

11-10-2023

Bowdoin College

Schiller Coastal Studies Center

A Passive House success story

PHIUScon 2023 HOUSTON



CENTERBROOK



CENTERBROOK ARCHITECTS
SIMPSON GUMPERTZ & HEGER
THORNTON TOMASETTI
VAN ZELM ENGINEERS
JF SCOTT CONSTRUCTION
RIST-FROST-SHUMWAY ENGINEERING
SEBAGO TECHNICS



OUTLINE

Project & Design *(René Brakels AIA, CPHC, Centerbrook Architects)*

Execution and Quality Control *(Gert Guldentops, P.E., SGH)*

Q&A



Centerbrook Architects



Bowdoin College

Project & Design

Execution and
Quality Control

Q&A

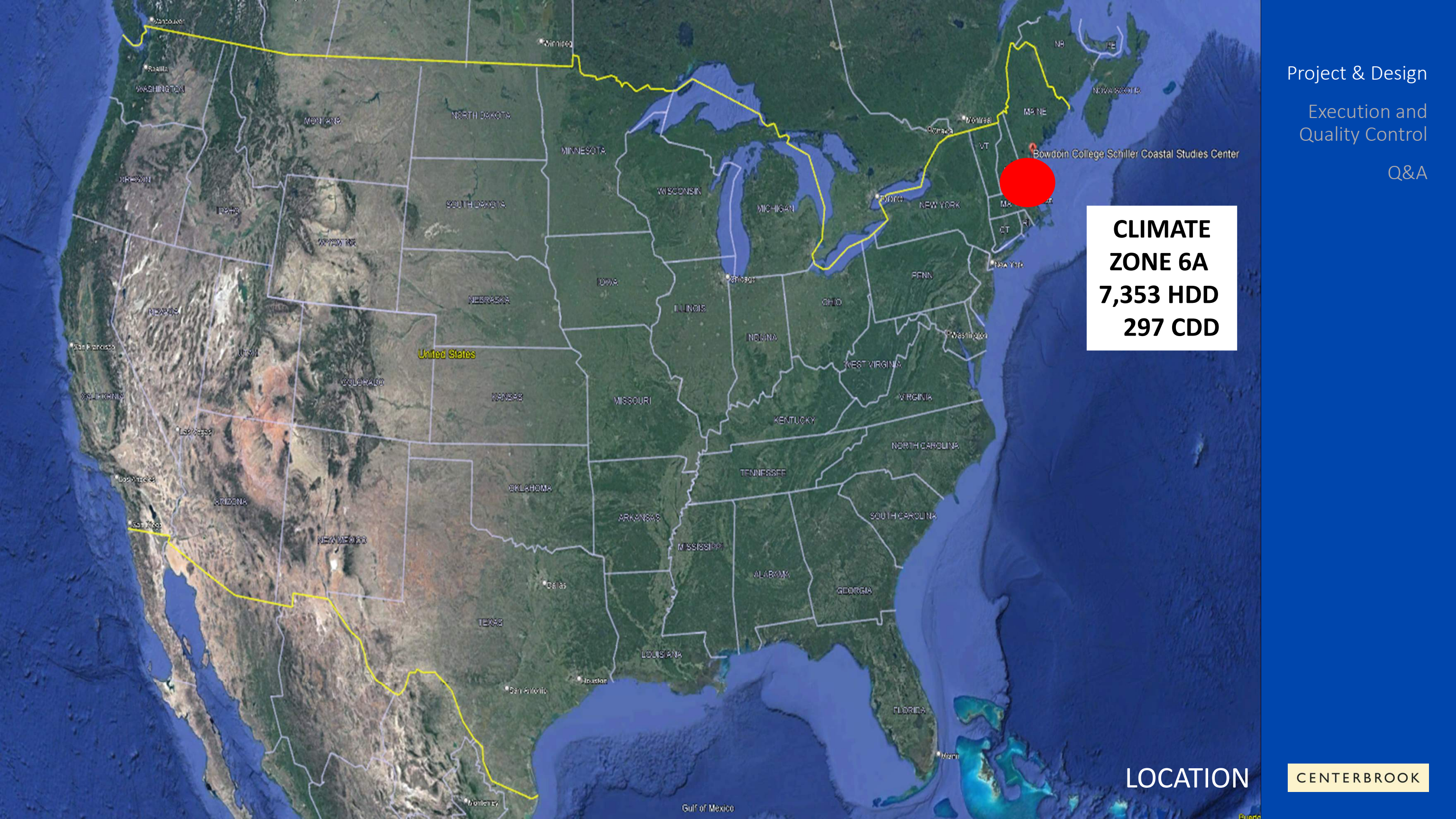
**CLIMATE
ZONE 6A
7,353 HDD
297 CDD**

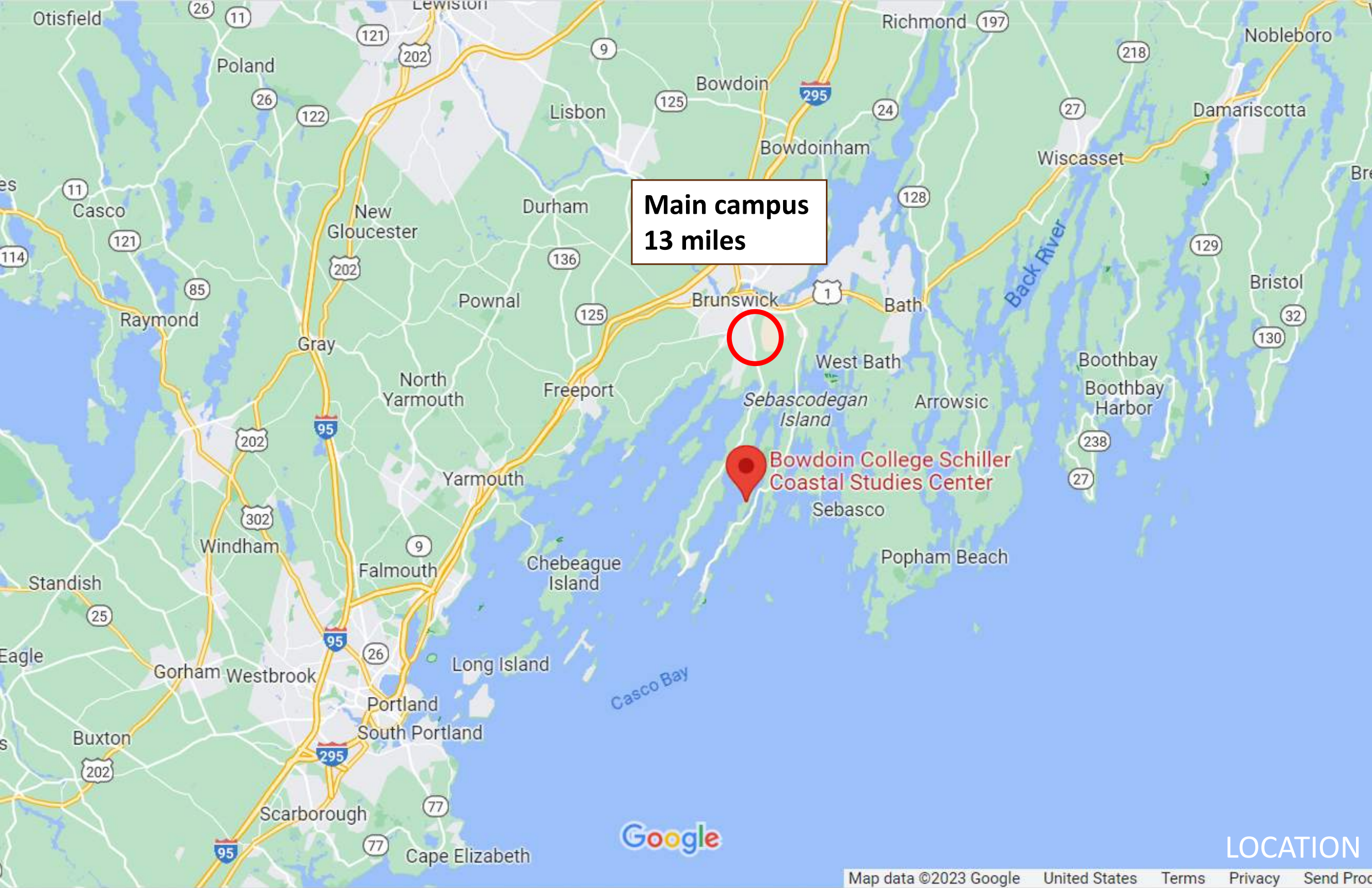


Bowdoin College Schiller Coastal Studies Center

