BUILDINGENERGY BOSTON

What's Old is New Again: Renewing Historic Enclosures for Modern Performance

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Curated by Fred Davis and John Deans

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Presenters

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Partners & Collaborators

Learning Objectives*

- **Identify types of exploratory and investigative work that should be completed in early pre-construction efforts**
- **Review types of analysis and how to interpret data from building investigations, including hygrothermal, embodied carbon, and stakeholder engagement**
- **Develop construction details, material and assembly selections based on analyses**
- **Act on lessons learned from construction, post-occupancy, and implementation for future projects**

*[approved for 1 credit hour toward AIA (LU), BOC, BPI, LEED (BD+C, ID+C), and NAHB certification.]

What’s Old Is New Again

What’s Old Is New Again

Stewarding our cultural heritage through renewal of existing buildings is an important and meaningful way to build enduring connections between past, present, and future.

As architects, engineers, builders and owners, we’re continuously exploring new ways to improve, modernize, and elevate existing buildings.

A regenerative renewal practice, which focuses on renewal of historic buildings, strategic reuse planning studies, and high-performance retrofits, is committed to identifying strategic and targeted investments that extend service life, improve functionality, reduce operating costs, and increase comfort.

Building the movement starts with a deep understanding of existing materials and assemblies, and through an integrated process, developing strategies that improve performance while simultaneously being conscientious of resources and cultural impact.

What’s Old Is New Again

Why it’s important:

- **Building reuse** is climate justice
- **Preserves** significant buildings that define the character of **legacy campuses**
- Addresses deferred maintenance and **extends the life** of current resources
- **Adapts** envelope for performance, programmatic, and social **needs**

What’s Old Is New Again

Why it’s hard:

- It can be a long, non-linear **process**
- Most early and mid-century buildings have **limited space** to support modern infrastructure or programmatic requirements
- **Client buy-in**: not all clients are eager to spend money renovating an ‘old’ building when they could build something flashy and new

Developing a Roadmap

A/E

Conservator/Lab

Building Scientist

Pre-design

SD

Initial building assessment

- Review existing documents
- Visual survey

Decision

- Renovate, rehab & addition

OR

- Demolish and build new

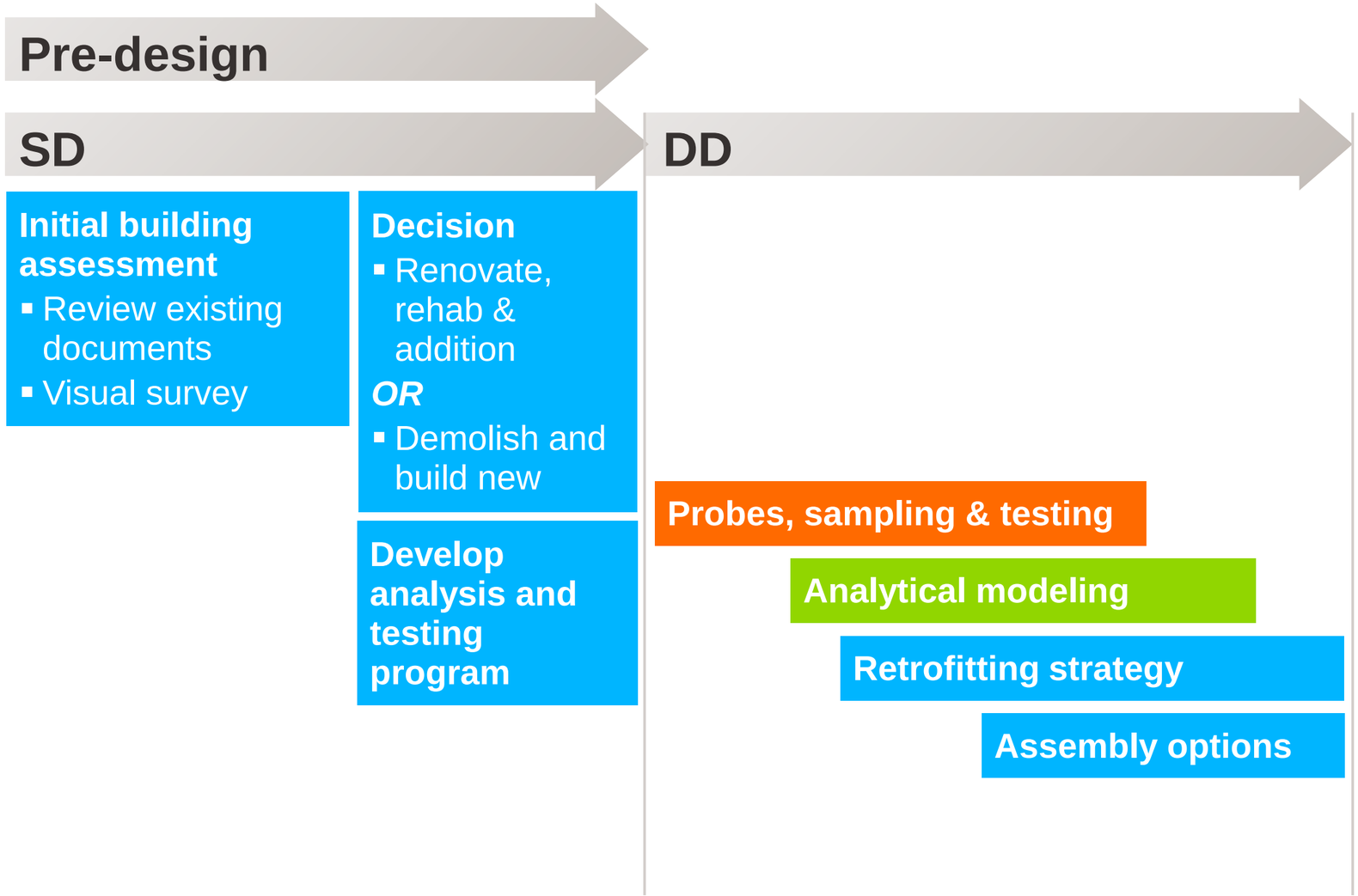
Develop analysis and testing program

Developing a Roadmap

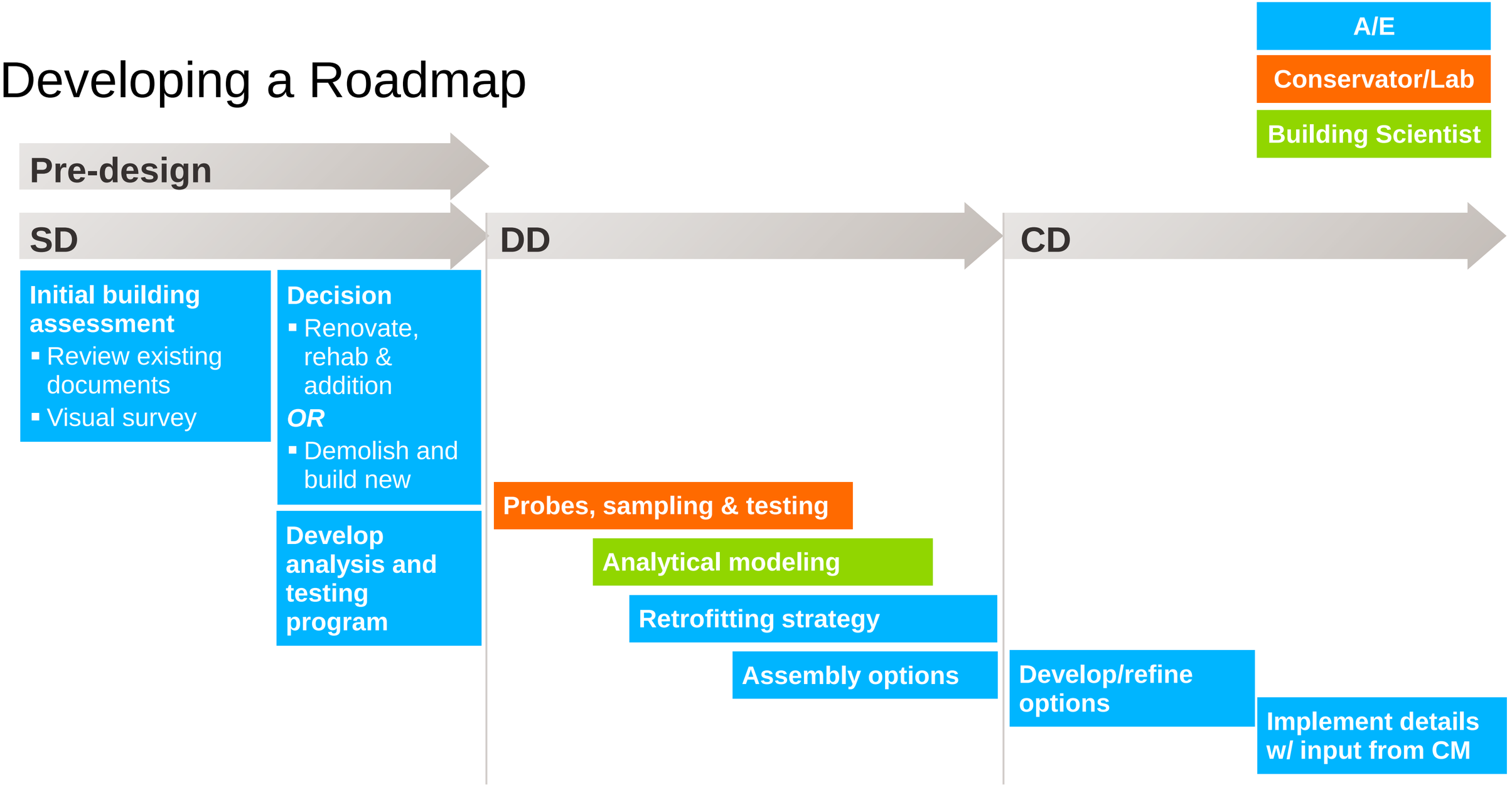
A/E

Conservator/Lab

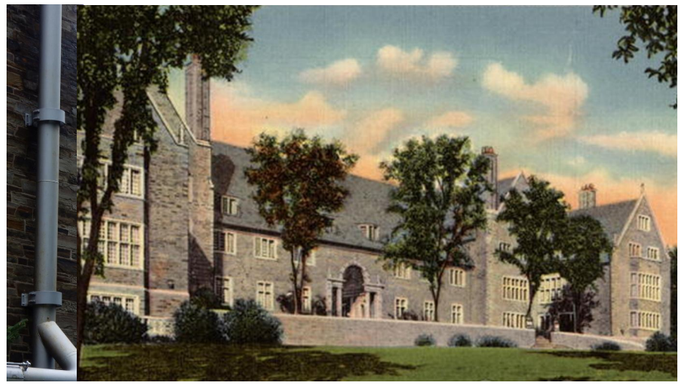
Building Scientist



Developing a Roadmap



Why these projects?



Balch Hall, Cornell University, 1929

- Retain **historic character**
- Improve envelope **performance**
- Address **deferred maintenance**

Addition/Renovation, Private Client, 1936

- Address **deferred maintenance**
- LBC energy & **embodied carbon reduction**
- Preserve **character** through upgrades

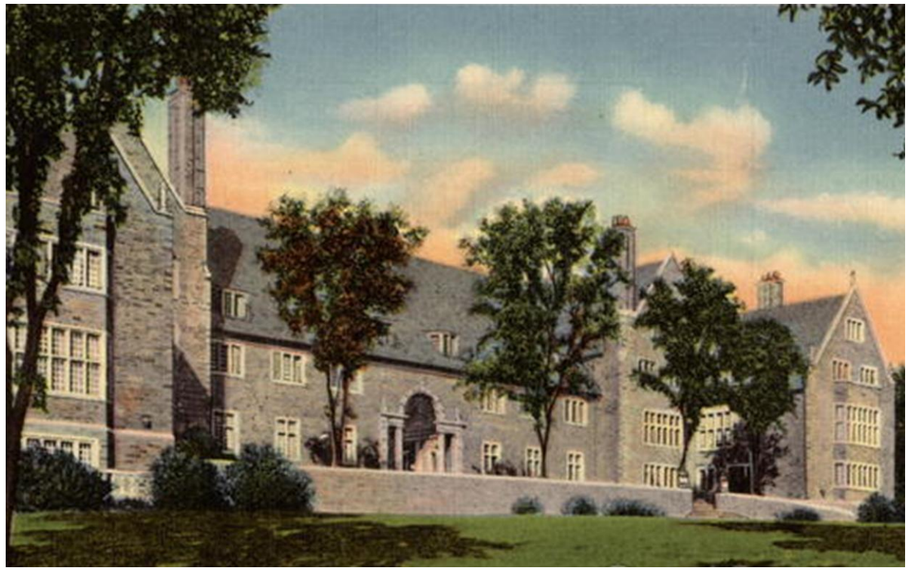
Gant Science Complex, University of Connecticut, 1969

- Reduce exterior air **infiltration**
- Improve envelope thermal **performance**
- **Repair** deteriorated concrete and masonry
- **Transform** into a user-friendly facility

Balch Hall, Cornell University

Project Info
- 1929
- 160,000sf
- Women's dormitory
- Steel frame structure with ribbed concrete slabs and Llenroc masonry exterior wall

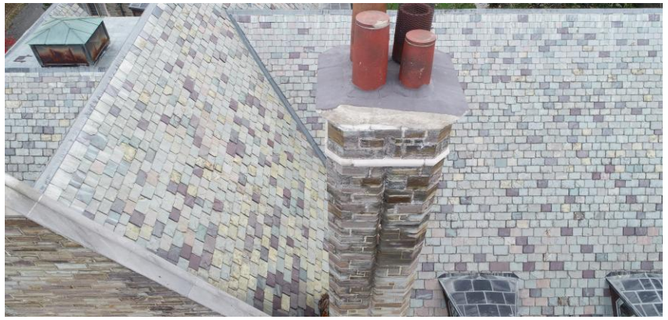
Goals for envelope:
- Retain **historic** character, inside and out
- Provide **equitable** and fully accessible student experience
- Improve envelope performance
- pEUI of 40 kBtu/sf/yr



Balch Hall, Cornell University

Investigations/Analyses

- Complete visual survey
- THERM
- WUFI hygrothermal analysis
- Existing materials testing
  - Dry Bulk Density Porosity
  - Thermal conductivity
  - Water Absorption
  - Vapor Permeance
  - Water content
  - Free water saturation
  - Freeze-Thaw Saturation
- Exploratory probes
- TALLY Lifecycle Carbon Assessment



