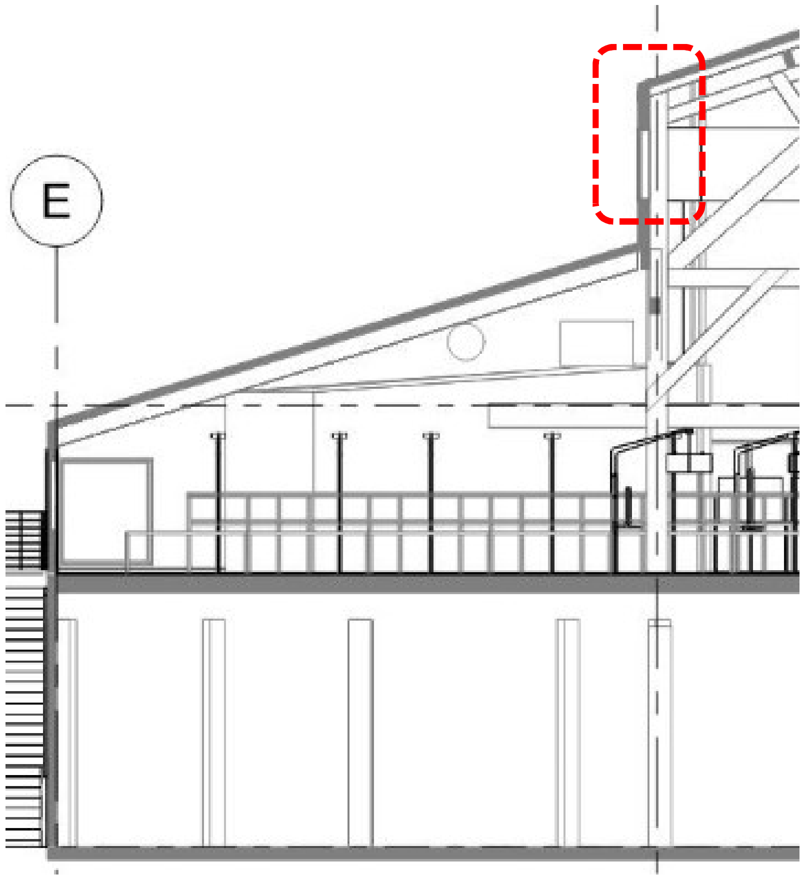
Testing and Diagnostics



Testing and Diagnostics



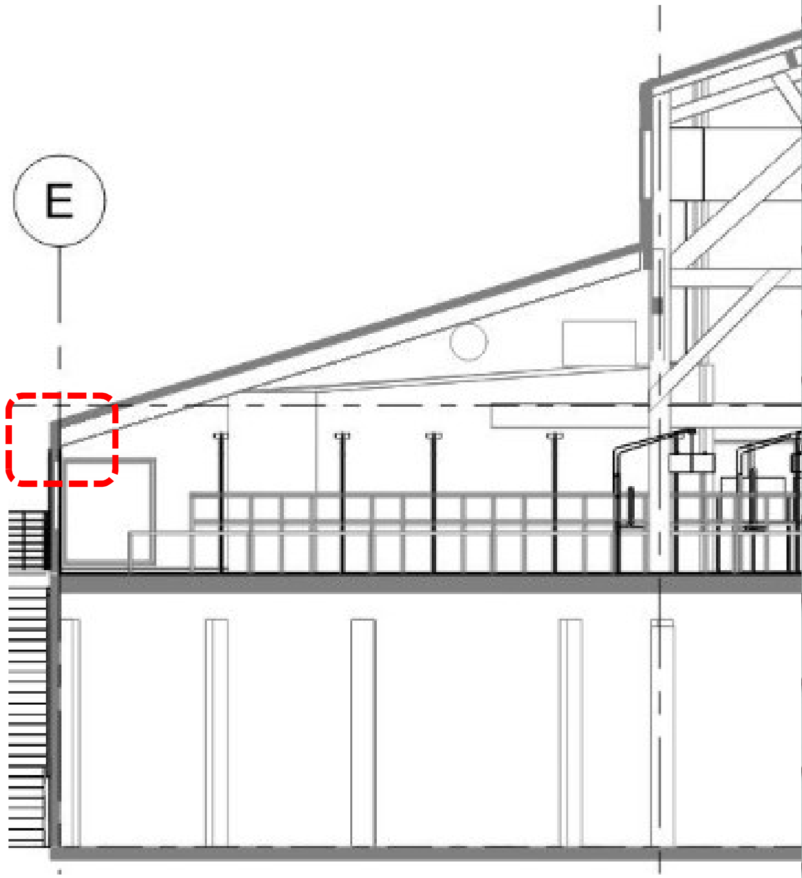
Testing and Diagnostics



abaa building enclosure conference

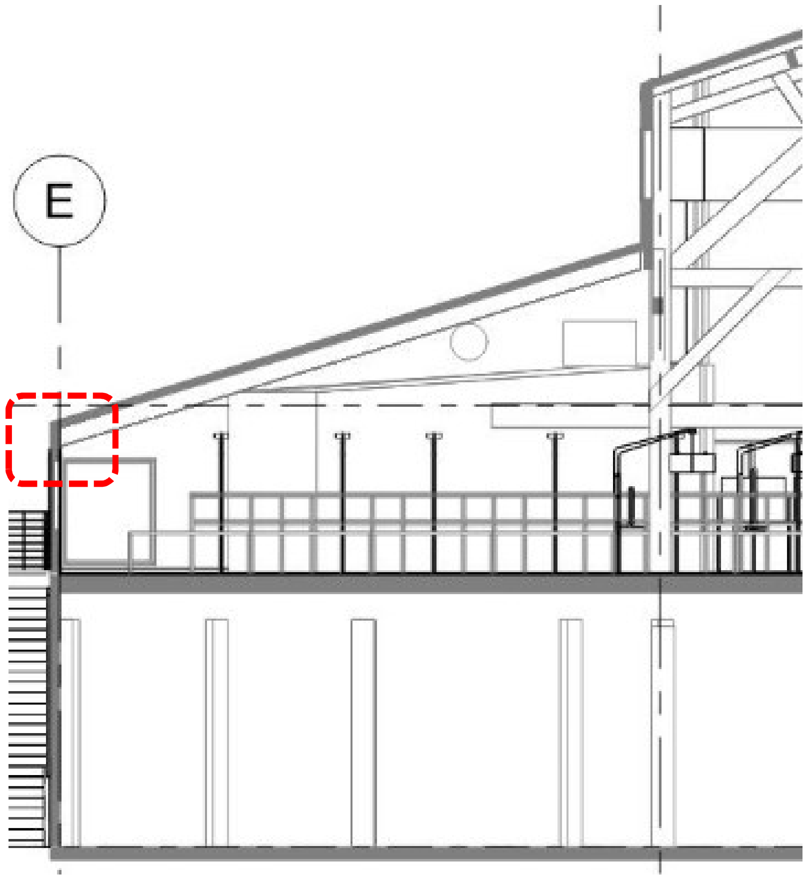
Testing and Diagnostics

Remedial Work



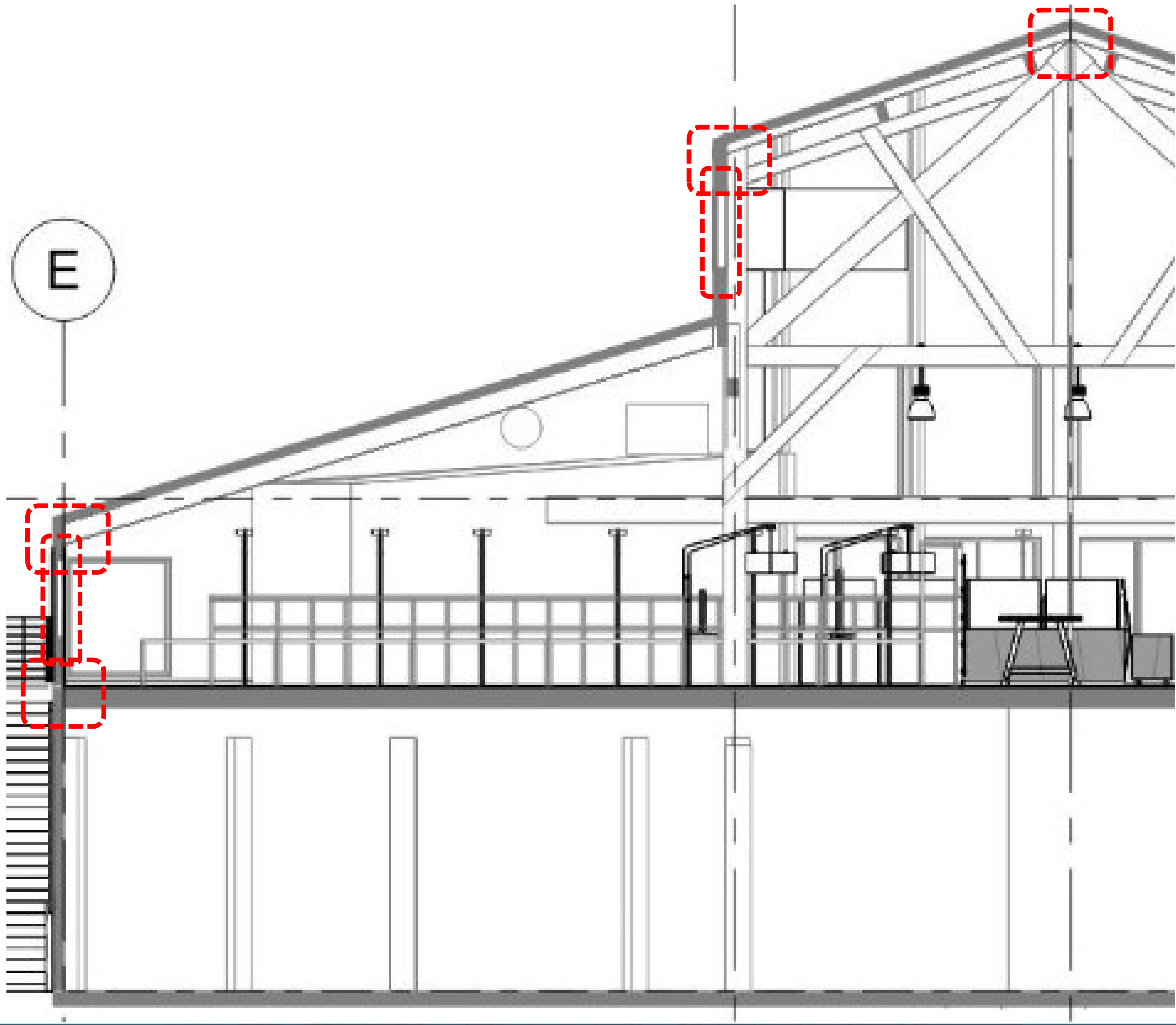
abaa building enclosure conference

Remedial Work



Remedial Work

- Sealant at eve blocking (lower and upper roofs)
- Sealant at windows on main level and clerestory
- Sealant wall columns to drywall
- Ridgeline
- Drywall to floor sheathing (rubber base removed for this work)



Re-Testing Setup

Results – Final Test

- All test conditions from the initial test were repeated, such as fan locations and temporary sealing
- Tested in May 2021

0.778 CFM/SF at 75 Pascals	Depressurization	4.863 ACH50
1.071 CFM/SF at 75 Pascals	Pressurization	7.030 ACH50
0.925 CFM/SF at 75 Pascals	**Average**	**5.950 ACH50**