LOCATION

CENTERBROOK





**Main campus
13 miles**

**Bowdoin College Schiller
Coastal Studies Center**

Project & Design

Execution and
Quality Control

Q&A

LOCATION

CENTERBROOK



Project & Design

Execution and
Quality Control

Q&A

REMOTE LOCATION

CENTERBROOK



Brunswick



Wyer Island

Long Cove



Project & Design

Execution and
Quality Control

Q&A

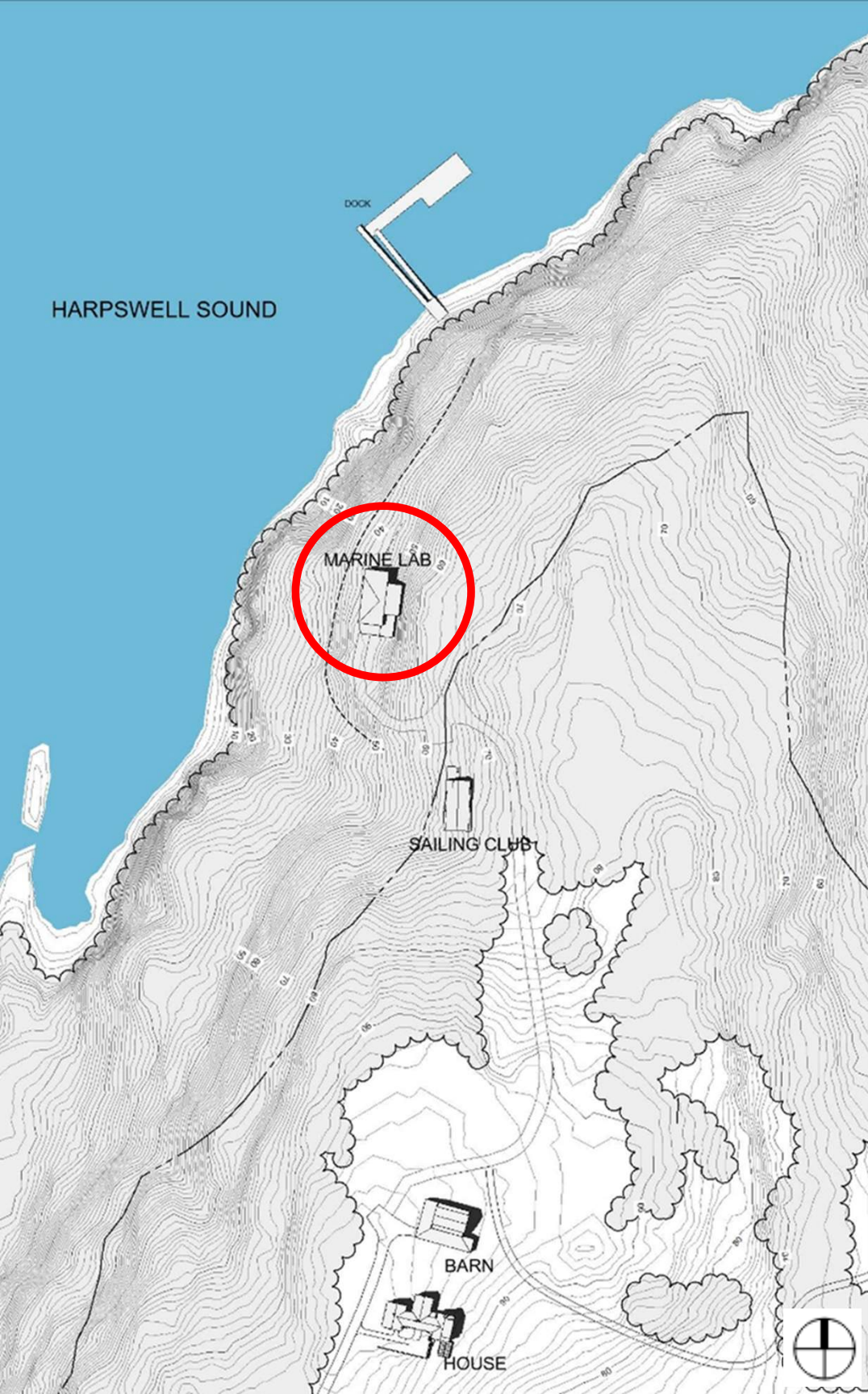
PH low loads

* RESILIENCY: longevity after a storm with partial buried electrical lines

* EFFICIENCY: Less demand on their solar farm

REMOTE LOCATION

CENTERBROOK



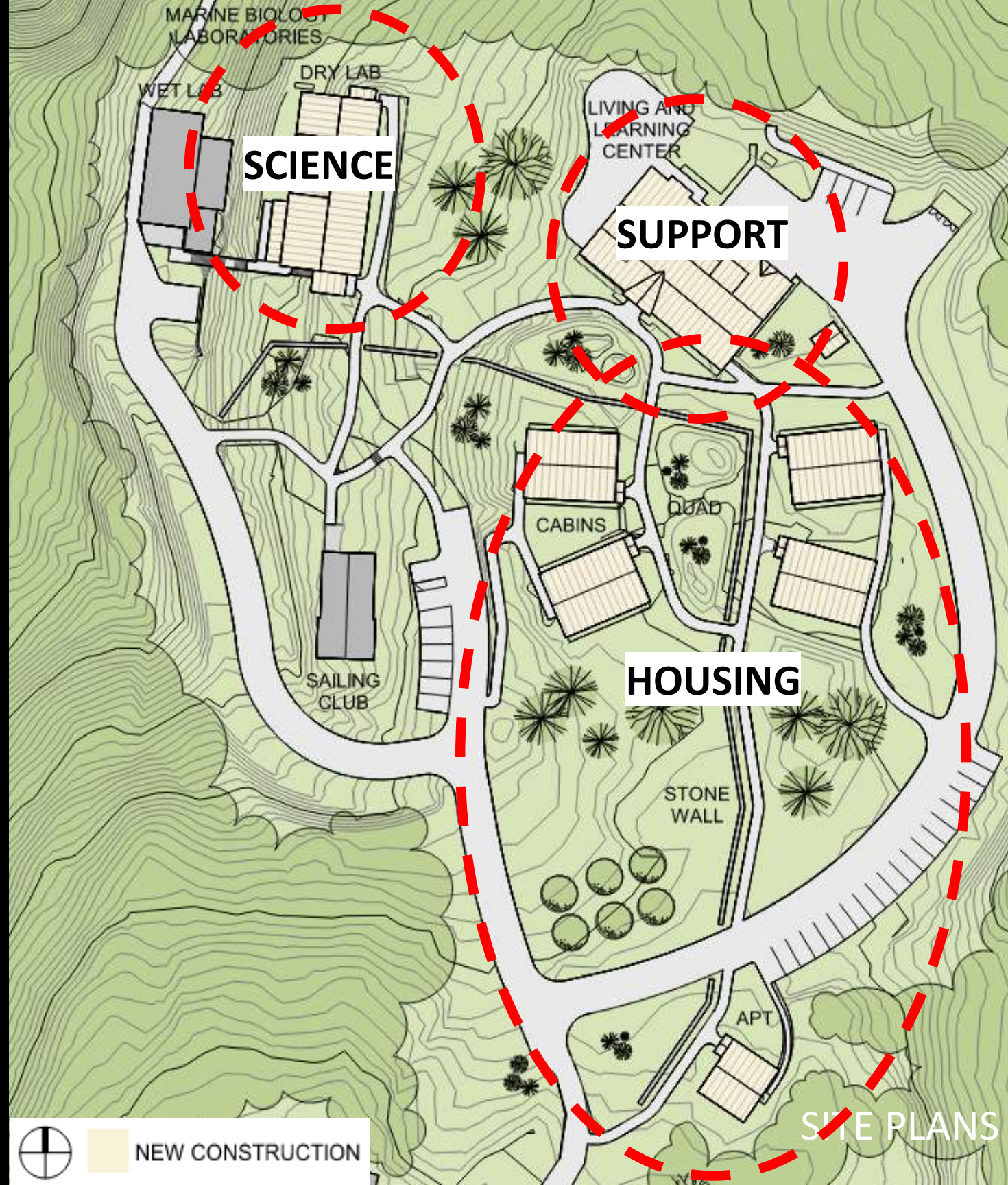
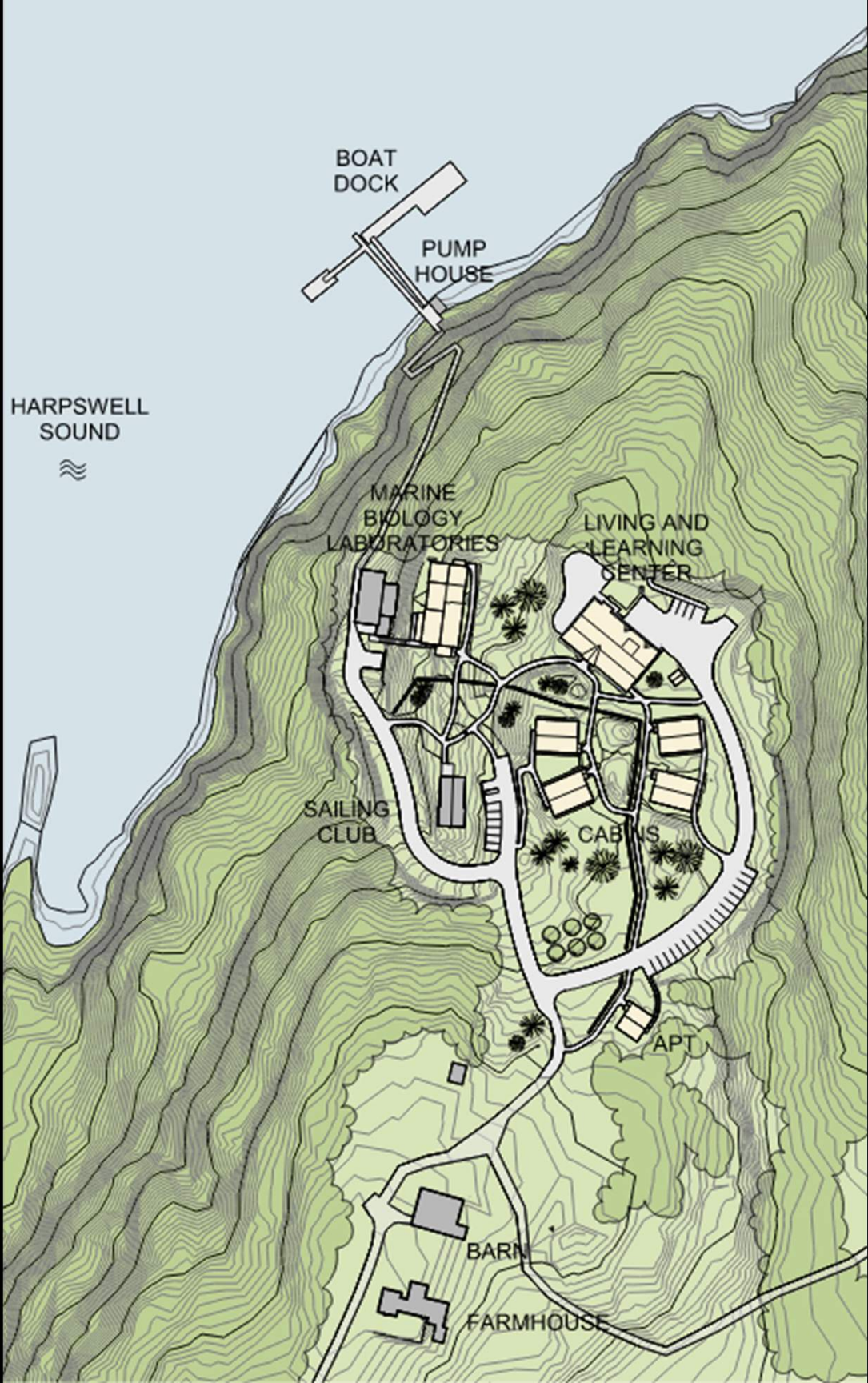
EXISTING CONDITIONS