DRONE SURVEY OF ROOF

FAÇADE SURVEY

MASONRY PROBES AND SAMPLES

WINDOW SILL CONDITION

INTERIOR WALL ASSEMBLY PROBE

Balch Hall, Cornell University

- Project Scope

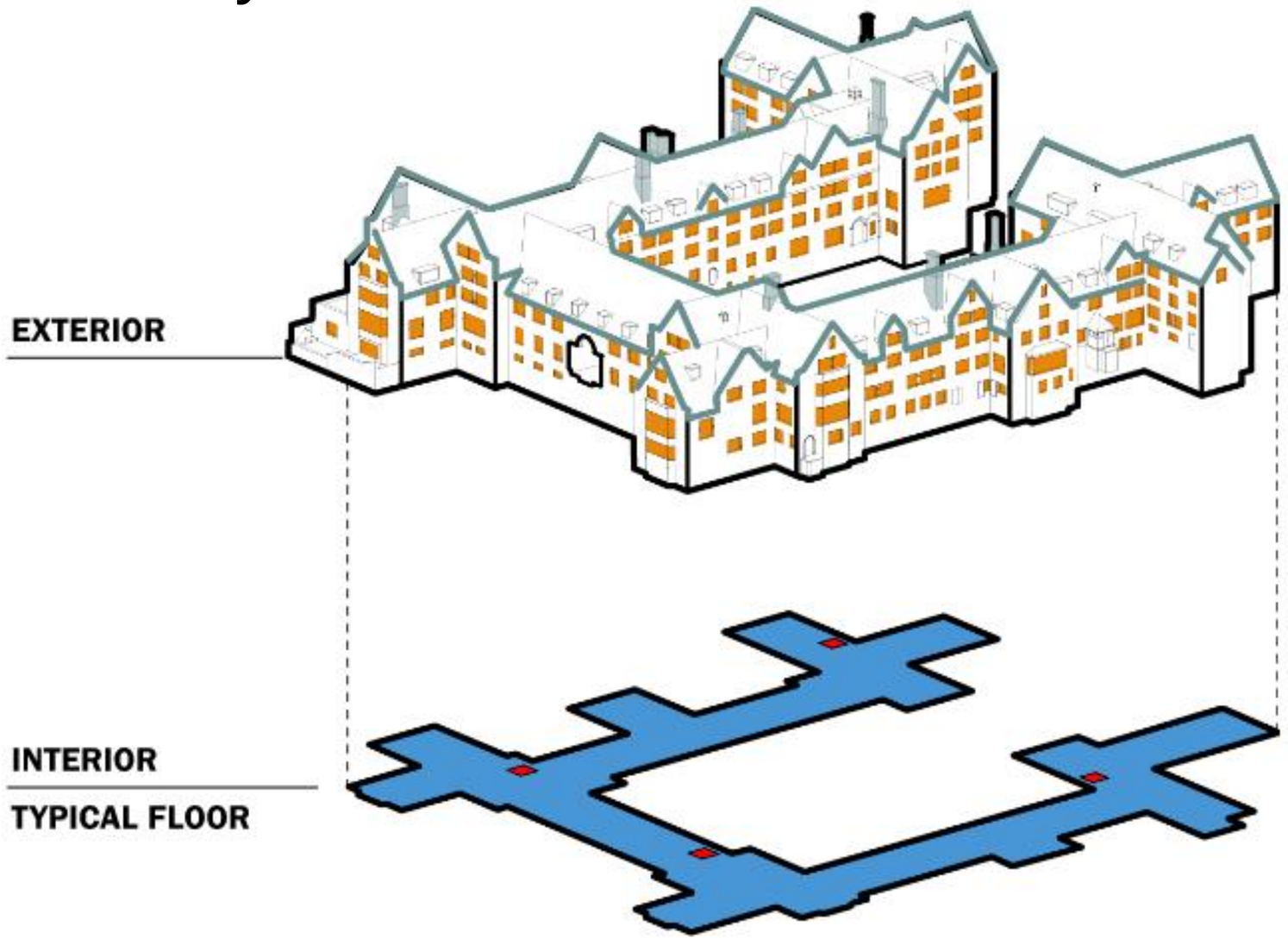
Replace Windows

Insulate from Interior

Limited Roof Restoration

Full Interior Reno

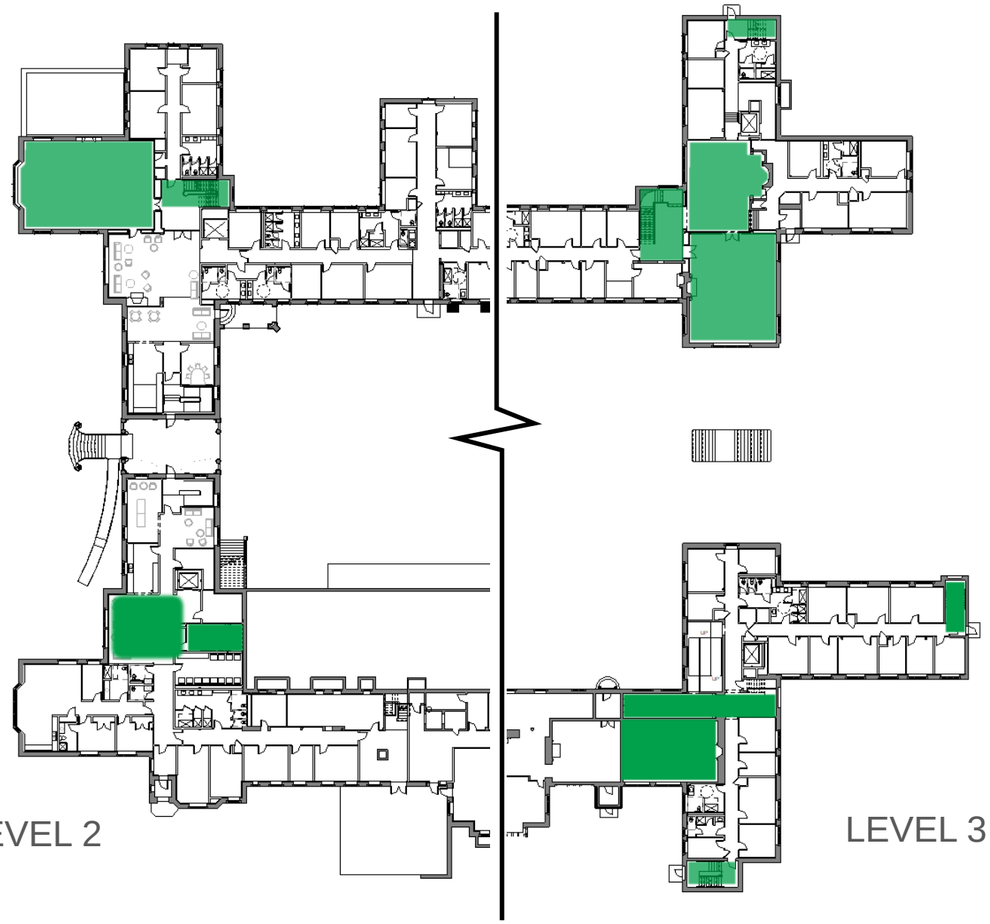
New Elevator



Balch Hall, Cornell University

- Continuity of character vs continuity of insulation

Areas with existing to remain finishes,
and no added insulation



Balch Hall, Cornell University

Insulation considerations for roof and wall assemblies each:

PERFORMANCE

- What thermal and moisture concerns do we need to address?
- What type of insulation and R-value should we use?
- How does thickness impact interior space?

REVERSIBILITY

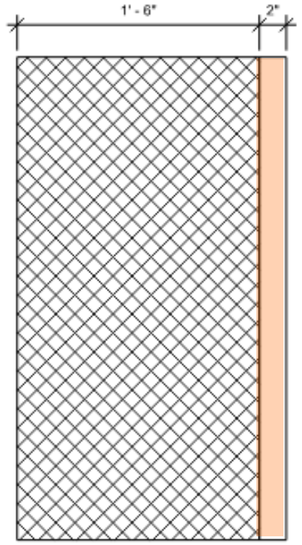
- How do we preserve or protect the original building?
- What happens if future damage, or maintenance is needed?

INSTALLATION

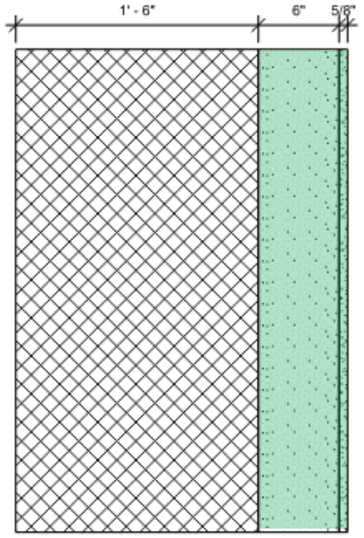
- What is the ideal product form (board, batt, spray)?
- How is it integrated with or fastened to existing assemblies?
- How does it handle complex geometries (pitched roof and dormer windows)?

Balch Hall, Cornell University

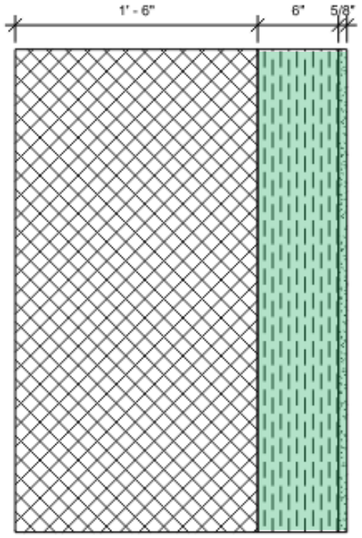
- Insulation questions at schematic design:
  - What type and thickness of insulation?
  - Keep or remove the existing plaster?



Existing
R3
- 18" Llenroc stone
- 2” plaster and metal lath

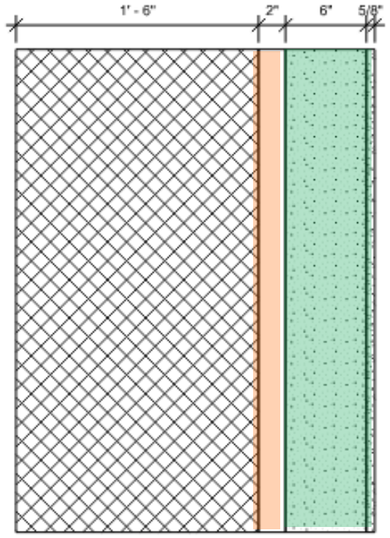


Proposed
6" Closed Cell Sprayfoam



Proposed
6" Mineral Wool + Smart Vapor Barrier

Remove plaster and lath



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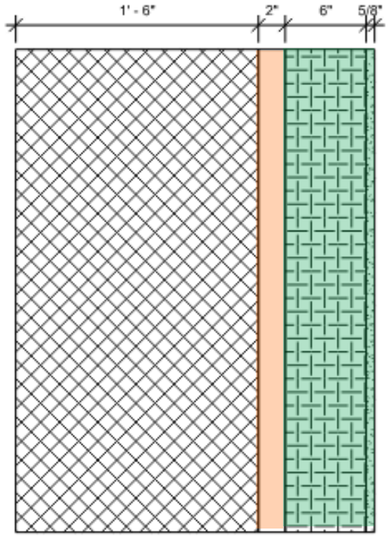


Proposed
6" Mineral Wool + Smart Vapor Barrier

Keep plaster and lath

Balch Hall, Cornell University

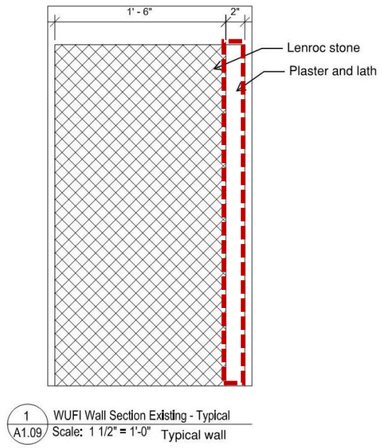
WUFI Analysis, Nov 2018

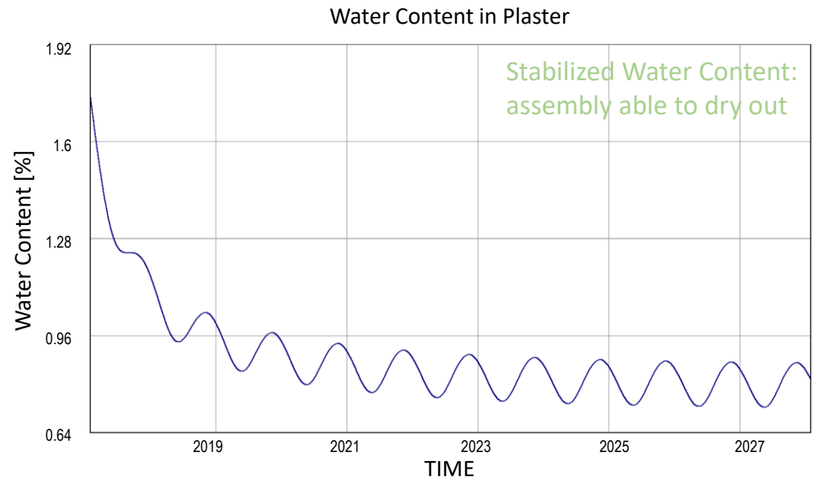
- Material Testing had not been performed
- Question: Should plaster/Lath be removed?
- Result: Yes.

Hygrothermal Analysis

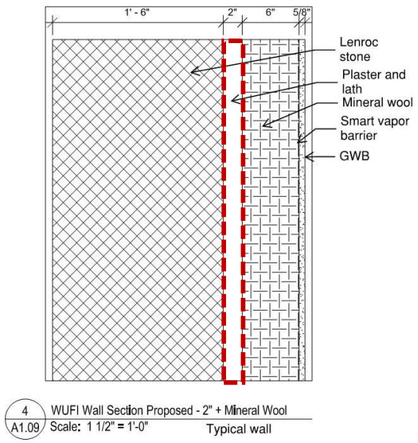
1. Plaster / lath: should it be removed?
   The addition of insulation prevents heating from inside from keeping plaster dry