Initial Test

1.094 CFM/SF at 75 Pascals	**Average**	**7.02 ACH50**

Air sealing measures decreased leakage by 15%

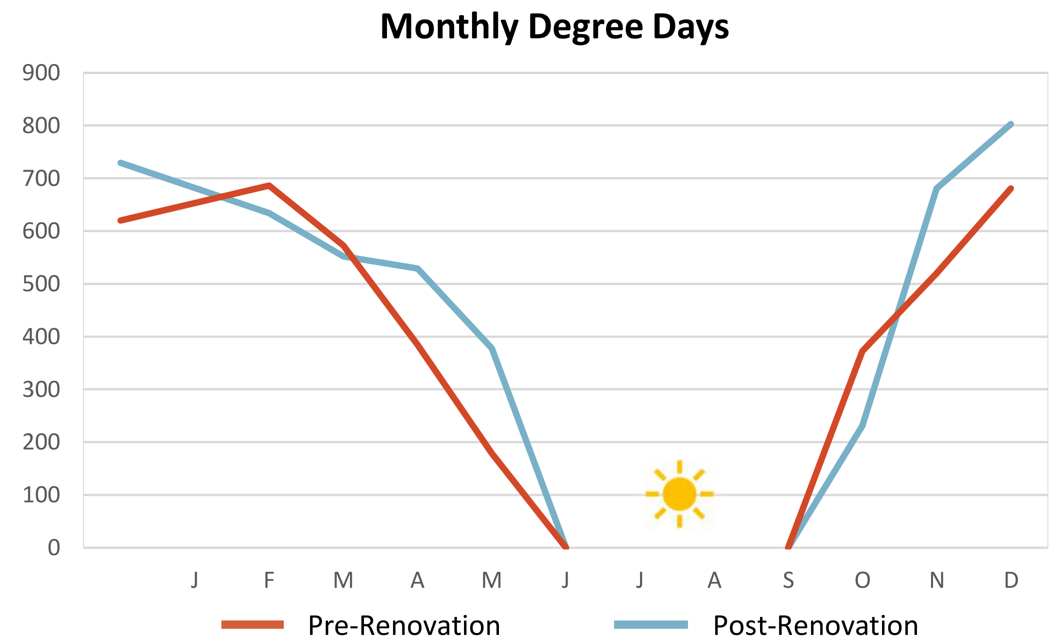
Results – Final Test

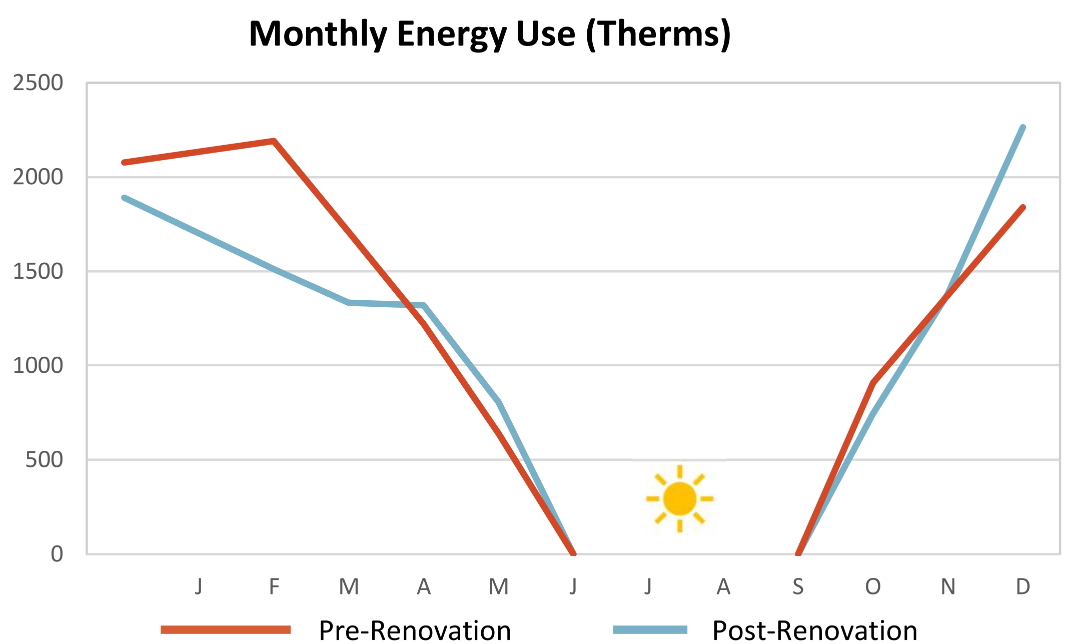
- Still room for improvement
- Some locations were missed or were not accessible
- Sealing of blocking at rafters was a 3D problem (car decking to rafters could not be sealed).