Project & Design

Execution and
Quality Control

Q&A

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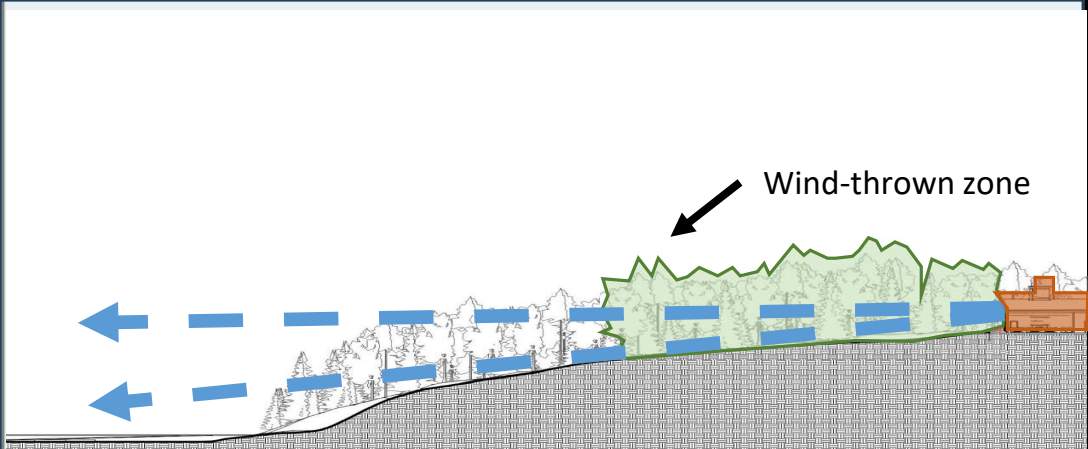



 NEW CONSTRUCTION

SITE PLANS

Project & Design
Execution and Quality Control
Q&A

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Project & Design

Execution and
Quality Control

Q&A

Project & Design

Execution and
Quality Control

Q&A



CONNECTION TO WATER

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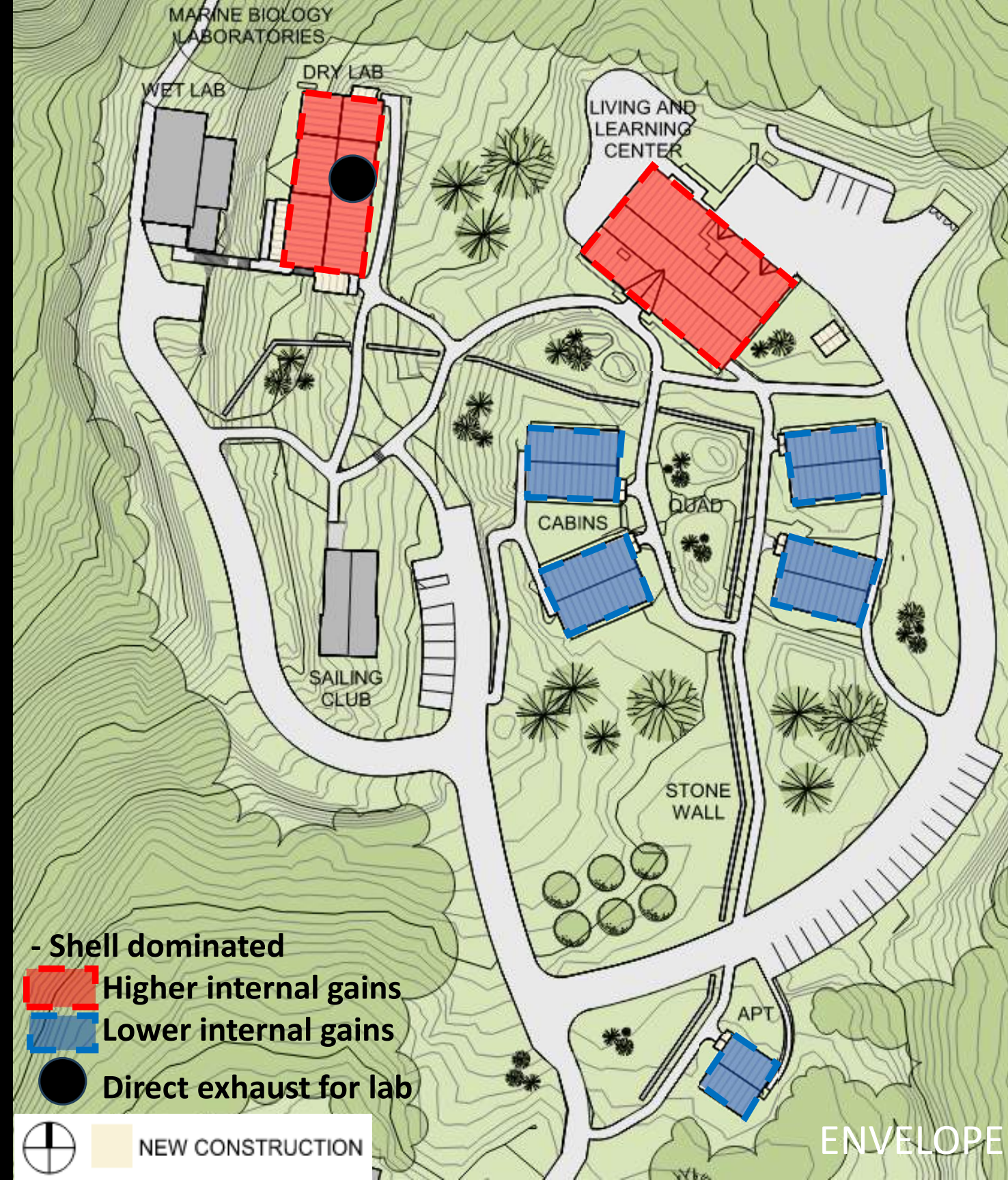
Project & Design

Execution and
Quality Control

Q&A

COMMUNITY SETTING

CENTERBROOK



Project & Design

Execution and
Quality Control

Q&A

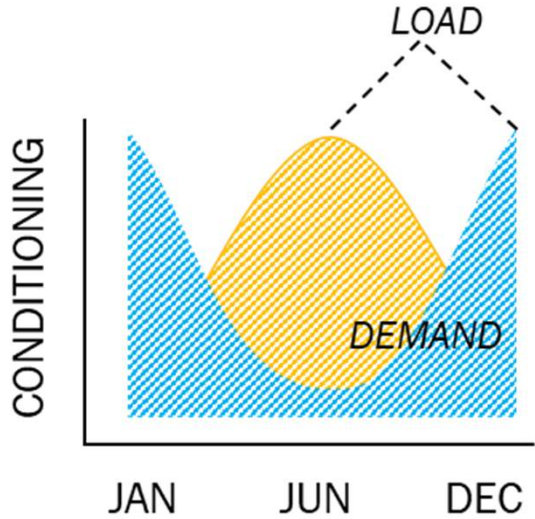
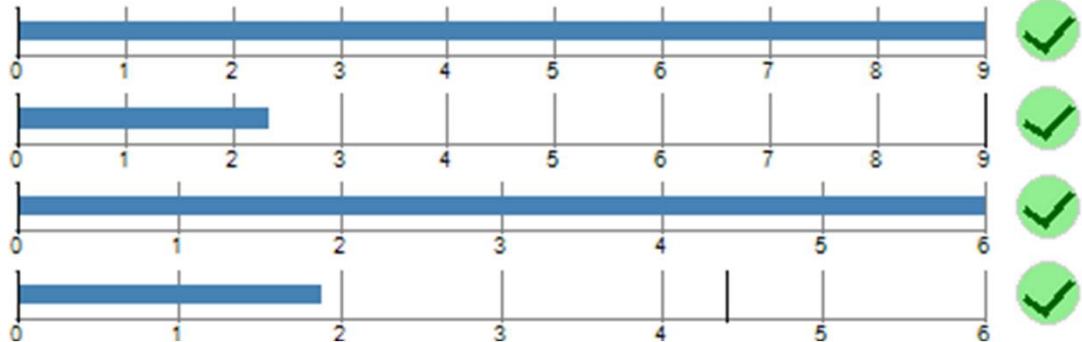
PHIUS+ 2018 METRICS: LLC