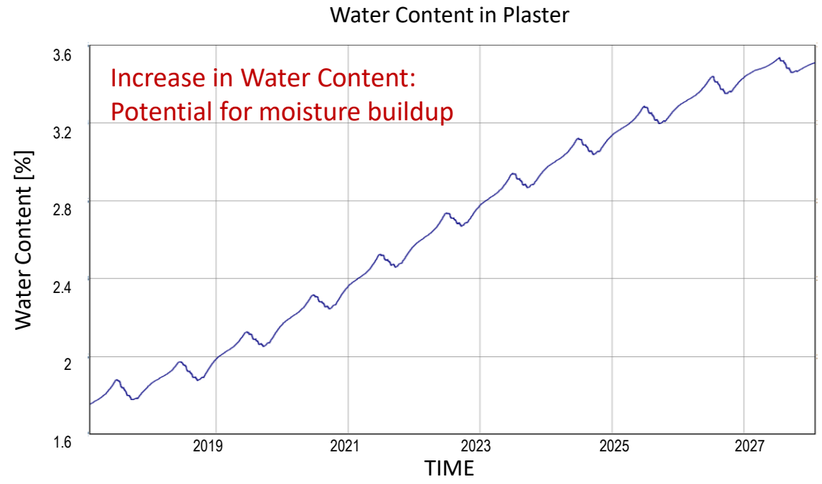
Existing





Proposed: Existing + MW



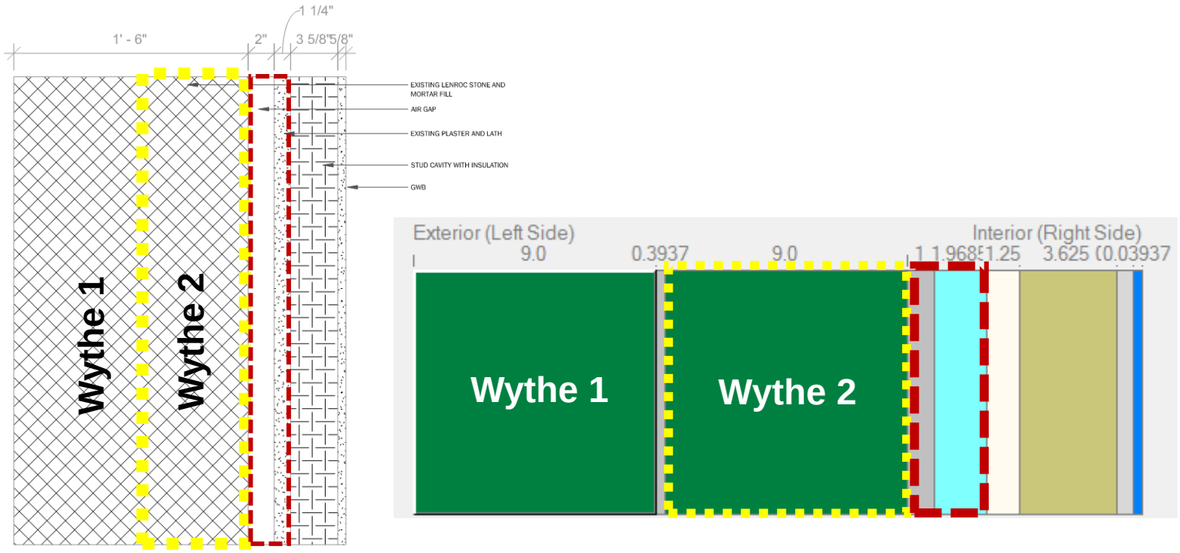


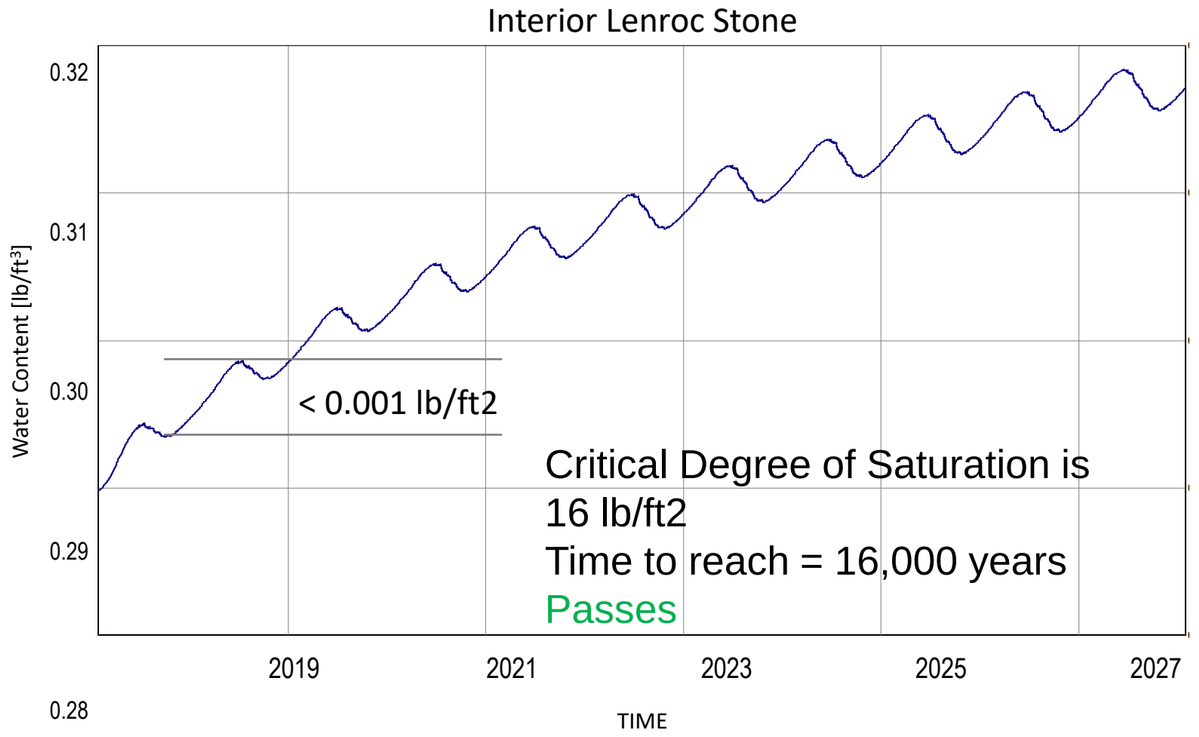
(Proposed: Existing + ccSPF is similar)

Balch Hall, Cornell University

WUFI Analysis, June 2019

- Material Testing results received
  - Llenroc stone has lower water absorption rate than assumed
- Result: Plaster and Lath can remain
  - Mineral Wool (MW):
    - Smart vapor retarder / air barrier on interior of MW is critical
    - 3 5/8” insulation thickness or lower is recommended
  - Closed-cell Spray Foam (cSPF):
    - cSPF acts as Class II vapor retarder
    - 3 5/8” insulation thickness or lower is recommended





Balch Hall, Cornell University

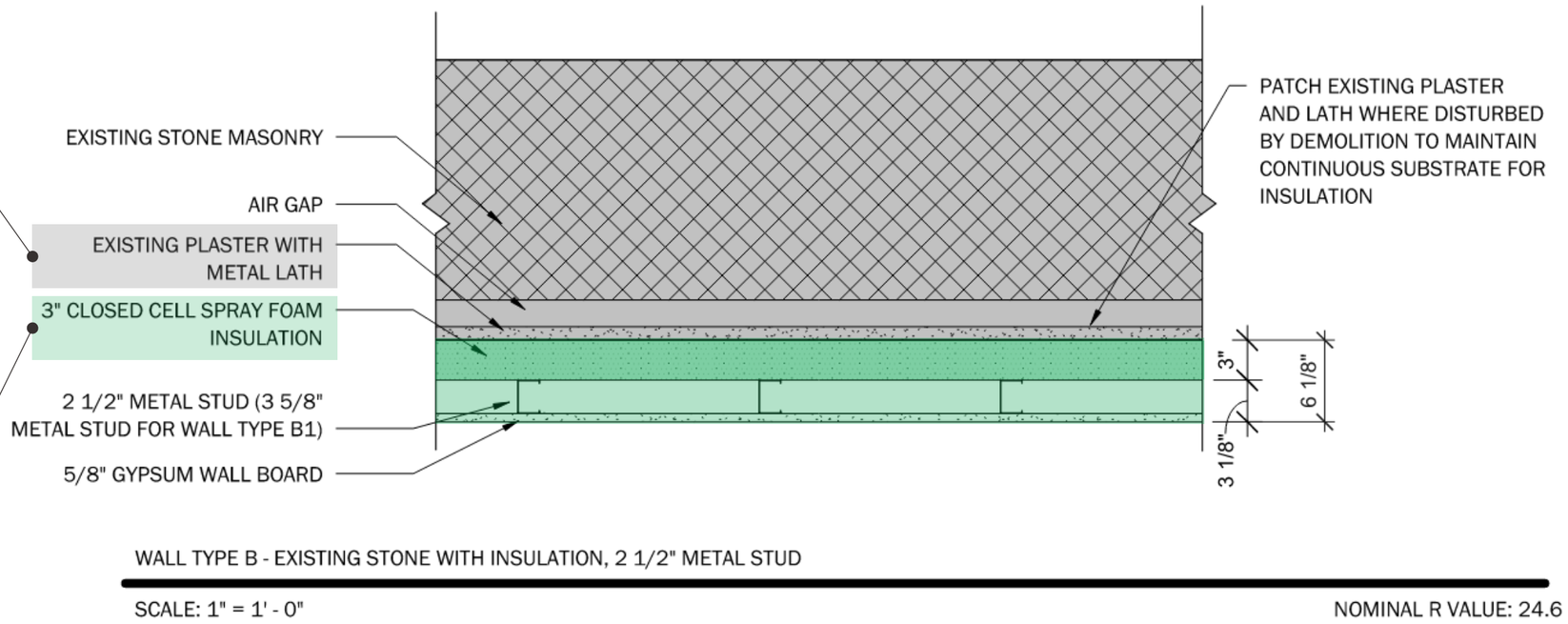
- Final wall assembly

REVERSIBILITY

- Protects Llenroc stone.
- Allows sprayfoam to be removed easily with plaster layer in the future.

PERFORMANCE & INSTALL

- Higher R-value per inch, gaining square footage on the interior
- Continuous application, even at odd geometries
- Functions additionally as vapor barrier, for fewer components to install



Addition/Reno, Private Client

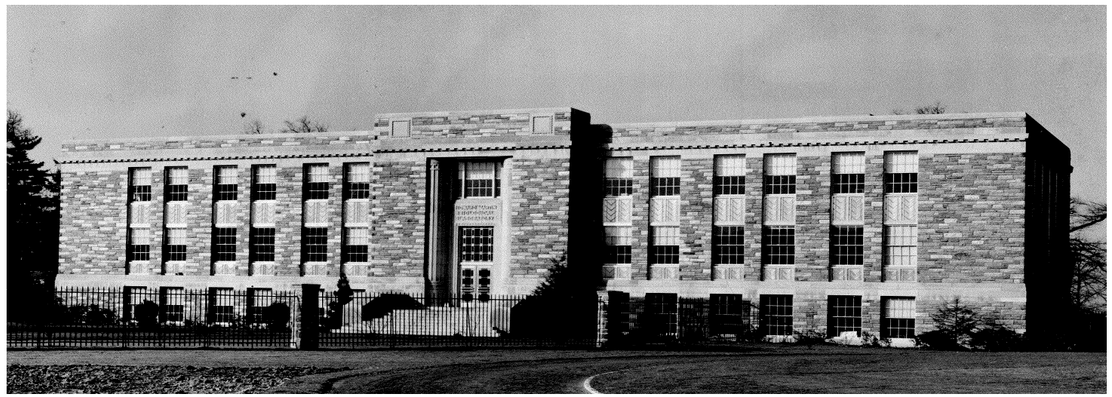
Project Info
- 1936
- 28,500sf (original building)
- 33,675sf new construction
- 13,937sf renovation
- Biology classrooms
- CIP concrete frame with local stone on cinderblock backup

Goals for envelope:
- Address deferred maintenance
- Universal accessibility
- Meet LBC Core goals for energy and carbon reduction
- Improve performance while preserving character

Addition/Reno, Private Client

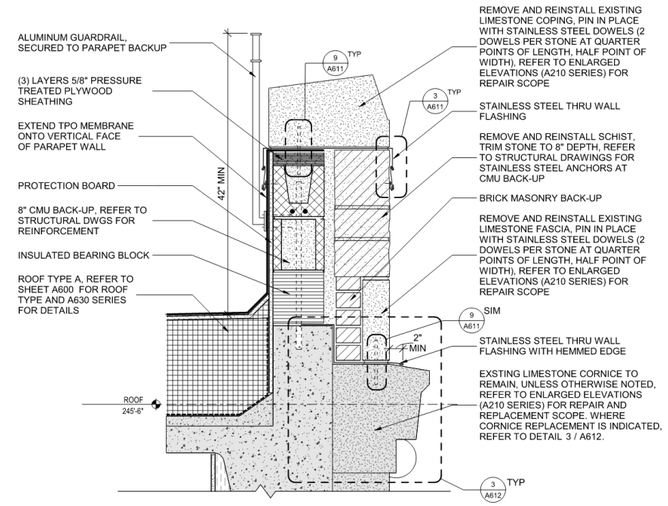
Investigations/Analyses

- THERM
- WUFI hygrothermal analysis
- LCA/LCCA
- Complete visual survey
- Review of Owner history
- Existing materials testing
  - Dry Bulk Density Porosity
  - Thermal conductivity
  - Water Absorption
  - Vapor Permeance
  - Water content
  - Free water saturation
  - Freeze-Thaw Saturation

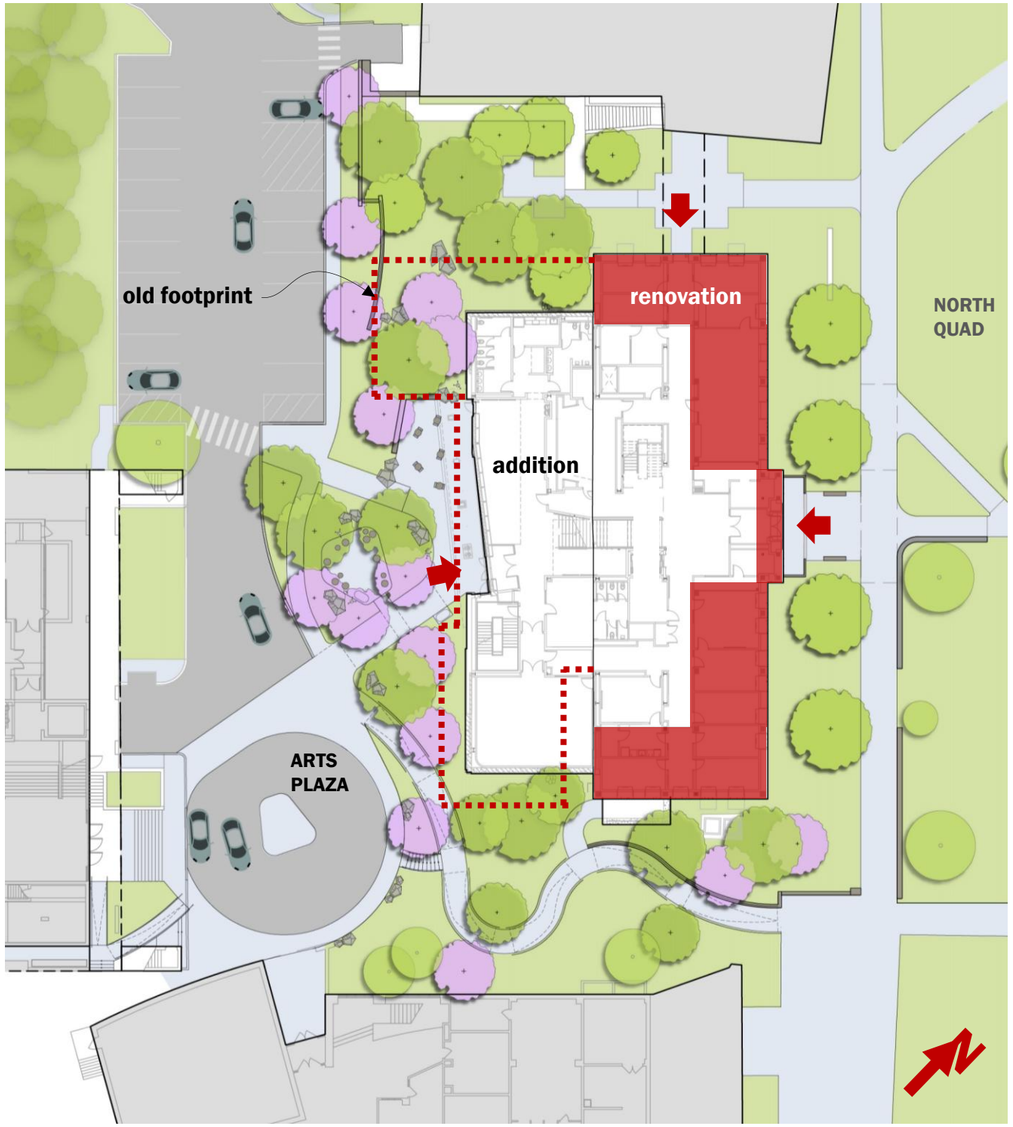


Addition/Reno, Private Client

- How much of the original building *can* we reuse?
- Priorities for façade repair?
- All interventions must be weighed against life cycle cost & character