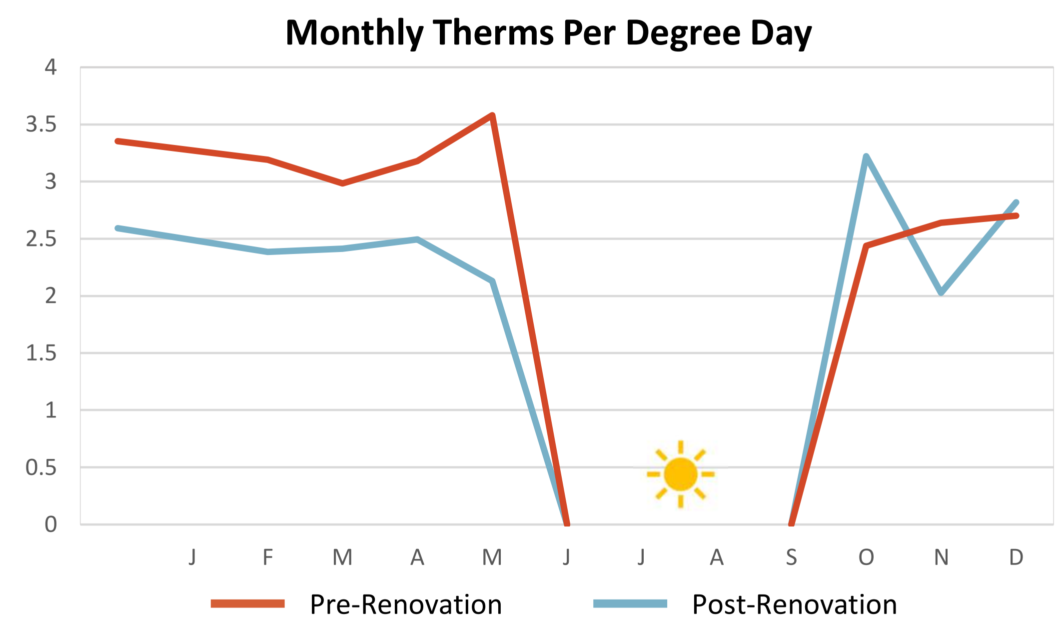
Data Analysis

After the first year of occupancy space heating was a 36.24 EUI, a 15.9% reduction in space heating energy use.

Normalized for weather, the savings were 16.8%.







Results – Occupancy

- *"Energy use is down, and definitely feels better for user comfort too."*

- *"I used to be able to see daylight between the rafters and the blocking at the perimeter of the pier. Unsurprisingly when that was closed up the draftiness and thermal comfort improved greatly!"*

- *"When I felt a breeze through the gaps between the wall and the roof structure, I knew I would have a tailwind on the way home."*

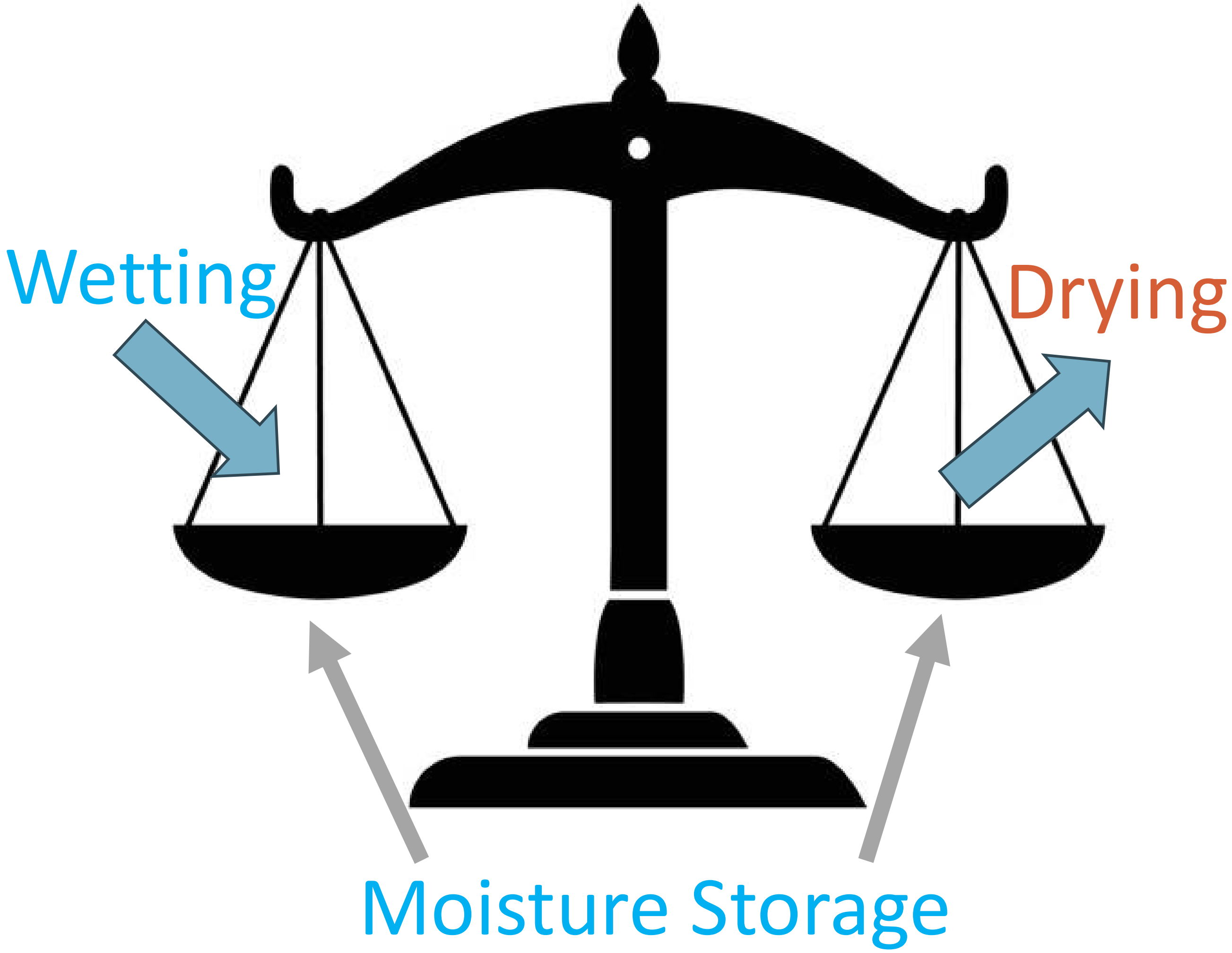
Moisture Risk Assessment – Historic Buildings