Heating demand: 10.5 kBtu/ft²yr

Cooling demand: 2.33 kBtu/ft²yr

Heating load: 7.66 Btu/hr ft²

Cooling load: 1.89 Btu/hr ft²



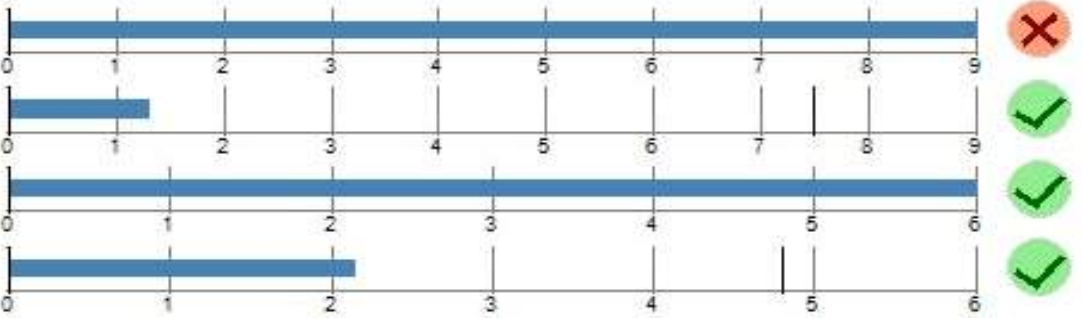
PHIUS+ 2018 METRICS: CABINS

Heating demand: 14.86 kBtu/ft²yr

Cooling demand: 1.32 kBtu/ft²yr

Heating load: 8.32 Btu/hr ft²

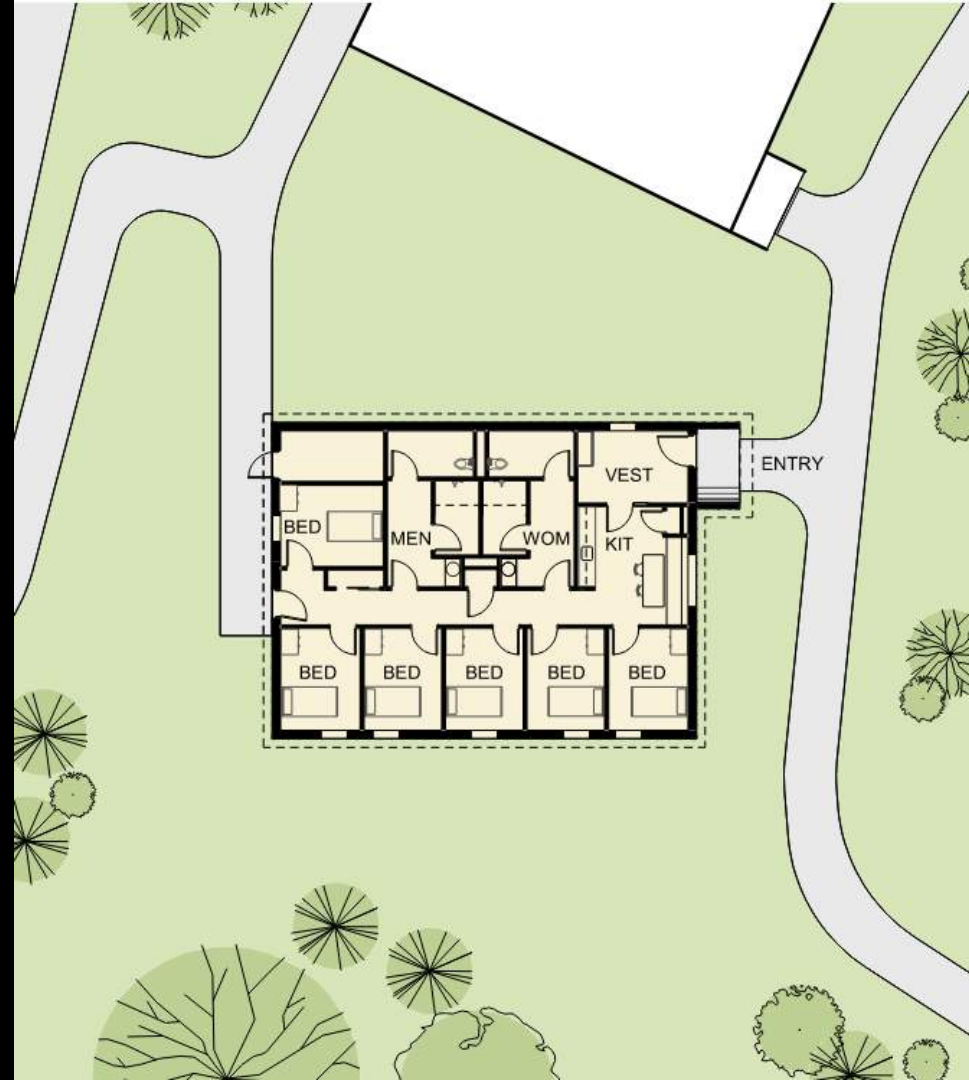
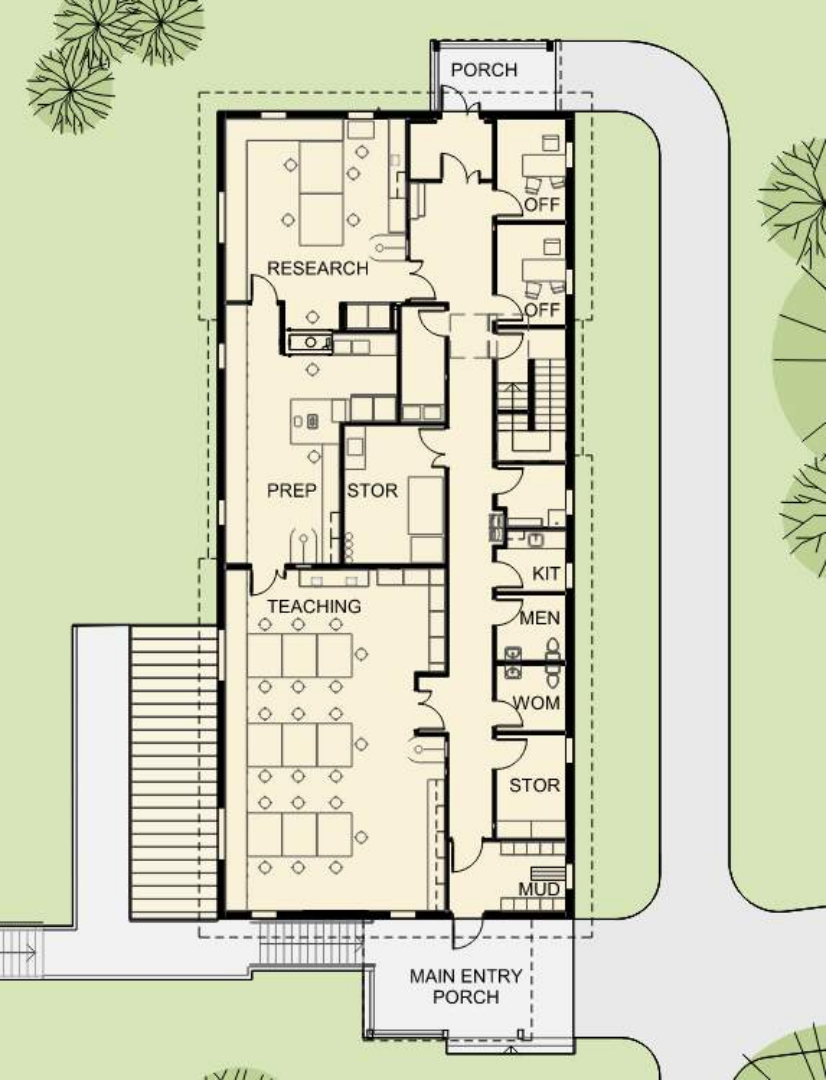
Cooling load: 2.16 Btu/hr ft²



- LLC envelope was leading

- Thanks to early modeling PH Cabins would require higher quality envelope because of low internal gains and more stringent requirements because of building type

* Space conditioning criteria is dependent on climate zone, building area, and building enclosure area; critical to leave a buffer in case iCFA changes