CARBON FIBER REINFORCING, PARAPET REBUILD

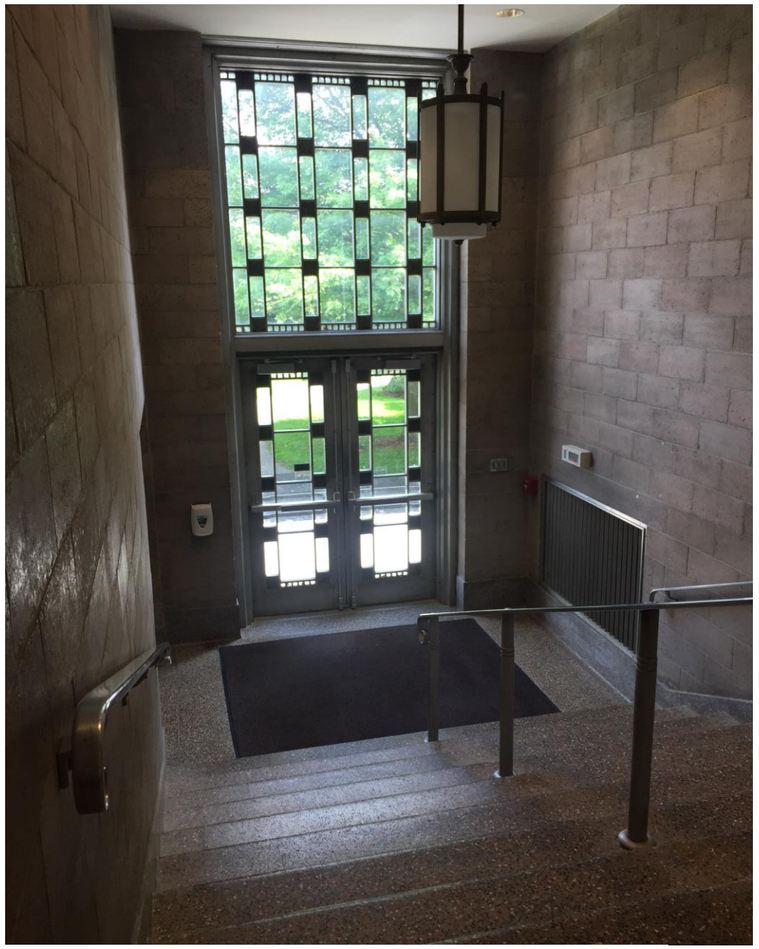


REBUILD STRATEGY

Addition/Reno, Private Client

- Character-defining feature that doesn’t support contemporary use (or social justice)

EXISTING MAIN ENTRANCE (EXTERIOR)

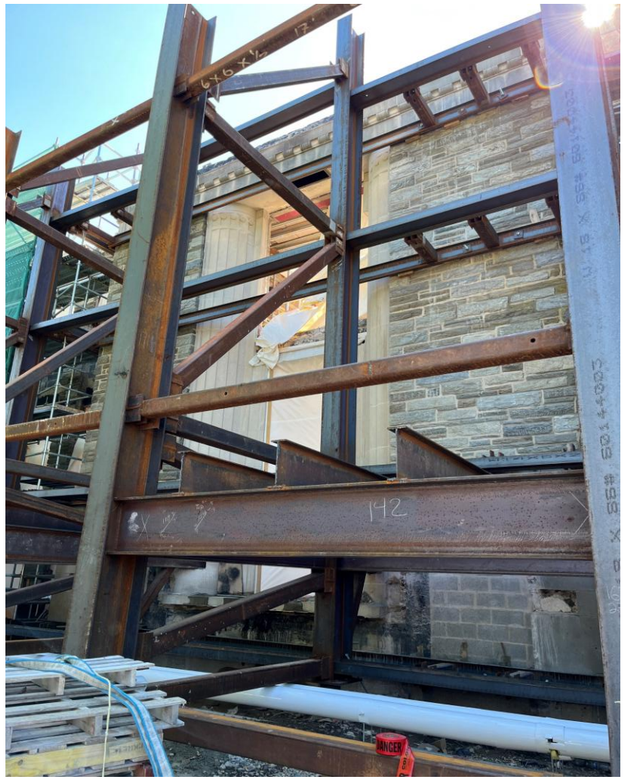


EXISTING MAIN ENTRANCE (INTERIOR)

Addition/Reno, Private Client

- Character-defining feature that doesn’t support contemporary use (or social justice)

RENOVATED ENTRANCE RENDERING

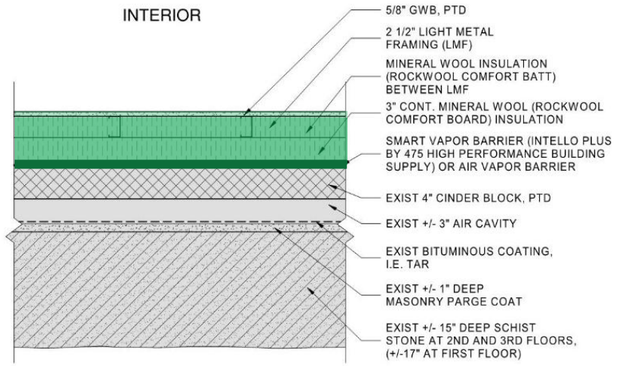


FAÇADE SHORING

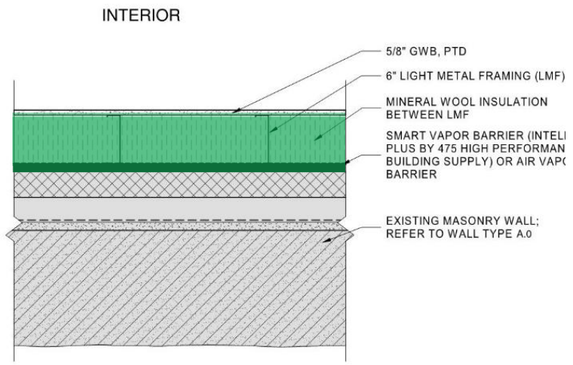
CONSTRUCTION PROGRESS (FEBRUARY ‘25)

Addition/Reno, Private Client

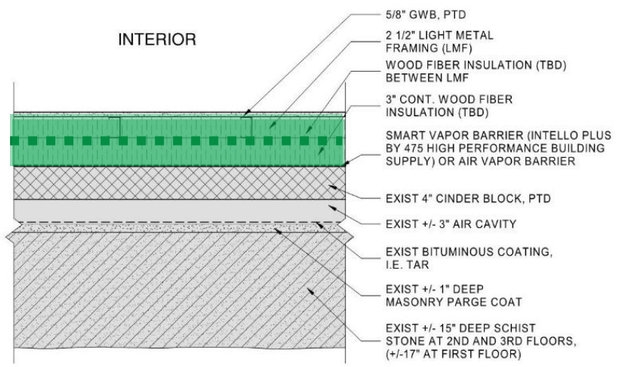
- Interior insulation
- Minimize loss of usable floor space
- Balance added insulation vs performance plateau
- Where to place the AVB?
- Installation?



EXTERIOR WALL TYPE A.0 -
ENLARGED PLAN AT EXISTING STONE PIER



EXTERIOR WALL TYPE A.1 -
ENLARGED PLAN AT EXISTING STONE PIER



EXTERIOR WALL TYPE A.2 -
ENLARGED PLAN AT EXISTING STONE PIER

Addition/Reno, Private Client

Superstructure (div 03-06)

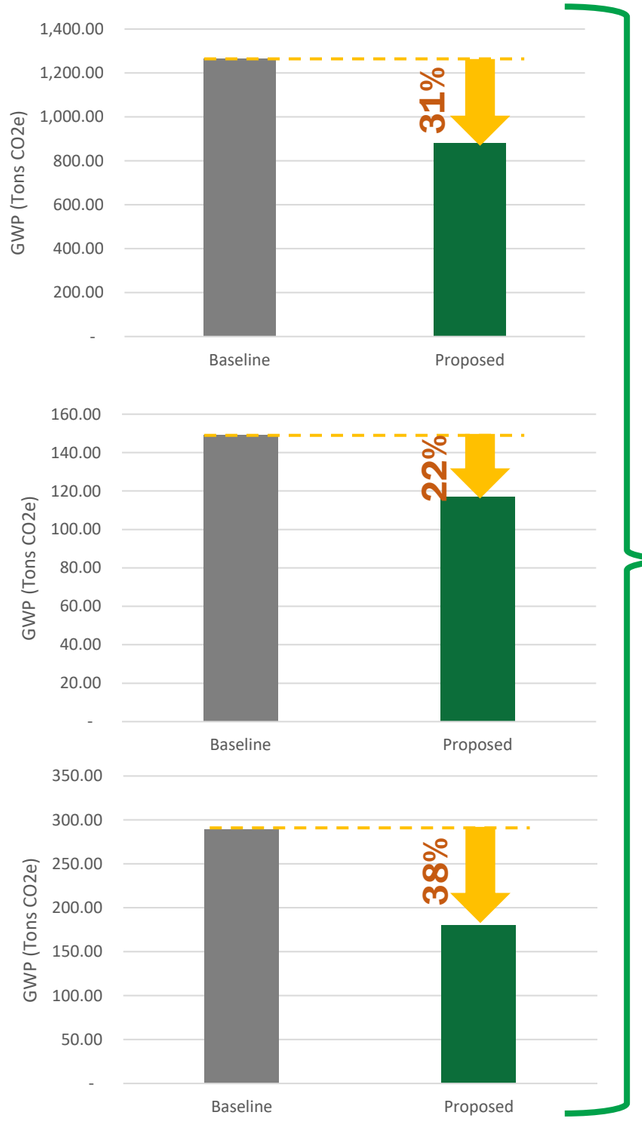
- Reuse Martin (as much as possible)
- Efficient retrofit of existing structure
- Cement replacement (40%)*
- *Wood structure – not feasible*

Enclosure (div 07-08)

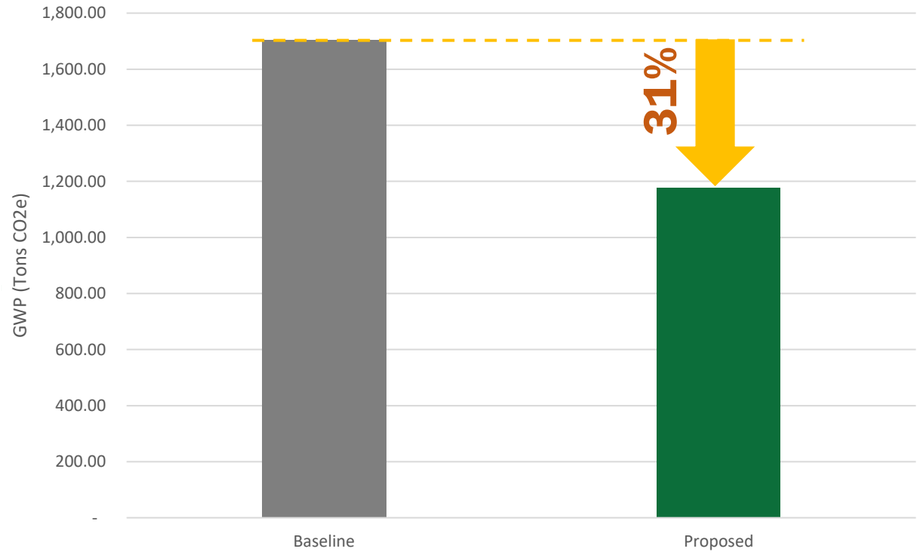
- Wood/composite glazing systems vs aluminum-framed
- Recycled brick veneer*
- *Wood fiber insulation i.l.o. mineral wool*
- *Exterior stud size reduction – not considered*

Interior Finishes (div 09)

- Targeted GWB, ACT, carpeting selections
- *Use of salvaged wood*



Whole Building Comparison



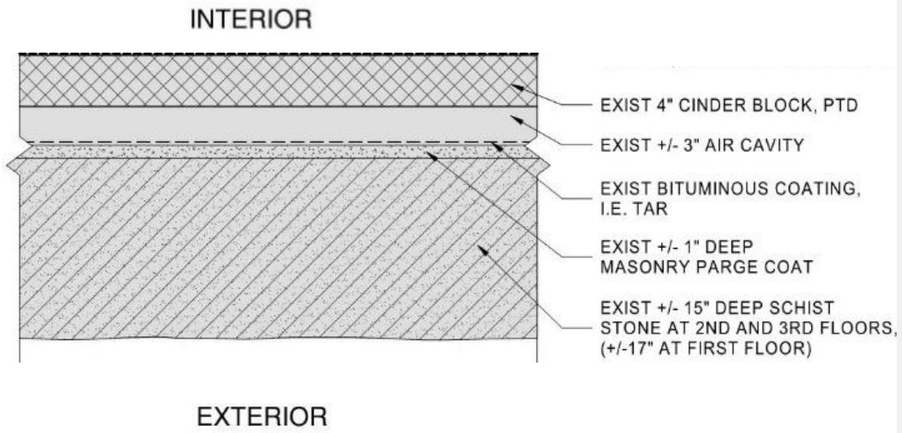
"Projects must demonstrate a 20% reduction in the embodied carbon of primary materials compared to an equivalent baseline."

Addition/Reno, Private Client

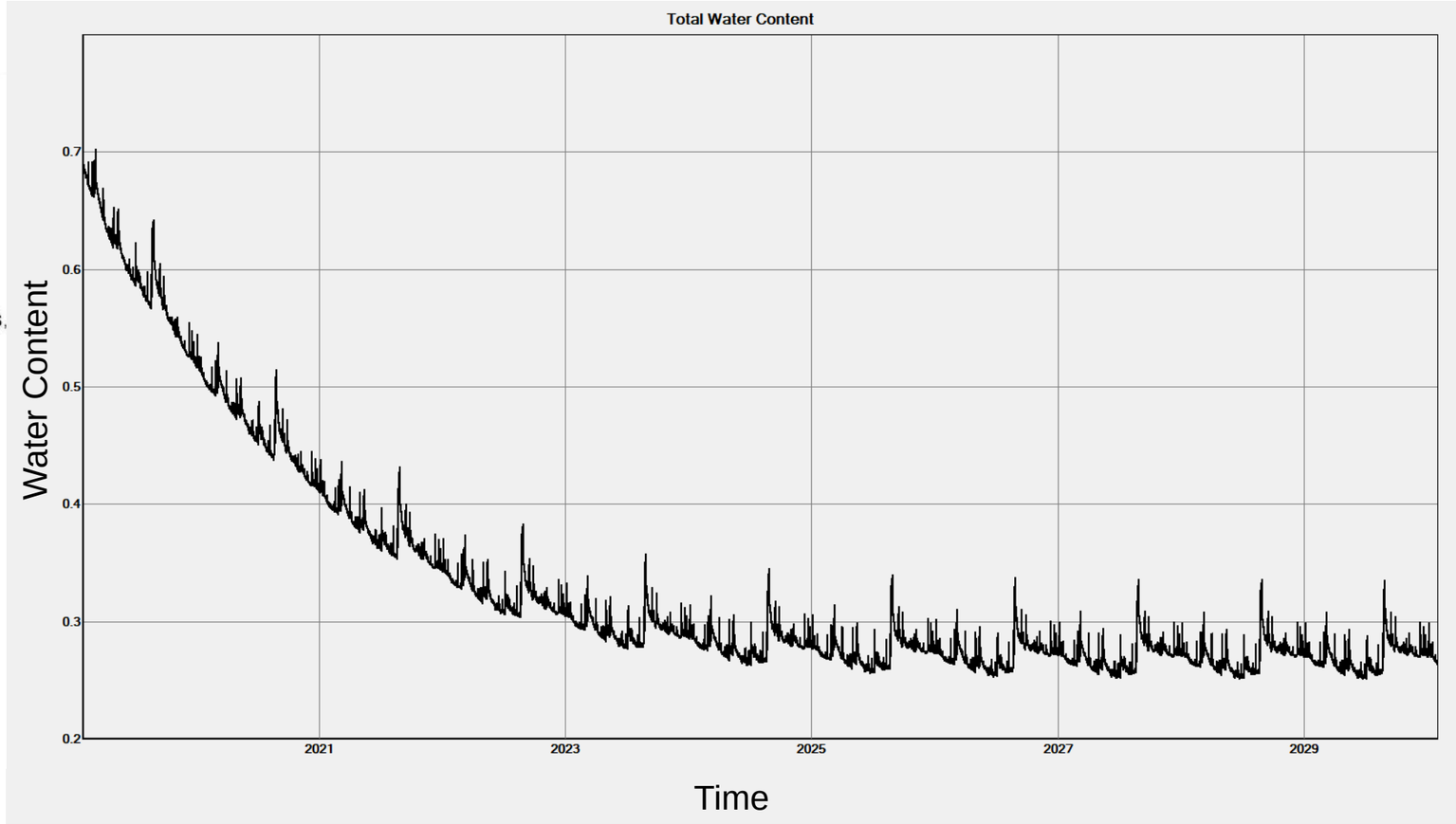
1. Testing from Highbridge Lab for Wissahickon schist, mortar, and painted concrete block
2. Bituminous coating (tar) assumed to be 5 perms
3. Interior paint assumed to be 1 perm for all proposed cases studied