- Start with analysis of the existing conditions

Credit: Big Fan of Building Science (@buildingscifan)

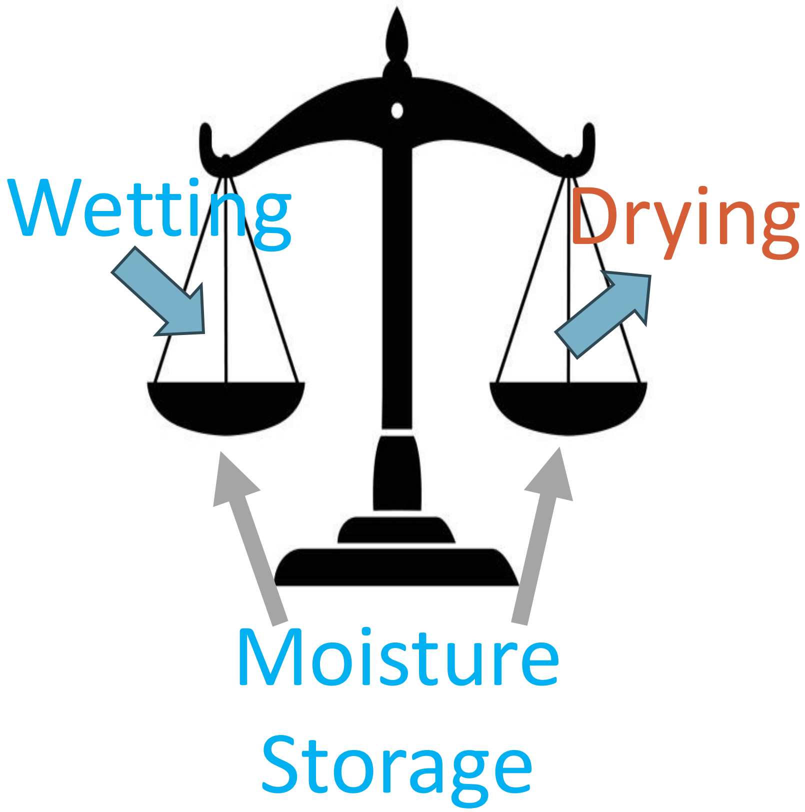
Moisture Risk Assessment

- Moisture management in a building requires balancing wetting and drying
- Typically consider the 4 D's
  - Deflection
  - Drainage
  - Drying
  - Durability