Project & Design

Execution and
Quality Control

Q&A



Dry lab



Cabins



Apartment



Project & Design

Execution and
Quality Control

Q&A

SENSE OF PLACE

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Project & Design

Execution and
Quality Control

Q&A

SET RESPECTFULLY WITH NAVITIVE PLANTS

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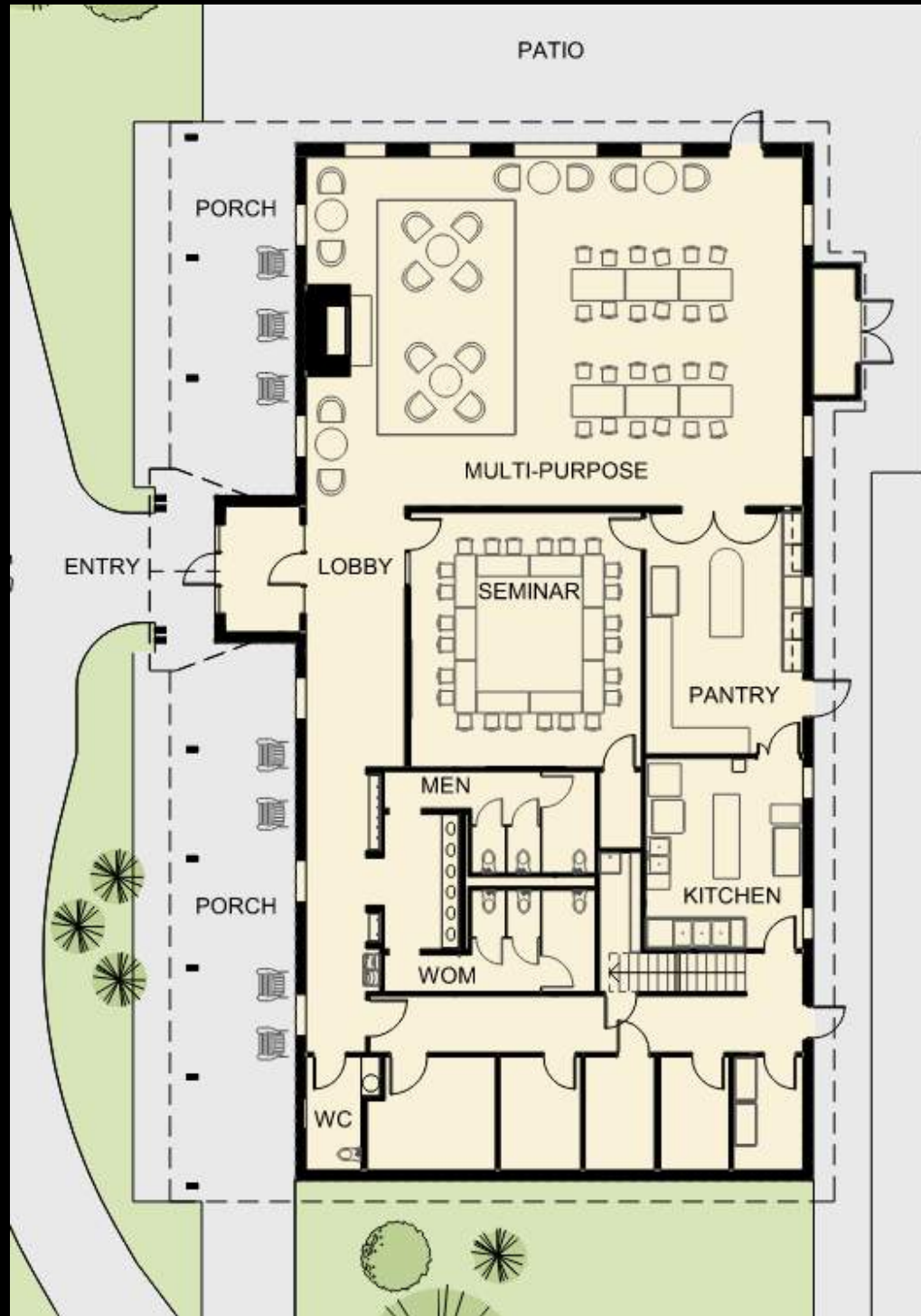
Project & Design

Execution and
Quality Control

Q&A

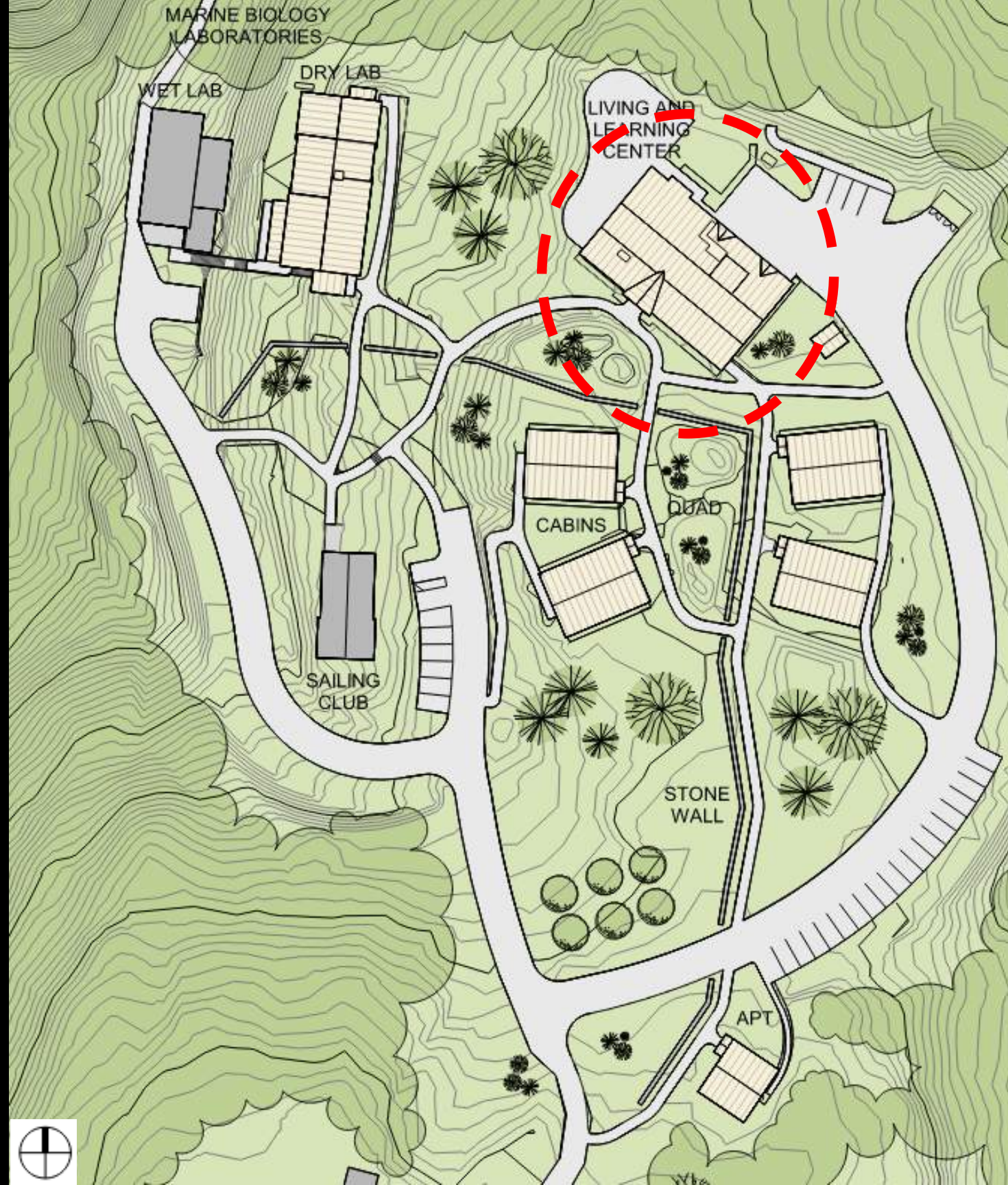
HUB OF ACTIVITY

CENTERBROOK



LIVING / LEARNING CENTER

6,290 SF



Project & Design

Execution and
Quality Control

Q&A



Project & Design

Execution and
Quality Control

Q&A

NESTLED

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Project & Design

Execution and
Quality Control

Q&A

CONNECTED TO ITS SURROUNDINGS

CENTERBROOK



Project & Design

Execution and
Quality Control

Q&A

COMMUNITY SETTING w/ BIOPHILIC CONNECTIONS

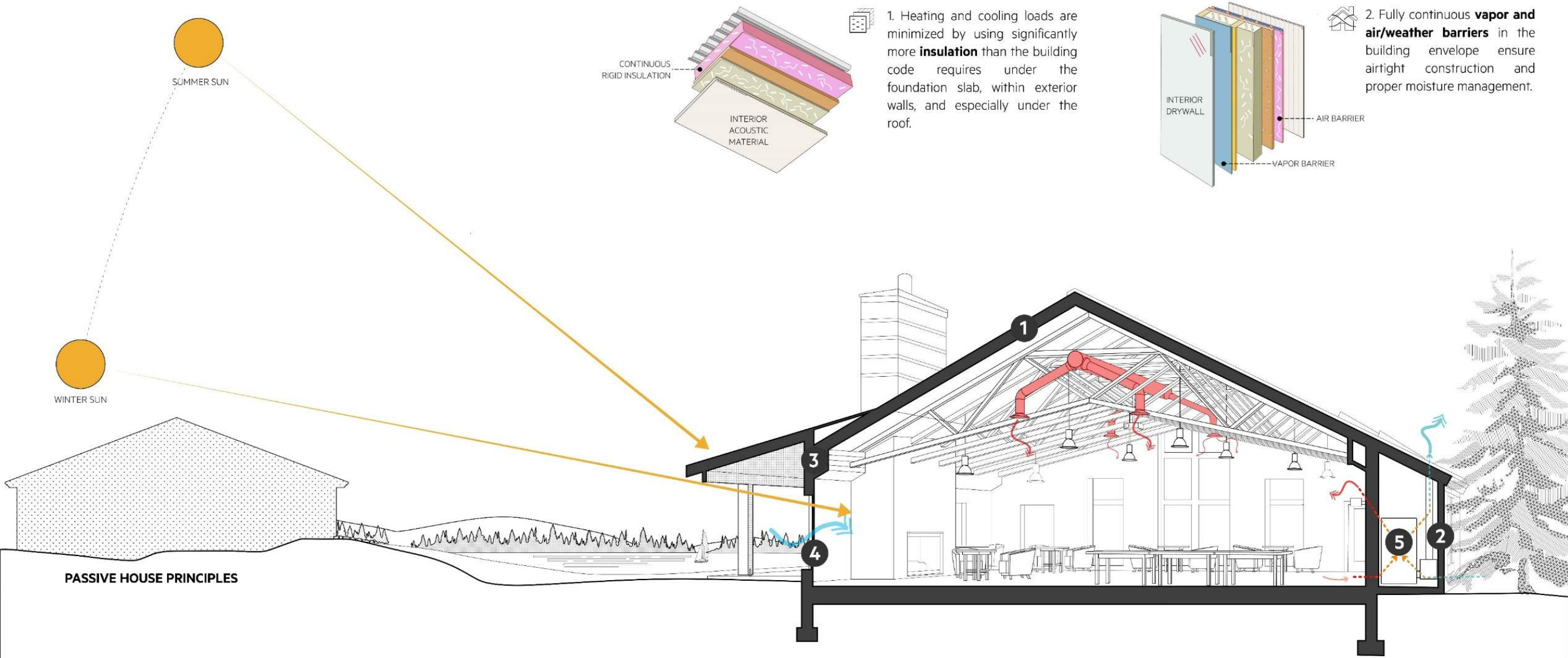
Bowdoin College Schiller Coastal Studies Center