Property	Units	Material		
		Wissahickon schist	Mortar	Concrete block
Absorption (2-hour boil)	%	0.39	8.6	26.0
Specific gravity (2-hour boil)	-	2.83	2.70	[2.04][1]
Apparent porosity (2-hour boil)	m^3/m^3	0.011	0.188	0.347
Dry bulk density (2-hour boil)	kg/m^3	2799	2190	1336
Porosity (vacuum saturation)	m^3/m^3	0.010	0.194	0.352
Thermal conductivity	$W \cdot m^{-1} \cdot K^{-1}$	2.63	2.05	0.758
Heat capacity	$kJ \cdot kg^{-1} \cdot K^{-1}$	0.728	0.770	0.831
Initial A-value [2]	$kg \cdot m^{-2} \cdot s^{-0.5}$	0.0012	0.0375	0.4092
Secondary A-value [2]	$kg \cdot m^{-2} \cdot s^{-0.5}$	0.0006	0.0178	0.1717
WVT rate	$g \cdot m^{-2} \cdot h^{-1}$	1.1	4.6	6.5
Water vapor permeance	US perms	2.3	9.5	13.5
Water vapor permeability	perm-in	1.8	4.9	10.3
Vapor diffusion resistance factor	-	87	30	14
Reference water content [3]	kg/m^3	1.66	25.32	19.41
Free water saturation	kg/m^3	11.25	189.87	287.26

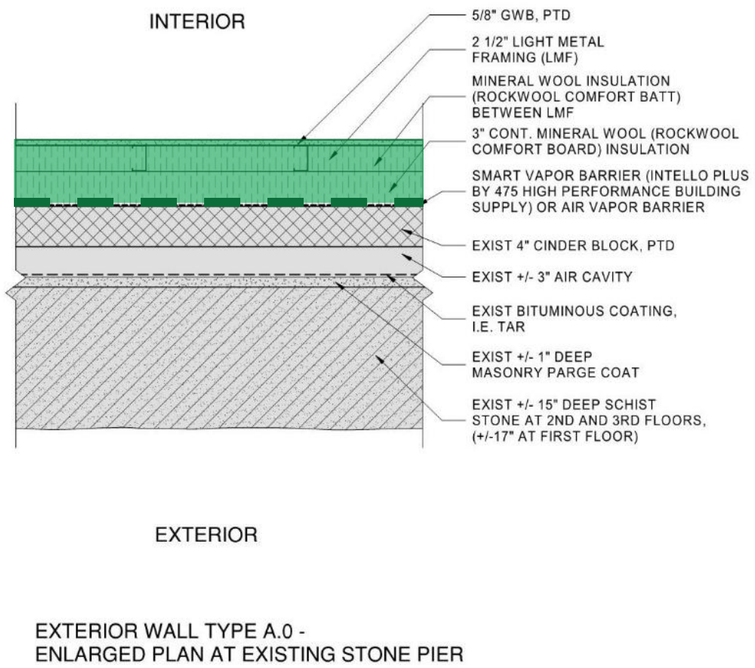
Addition/Reno, Private Client



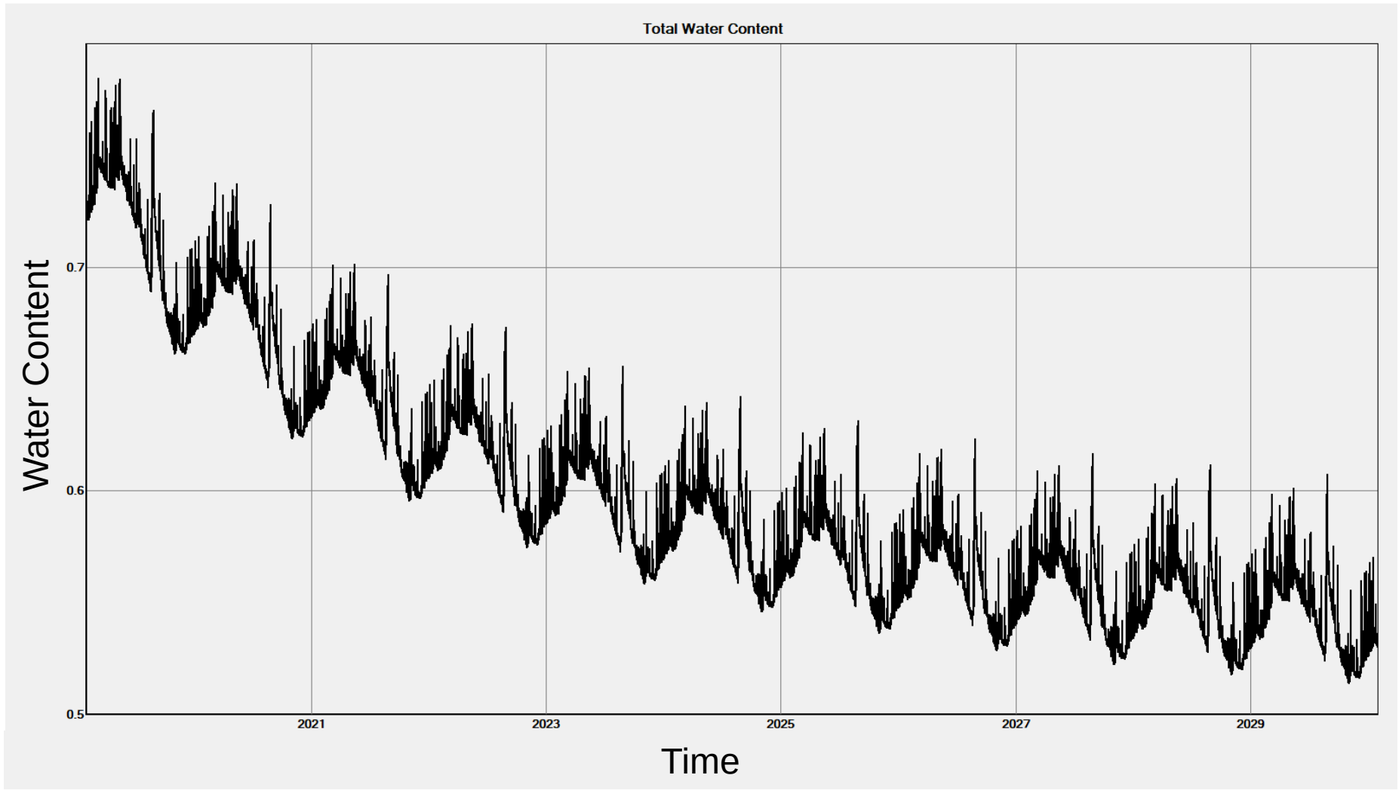
Observed to be in overall good condition – hygrothermal analysis matches, passing all criteria studied



Addition/Reno, Private Client



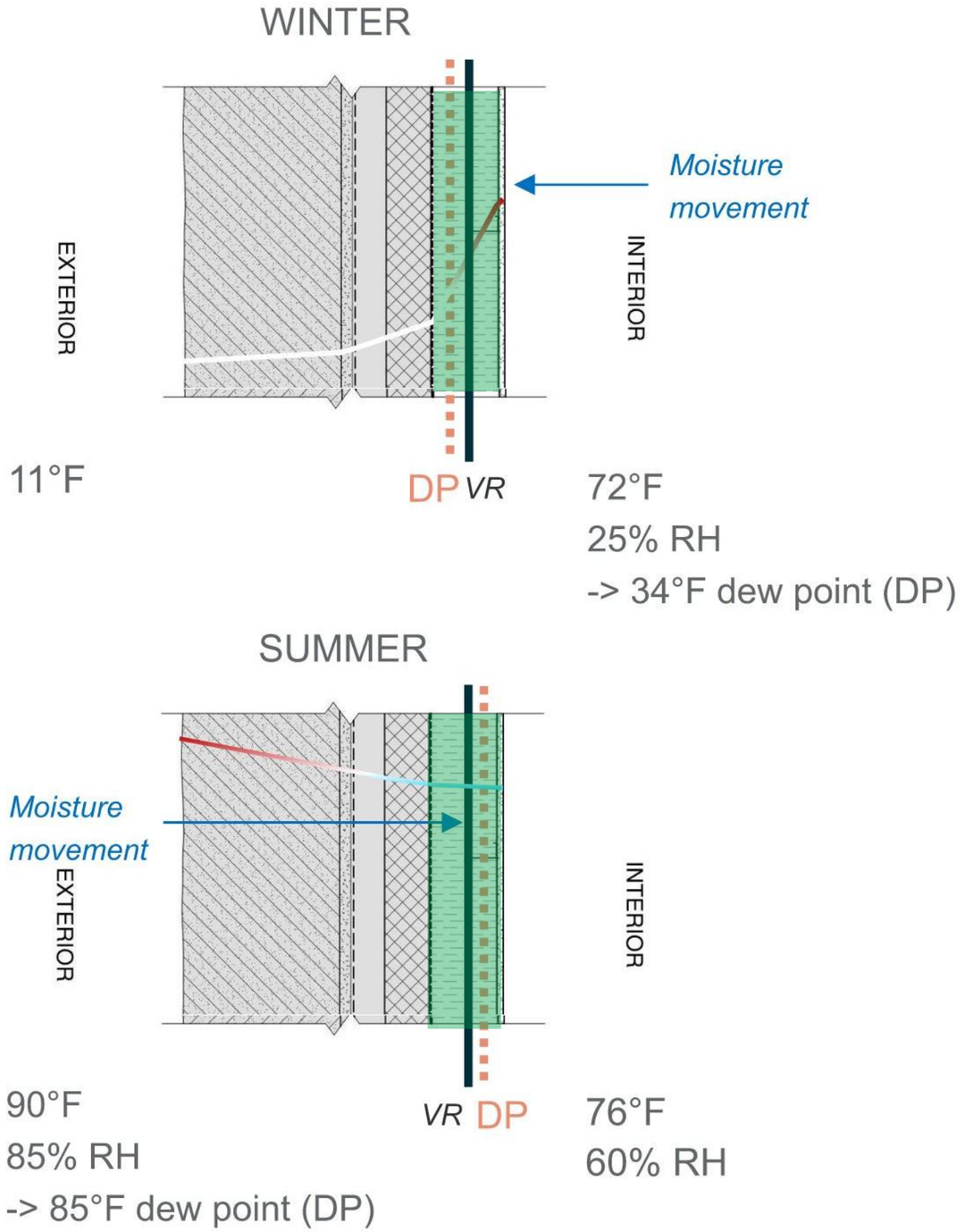
EXTERIOR WALL TYPE A.0 -
ENLARGED PLAN AT EXISTING STONE PIER



- Total water content and individual water for the proposed options studied trend downward or stabilize – see above for A.0 (all others are similar)
- Because water content is lower that the critical degree of saturation (Scrit) provided by Highbridge's materials testing, the cases studied pass freeze-thaw criteria
- Mold growth at key interfaces for the cases studied has been found to meet the criteria for the Viitanen Mold Growth Index (MGI)
- Dew point is outlined in the following slides

Addition/Reno, Private Client

- Existing elastomeric coating was sufficient as AVB
- Added insulation balanced w/ carbon reduction and energy savings
  - (more insulation wasn't improving energy performance, and caused concerns hygrothermally)
- 3" continuous between existing wall and new framing



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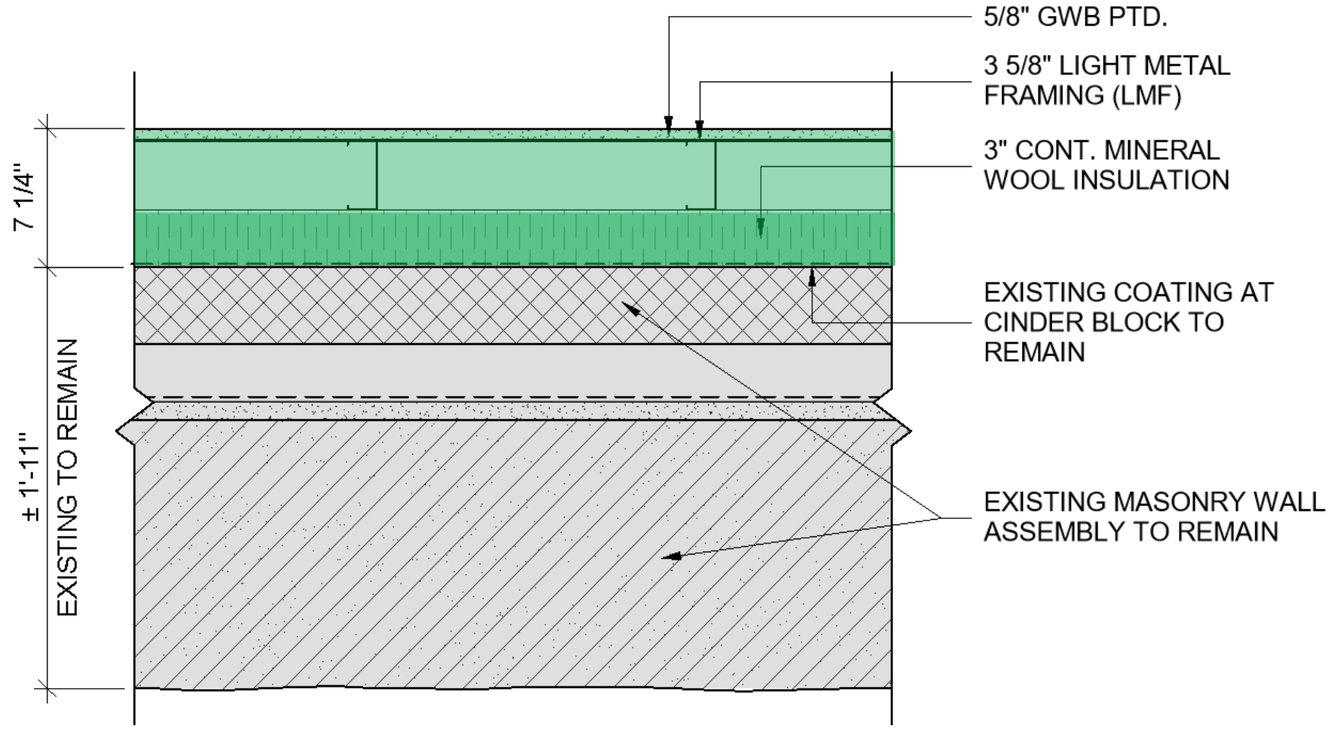


EXTERIOR WALL TYPE A - EXISTING MASONRY WITH INTERIOR INSULATION

Gant Science Complex, University of Connecticut

Project Info

- 1969
- 285,000 sf (renovation)
- 25,000 sf (new construction)
- Multi-disciplinary science teaching & research labs
- CIP concrete frame with brick spandrel and CMU back-up

Goals for envelope:

- Reduce air infiltration
- Improve thermal performance
- Repair deteriorated concrete and masonry
- Transformative

Gant Science Complex, University of Connecticut

Investigations/Analyses

- THERM
- WUFI hygrothermal analysis
- Energy Modeling
- Daylighting Studies
- Existing materials survey
- Existing Envelope Benchmark Testing
  - Infrared scanning
  - Blower Door Testing

SPANDRELS & BRICK PANELS

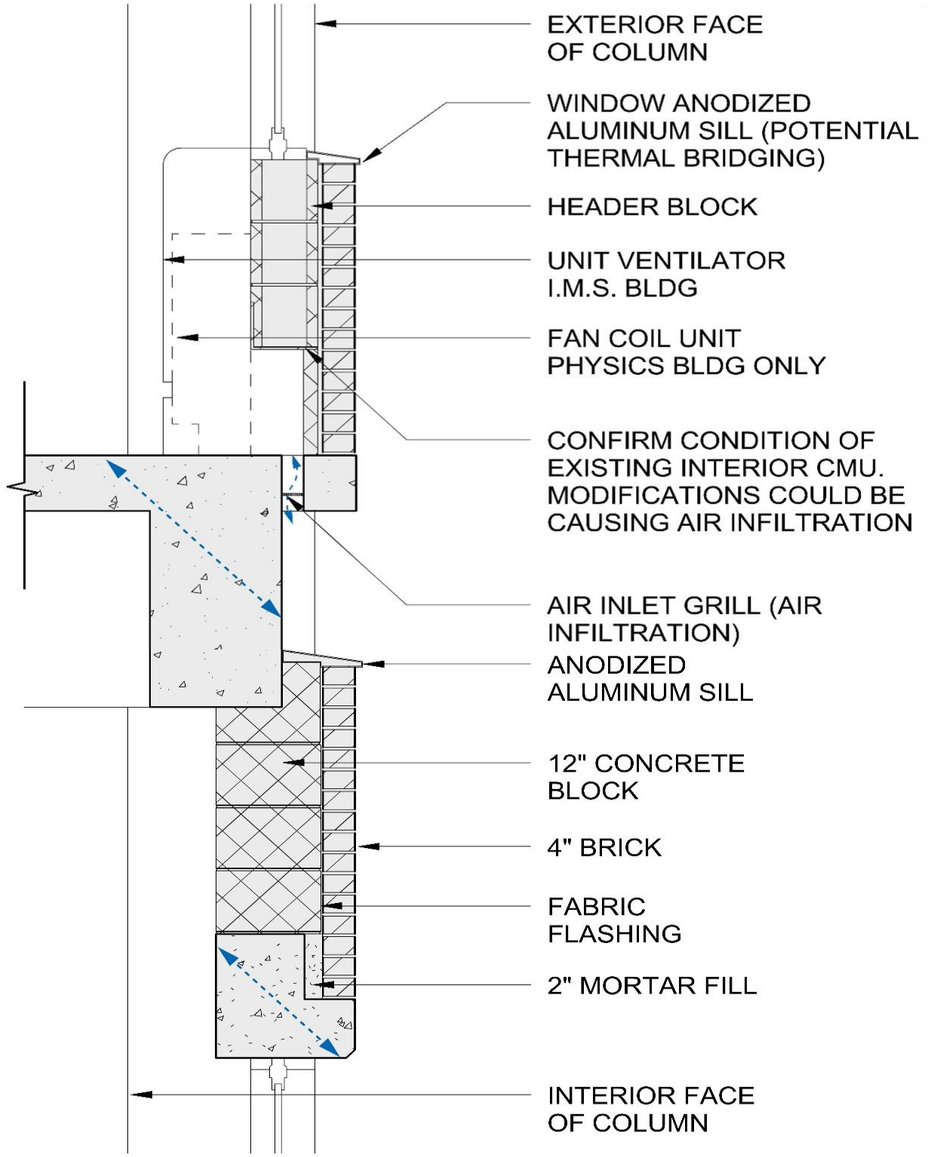
FAILED CONCRETE PATCHES

EXPOSED REBAR

Gant Science Complex, University of Connecticut

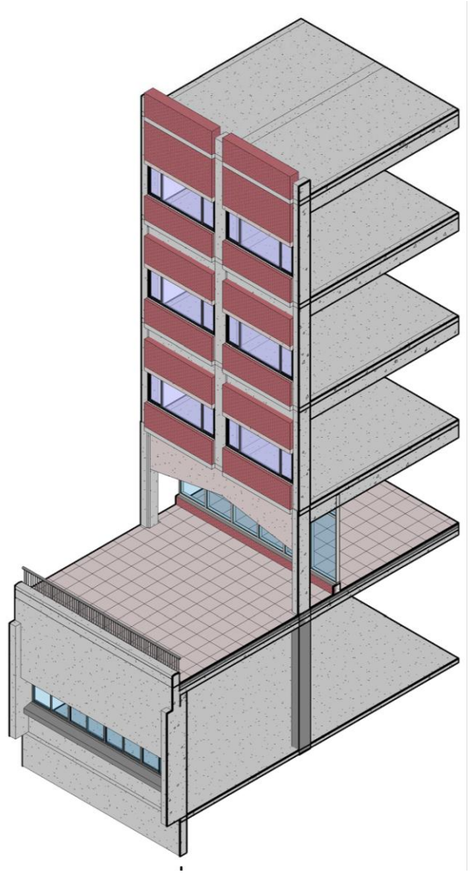
Existing Façade Evaluation:

- R=2.0 (U=0.4) Thermal Resistance
- Air infiltration (severe)
- Deteriorated concrete and masonry

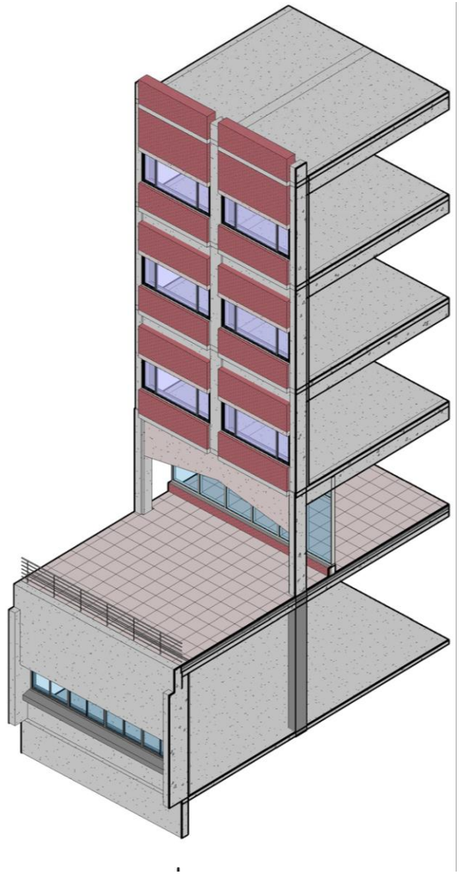


Gant Science Complex, University of Connecticut

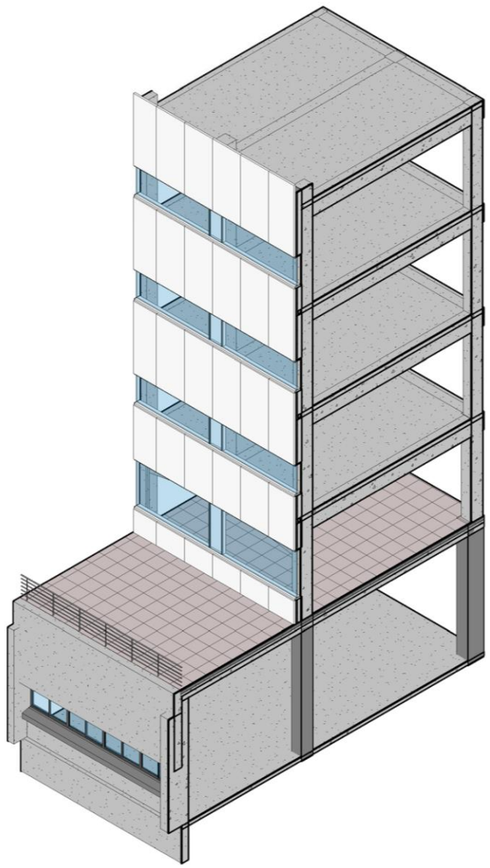
Highest & Best Re-Use: Façade Options



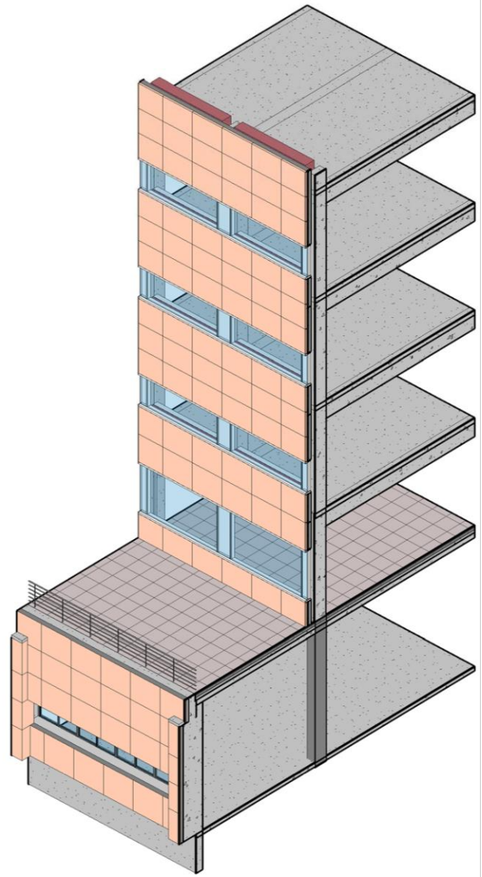
Existing
No Insulation



Interior Insulation
3 ½” Spay Foam

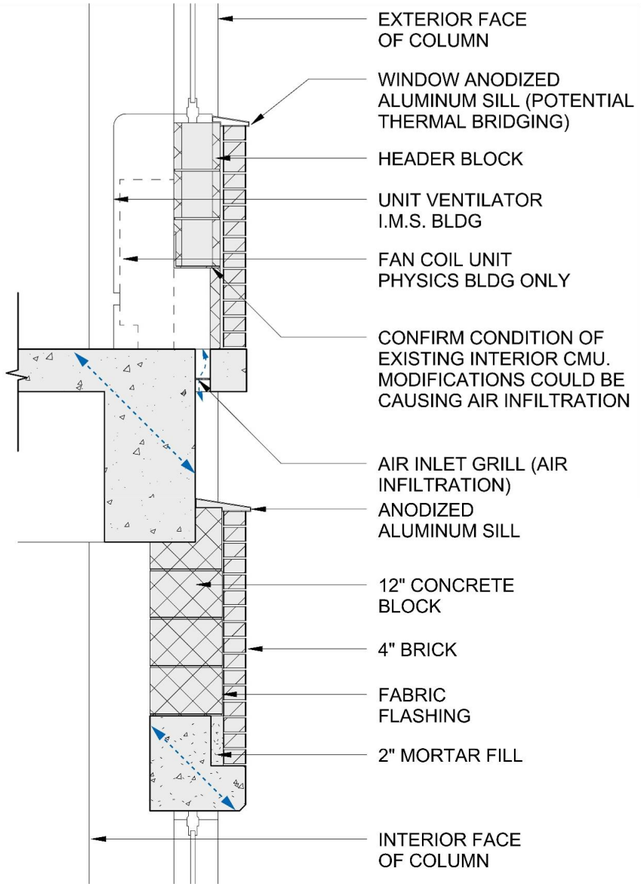


Re-Cladding
3” Semi-Rigid Insulation

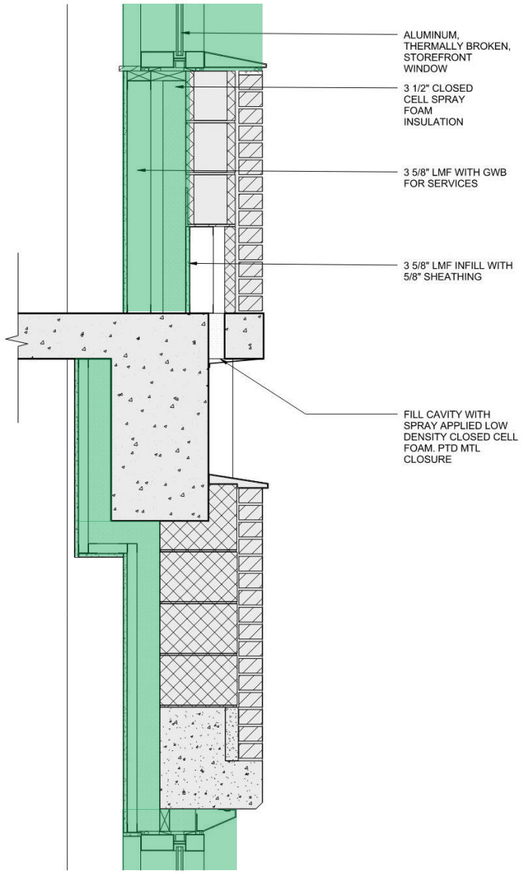


Over-Cladding
3” Semi-Rigid Insulation

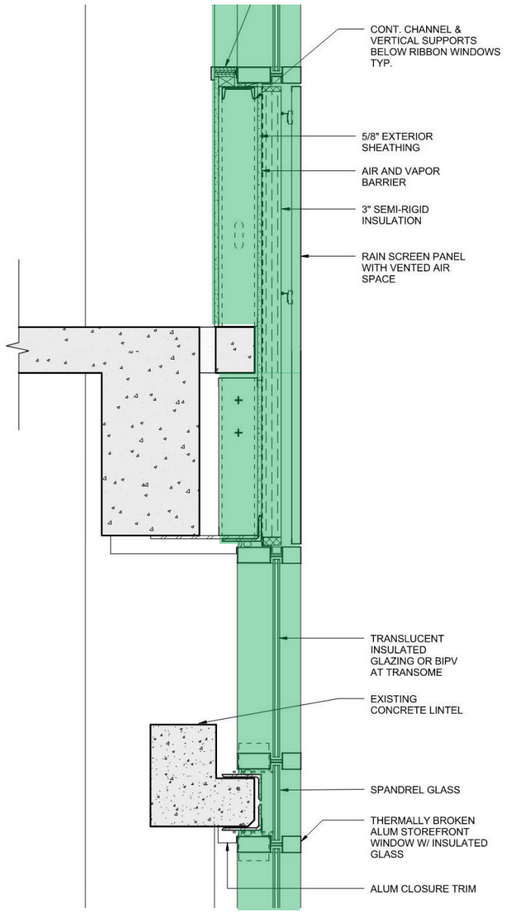
Gant Science Complex, University of Connecticut