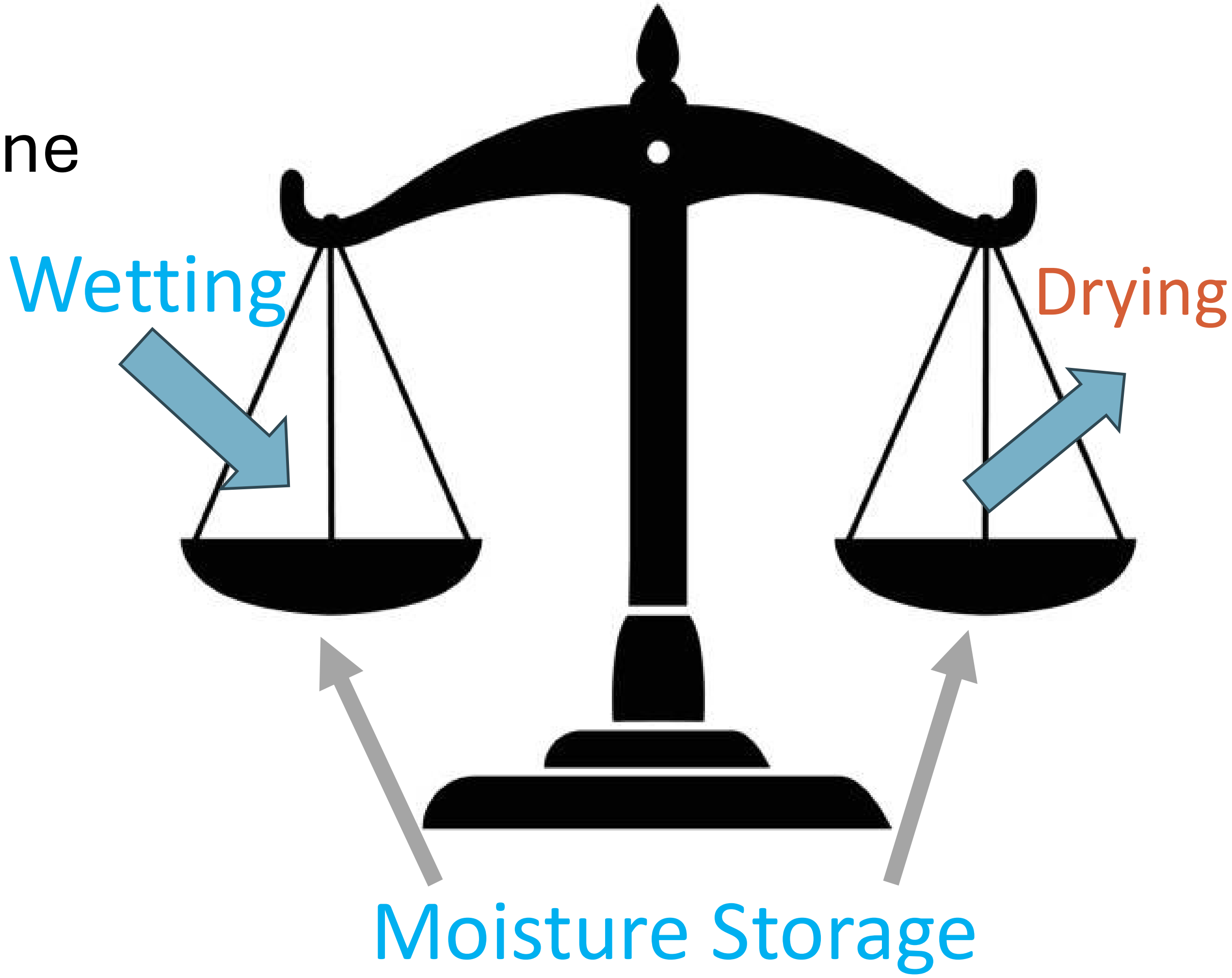
Moisture Risk Assessment

- Moisture balance before work done



Moisture Risk Assessment

- Moisture balance after work done



Moisture Risk Assessment

- Mechanical system is unchanged
- Insulation unchanged
- Air leakage decreased by 15%

Conclusions

- Increasing the air tightness of existing larger buildings is necessary.
- Can maintain historic character while improving performance.

Conclusions

- Diagnostic testing can yield informative and actionable data.
- Although the improvements may be small, they do have an impact.

Thank you

Questions?

Jeff Speert, AIA LEED AP
4EA Building Science
jeffs@team4EA.com

4EA
team4EA.com


abaa2024
building
enclosure
conference