Sustainability Strategies

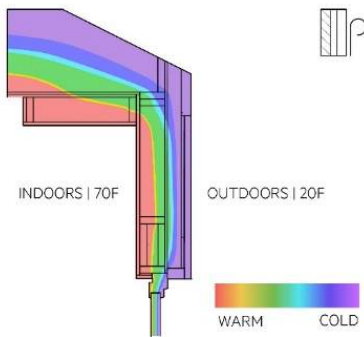
Project & Design

Execution and Quality Control

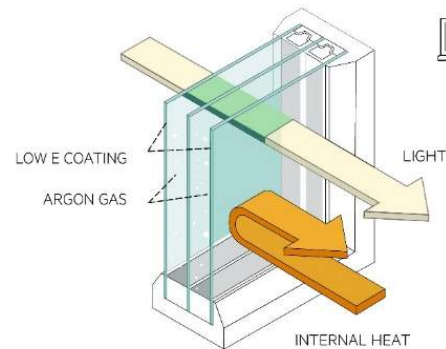
Q&A



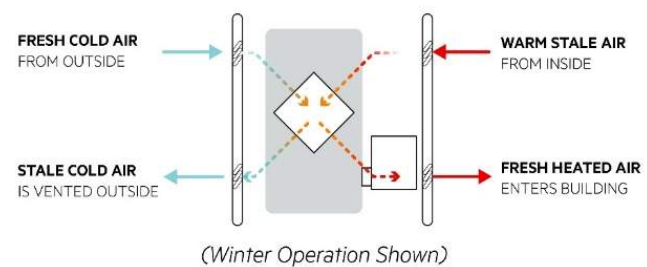
PASSIVE HOUSE PRINCIPLES



3. **Thermal bridging** in the exterior envelope, which occurs when components span through walls, floors, and ceilings, should be minimized through careful detailing.



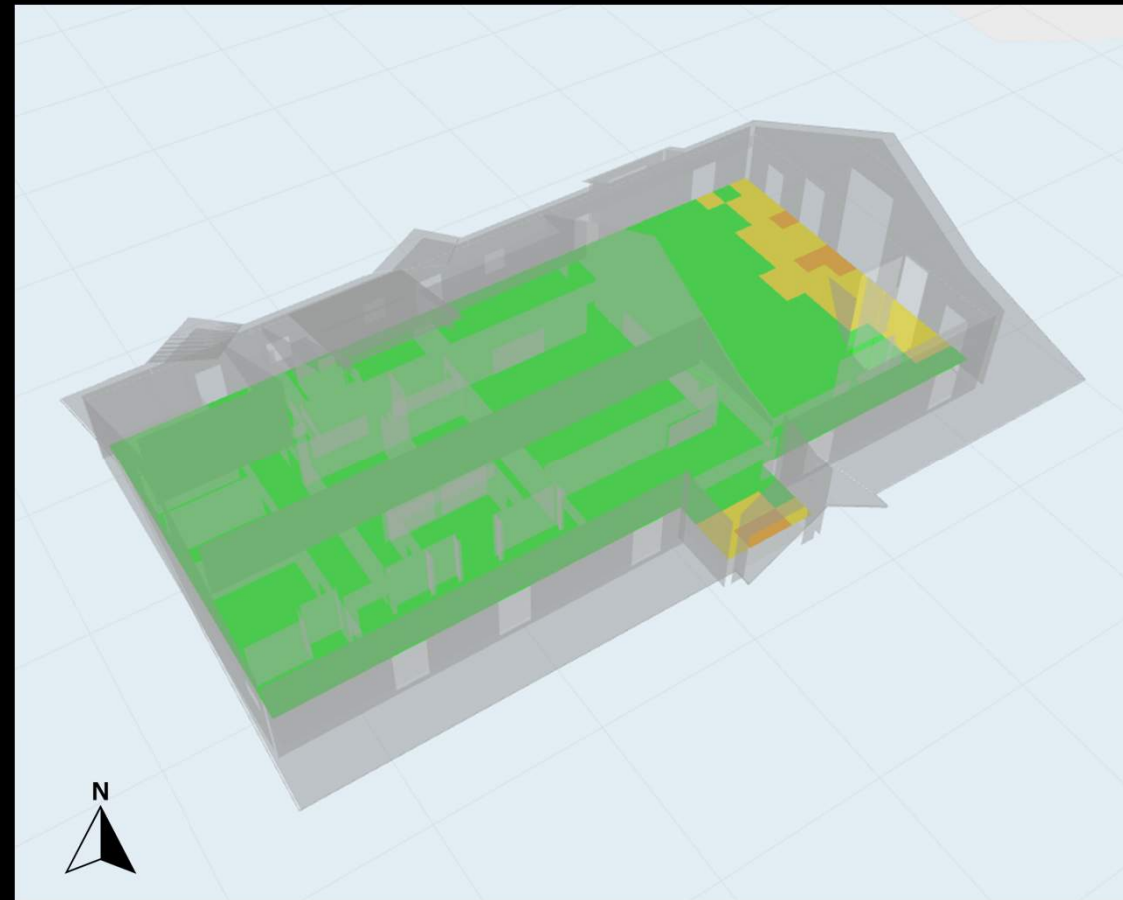
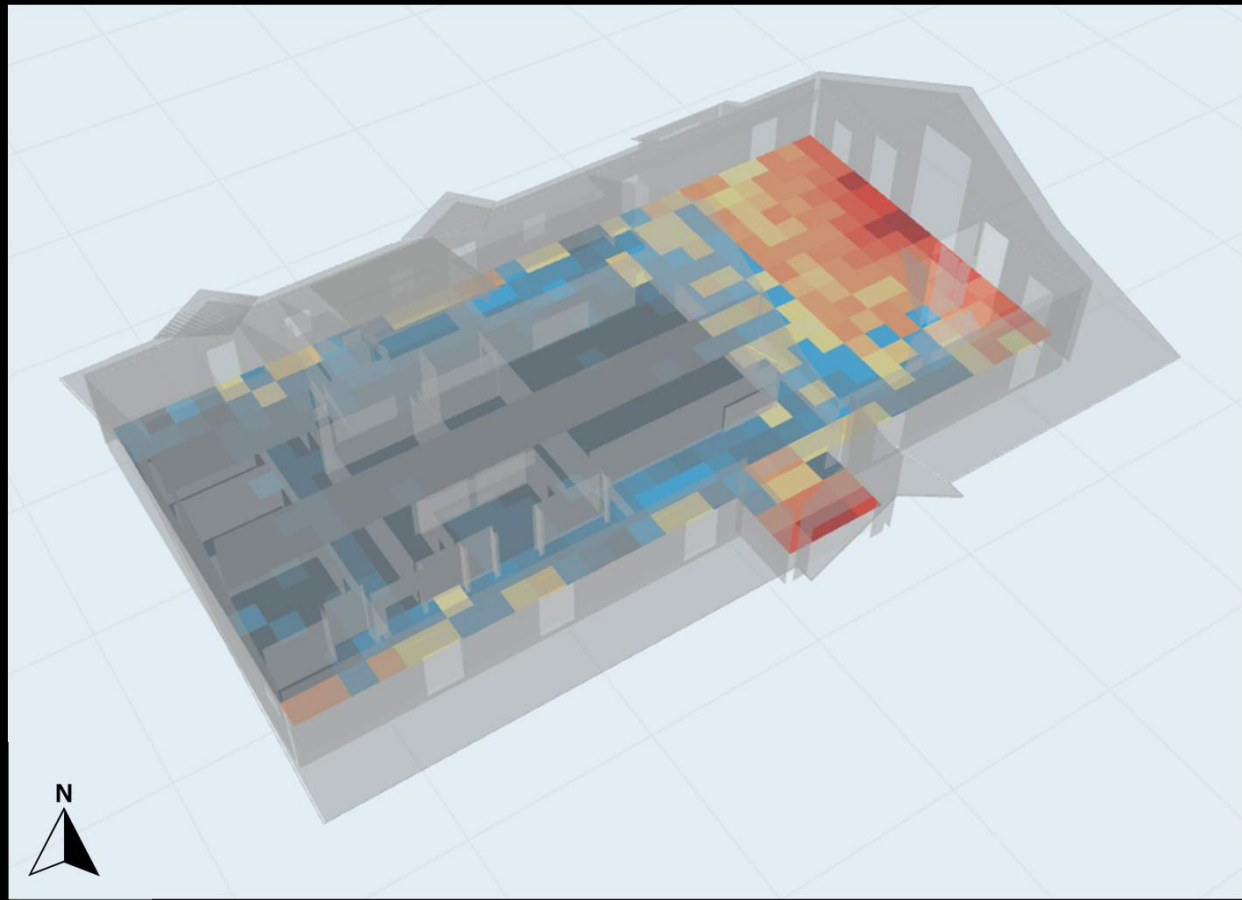
4. **High performance windows** in colder climates should have three layers of glass. Using fewer windows reduces winter heat loss, while optimizing their location encourages winter solar heat gain. **Passive strategies**, like solar shading to reduce summer heat gain, reduce energy consumption.