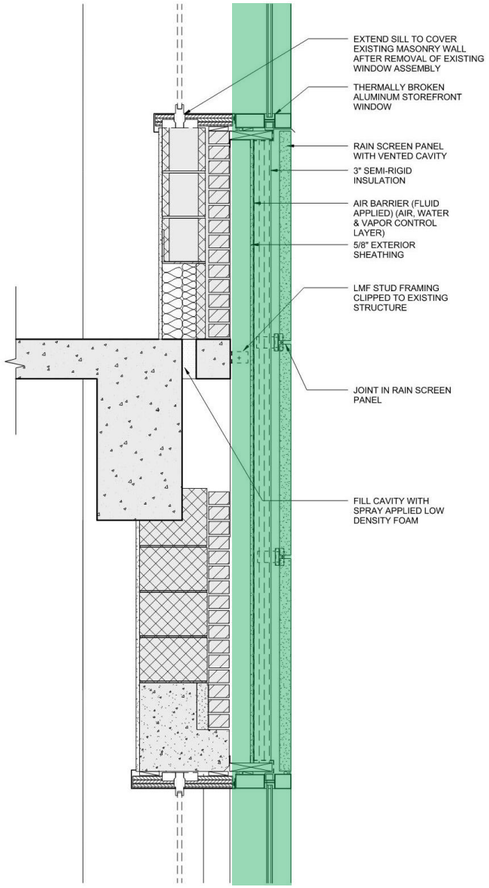
Existing
No Insulation



Interior Insulation
3 ½” Spay Foam



Re-Cladding
3” Semi-Rigid Insulation

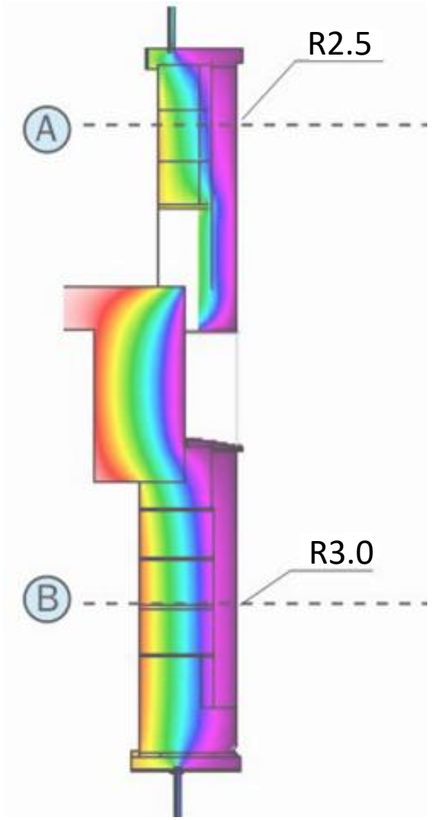


Over-Cladding
3” Semi-Rigid Insulation

Gant Science Complex, University of Connecticut

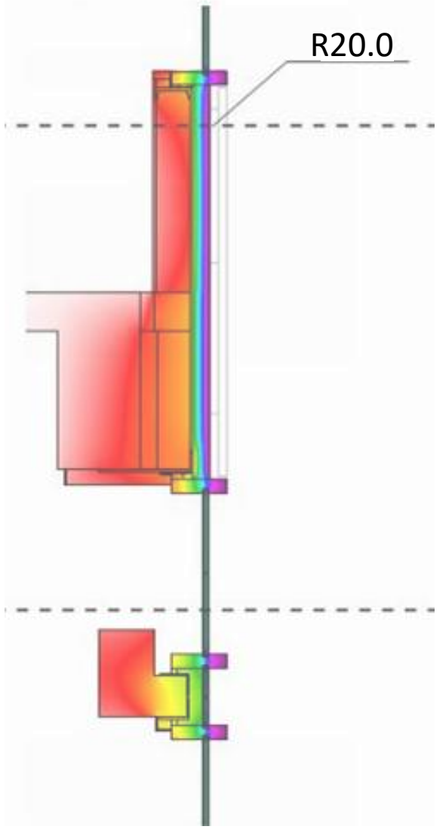
Thermal Analysis

- Interior Insulation achieved highest R-Value

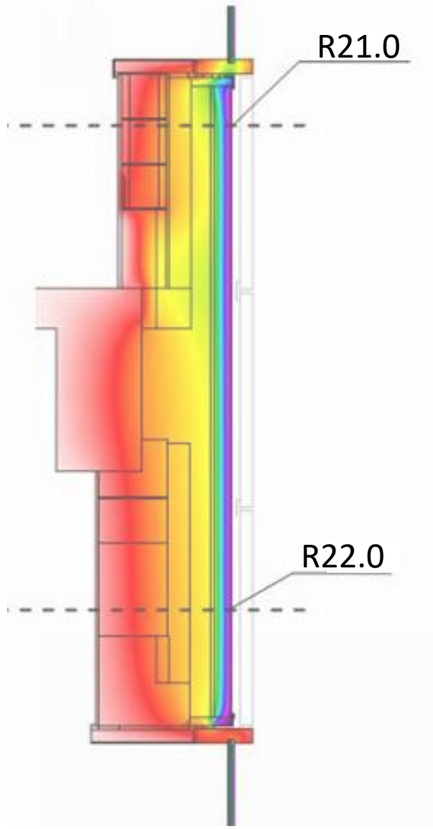


Existing
No Insulation

Interior Insulation
3 ½” Spay Foam



Re-Cladding
3” Semi-Rigid Insulation

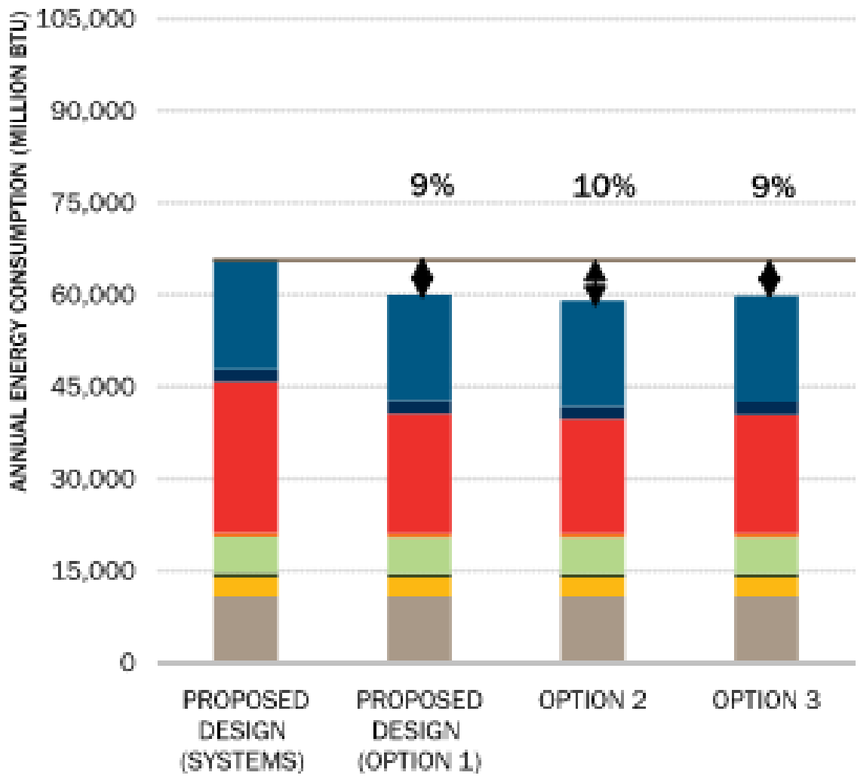


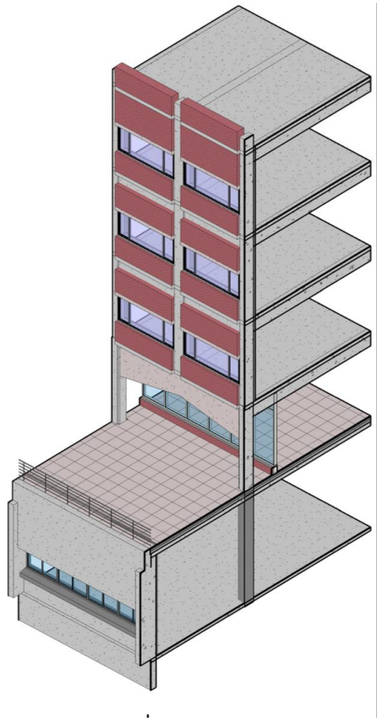
Over-Cladding
3” Semi-Rigid Insulation

Gant Science Complex, University of Connecticut

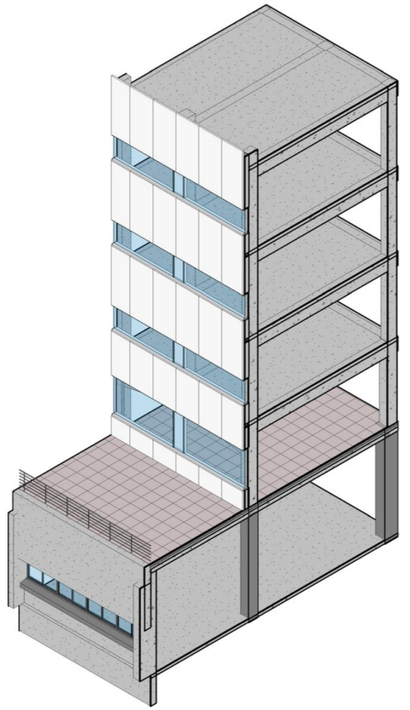
Energy Analysis

- Comparable Energy Savings for Each Option

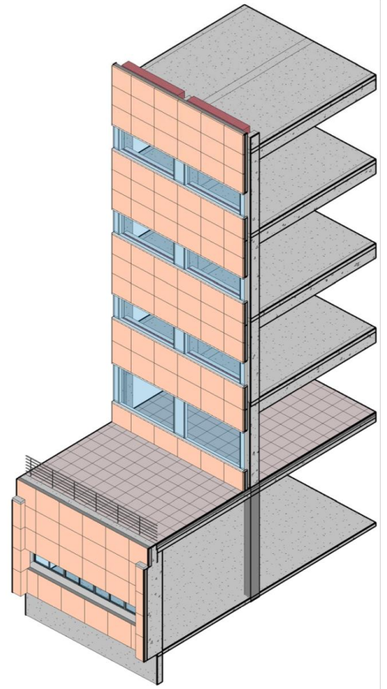




OPTION 1
Interior Insulation



OPTION 2
Re-Cladding



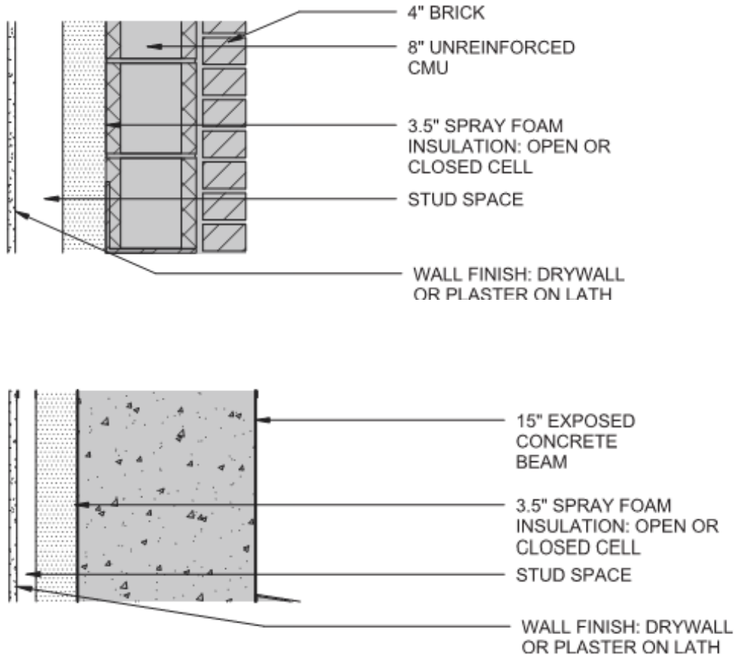
OPTION 3
Over-Cladding

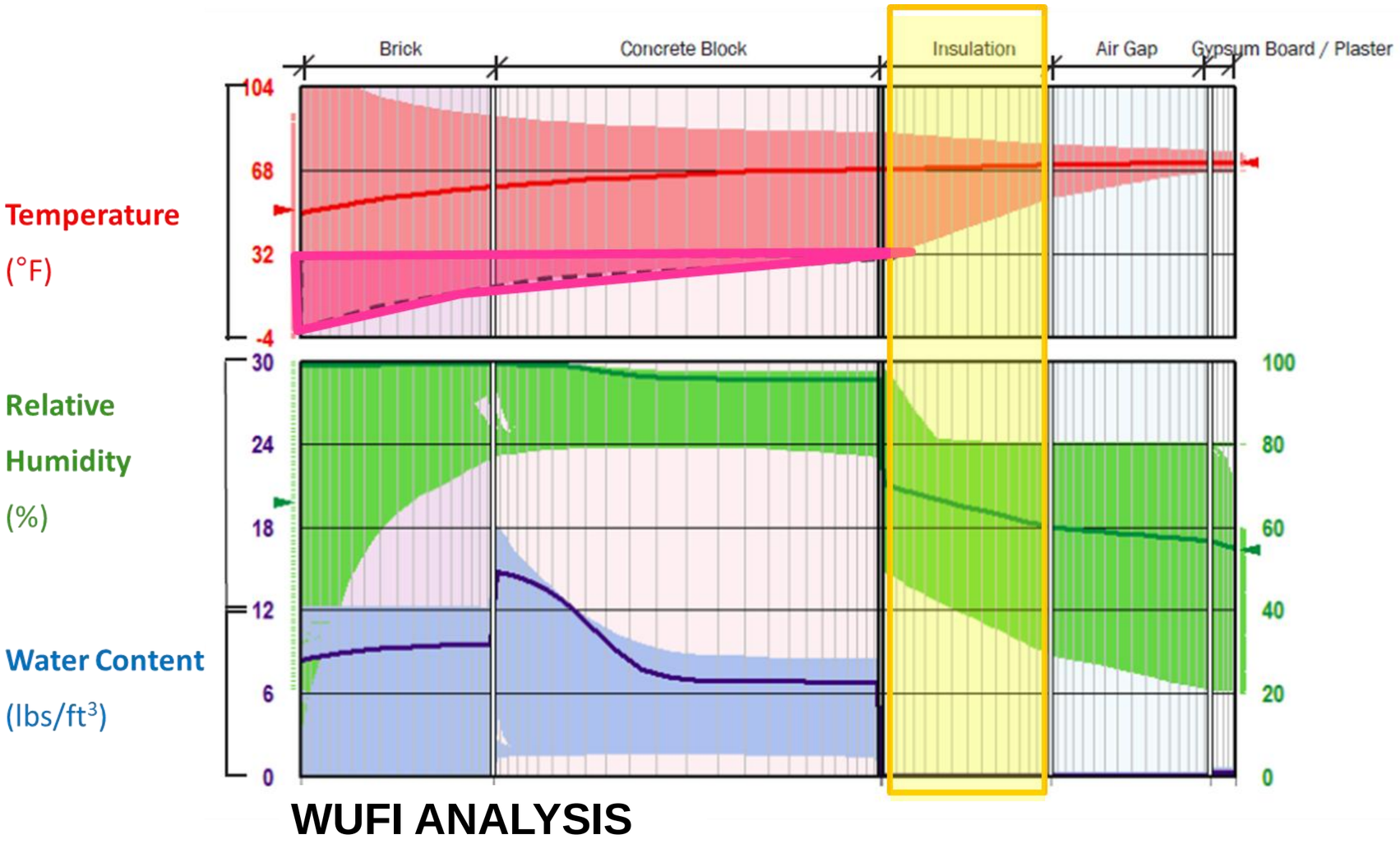
Gant Science Complex, University of Connecticut