5. Mechanically-provided outdoor air is needed inside well-insulated and airtight buildings. As it is added, **energy recovery systems** transfer energy from the exhaust air to the incoming air stream.

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Project & Design

Execution and
Quality Control

Q&A

LIGHTING / GLARE

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Project & Design

Execution and
Quality Control

Q&A

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LOW-E GLASS IN A WOODED AREA CAUSES REFLECTIONS. CONSIDER / FIGHT FOR BIRDBGLASS / FILM



Project & Design

Execution and
Quality Control

Q&A

**Self contained air sealed chimney box
with damper, coaxial direct exhaust
and air intake**

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Project & Design

Execution and
Quality Control

Q&A

VRF units

**Tempered Air
supply via ERV**

Project & Design

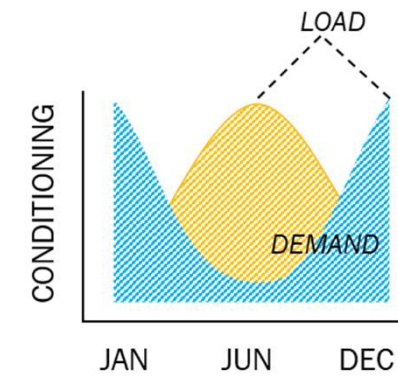
Execution and
Quality Control

Q&A



'Simple' fully electric mechanical system:

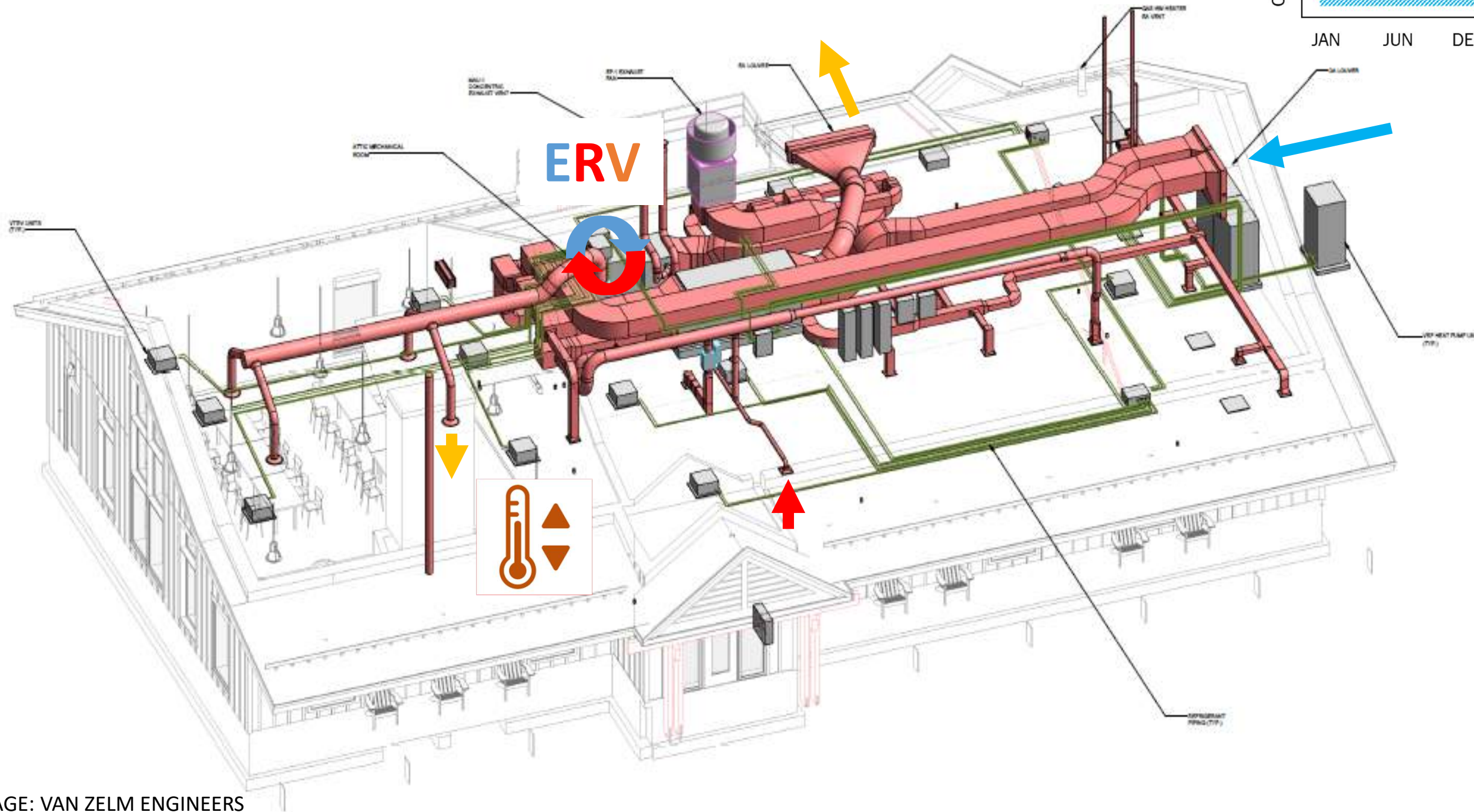
- Air intake / exhaust with ERV (80% heat, 68% humidity)
- Local VRF heating / cooling