Testing the Enclosure Strategy

- Will added insulation cause damage to the existing façade?
- **Answer: No**

PROPOSED FAÇADE SECTIONS





WUFI ANALYSIS

Gant Science Complex, University of Connecticut

Life Cycle Cost Analysis

The Cost Factor

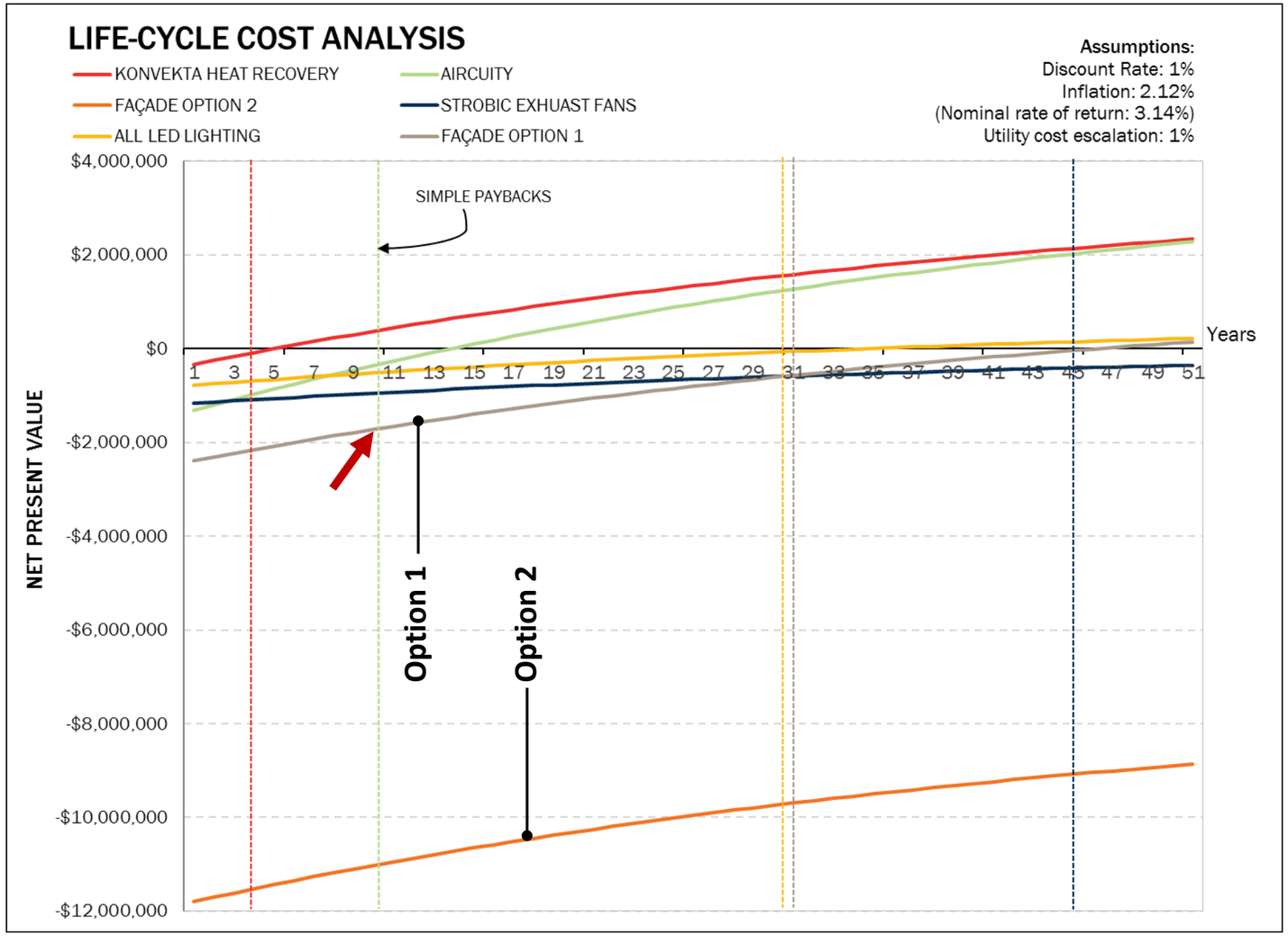
- Estimated first-costs of both systems & 2 façade options by construction cost estimator.
- Short + long-term cost analysis based on first-cost investment
  - Simple payback (1 year ROI).
  - Life-cycle cost analysis (net present value) over 50 years.

Results

- Option 1: Approx $2.5M, payback ~ 30 years.
- Option 3: Approx. $12M, payback ~ 150 years

Owner's decision for the façade:

Option 1



Gant Science Complex, University of Connecticut

Testing the Enclosure Strategy

- Enclosure interventions resulted in a **40% reduction** of air infiltration

Pre-Construction Blower Door Test

Ambient Exterior Air Temperature: 7°F
Ambient Interior Air Temperature: 56°F

Title of Test	Test Results	Allowable
Air Infiltration @ 25 pa	305 cfm	N/A
@ 50 pa	430 cfm	N/A
@ 75 pa	530 cfm	N/A
Air Exfiltration @ 75 pa	318 cfm	N/A

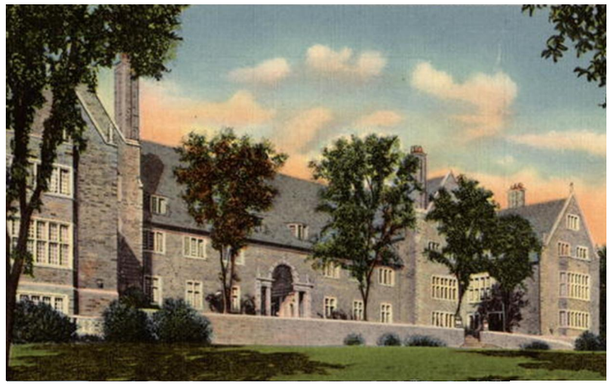
Post-Construction Blower Door Test

Ambient Exterior Air Temperature: 80°F
Ambient Interior Air Temperature: 78°F

Title of Test	Test Results	Allowable
Air Infiltration @ 25 Pa	120 cfm	N/A
@ 50 Pa	174 cfm	N/A
@ 75 Pa	219 cfm	N/A
Air Exfiltration @ 75 Pa	109 cfm	N/A

Gant Science Complex, University of Connecticut

What’s Old Is New Again: Takeaways



Balch Hall, Cornell University, 1929

- 160,000sf

64% reduction
in embodied emissions
from building new

75% reduction
in operational emissions
from current

Addition/Renovation, Private Client, 1936

- 47,600sf

31% reduction
in embodied emissions
from building new

46% reduction
in operational emissions
from current

Gant Science Complex, University of Connecticut, 1969

- 310,000sf

39% reduction
in embodied emissions
from building new

65% reduction
in operational emissions
from current

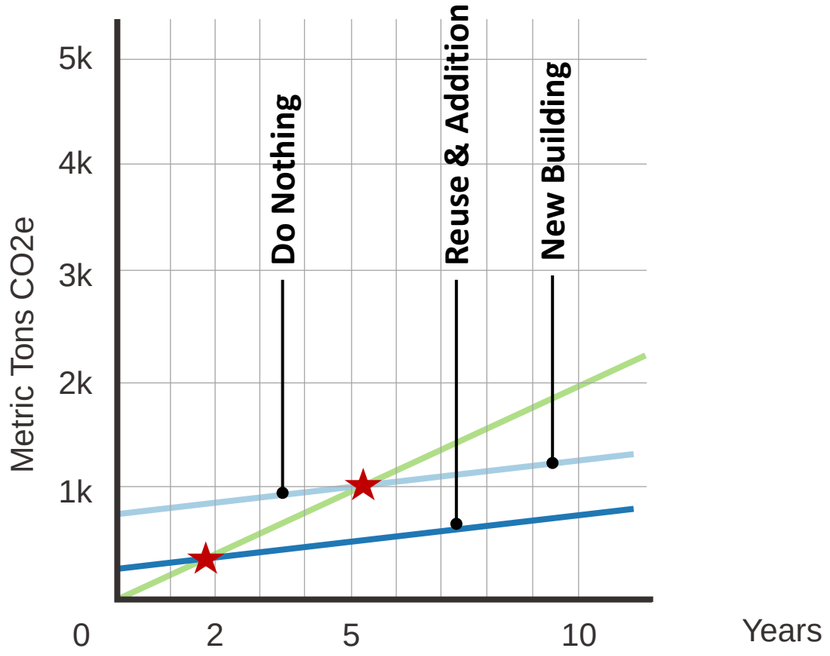
What's Old Is New Again: Takeaways

Cumulative Emissions (Operational & Embodied) Over Time

Do Nothing Reuse & Addition New Building

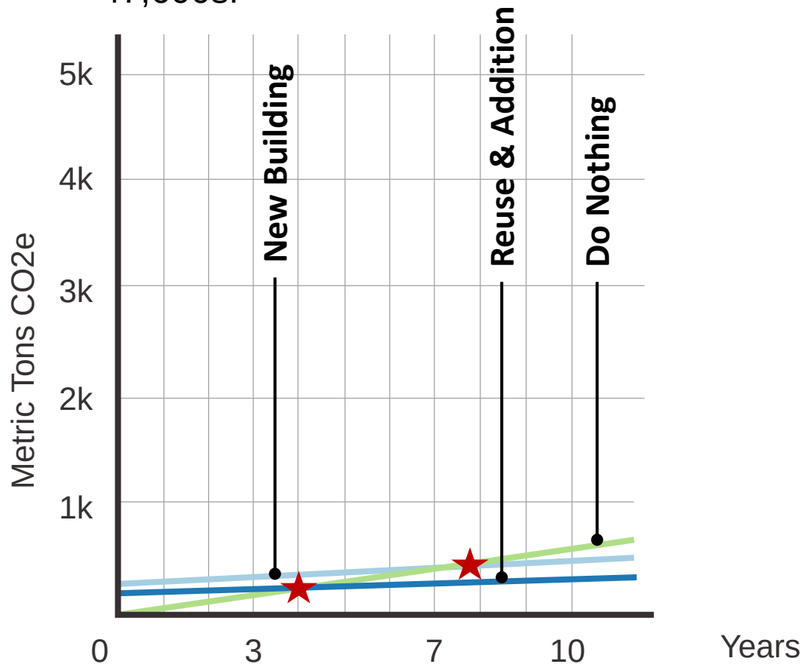
Balch Hall, Cornell University, 1929

- 160,000sf



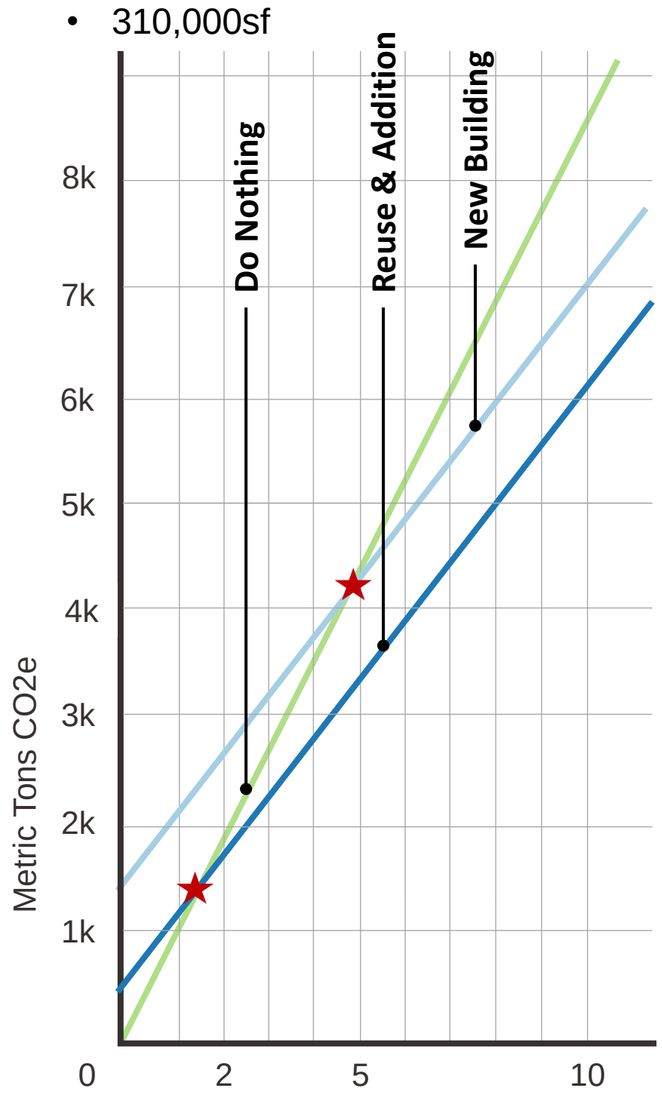
Addition/Reno, Private Client, 1936

- 47,600sf

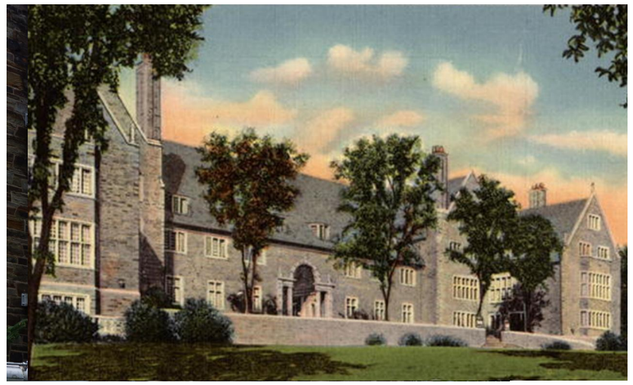


Gant Science Complex, University of Connecticut, 1969

- 310,000sf



What’s Old Is New Again: Takeaways



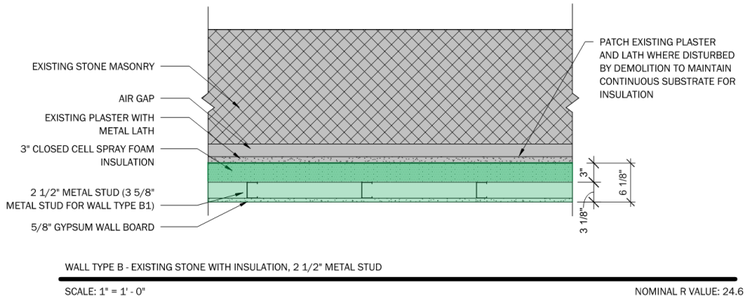
Balch Hall, Cornell University, 1929

Addition/Renovation, Private Client, 1936

Gant Science Complex, University of Connecticut, 1969

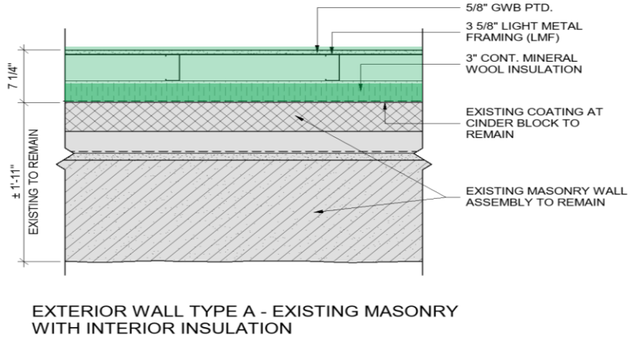
LISTEN

Understanding the existing materials and assemblies drives design decisions.



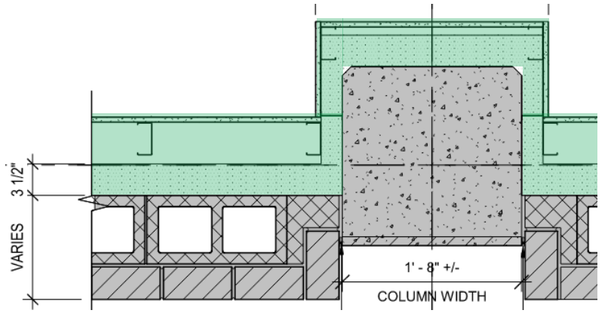
ASPIRE

Achieving high standards for a lower-carbon future is possible with existing buildings.



DISCUSS

Communication is key for making data-driven decisions and getting transformative results.



Q&A

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Thank you!