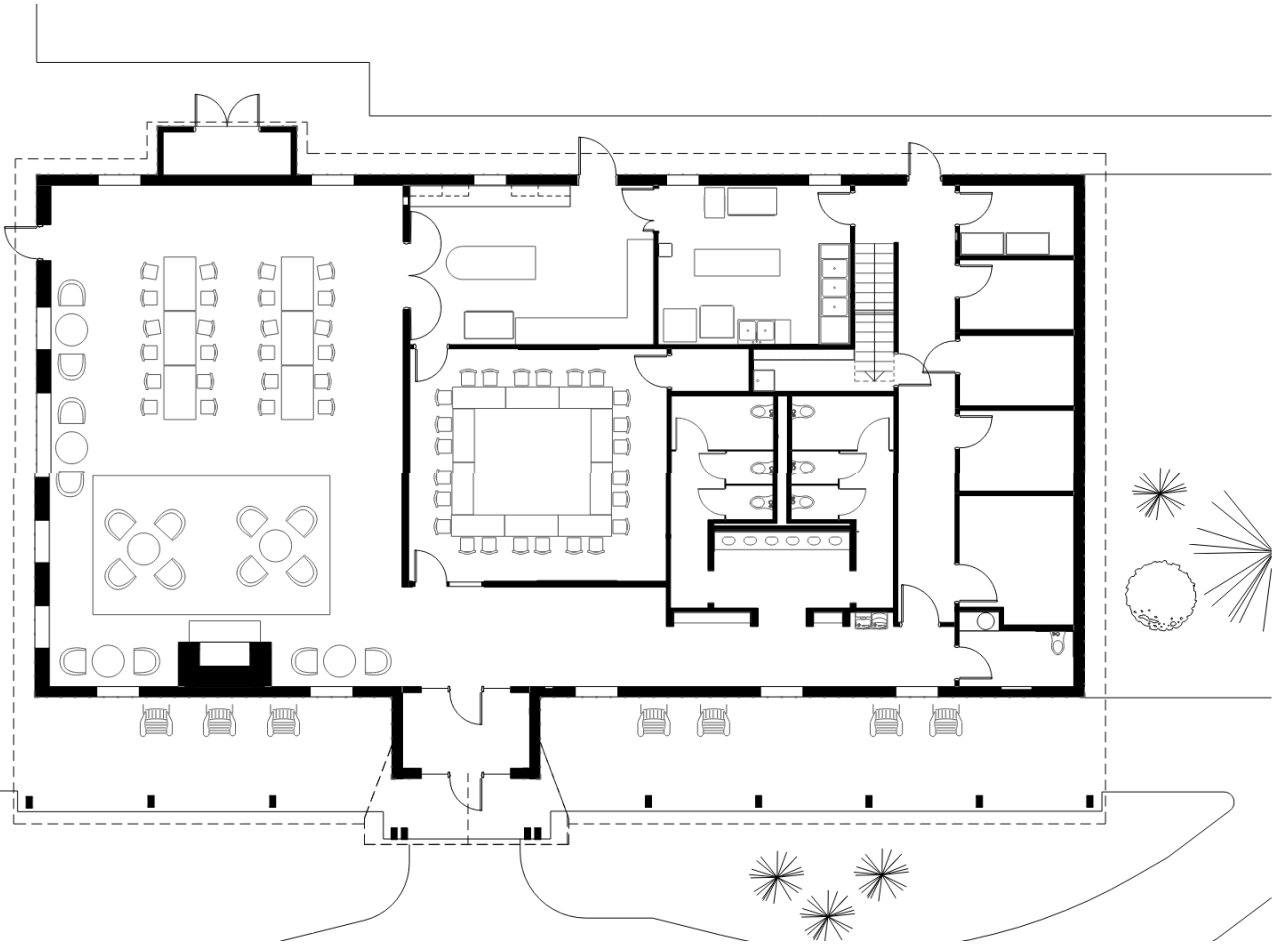


Project & Design

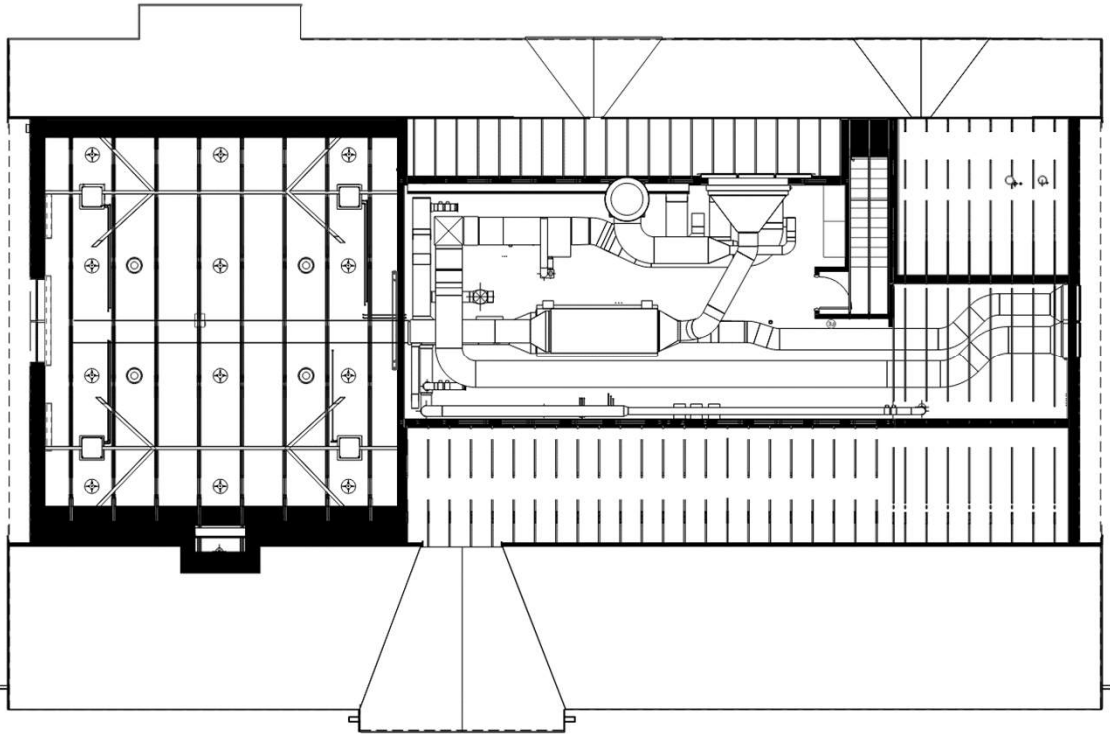
Execution and
Quality Control

Q&A

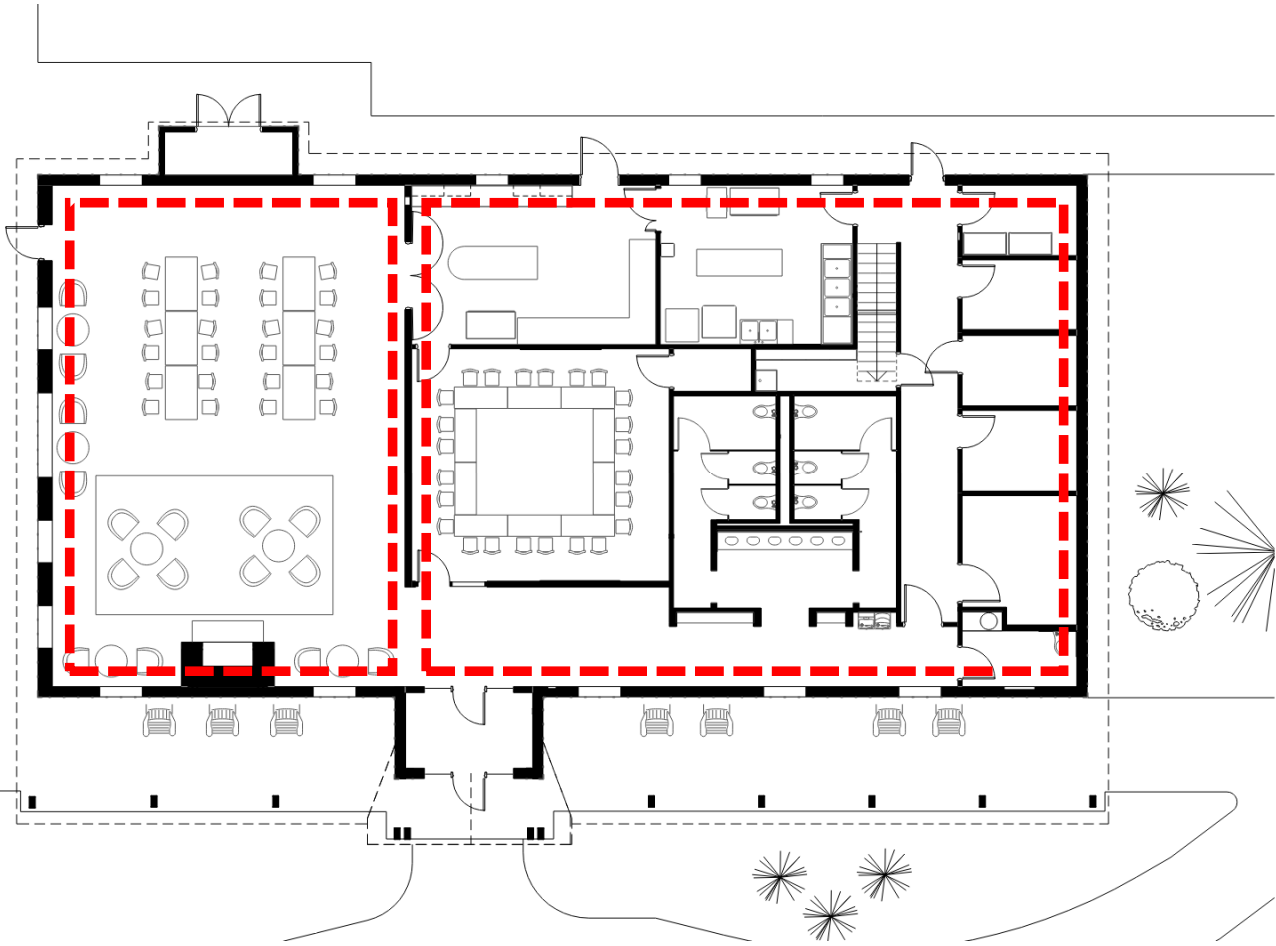




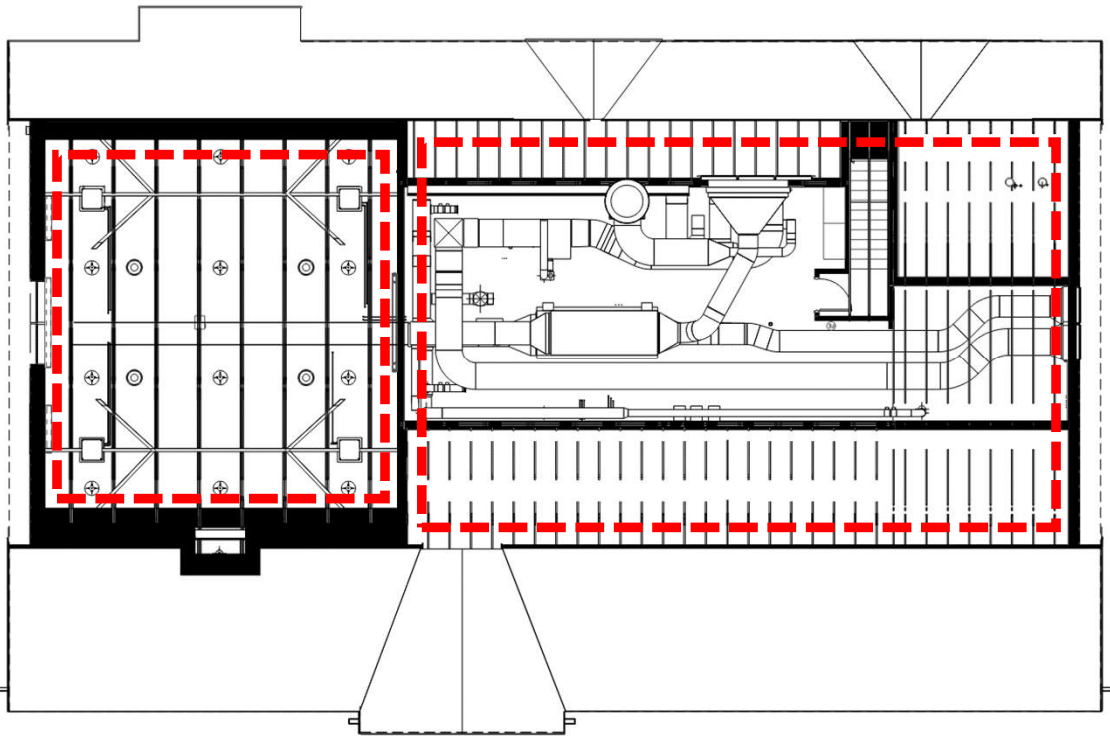
1ST FLOOR



MECHANICAL ATTIC



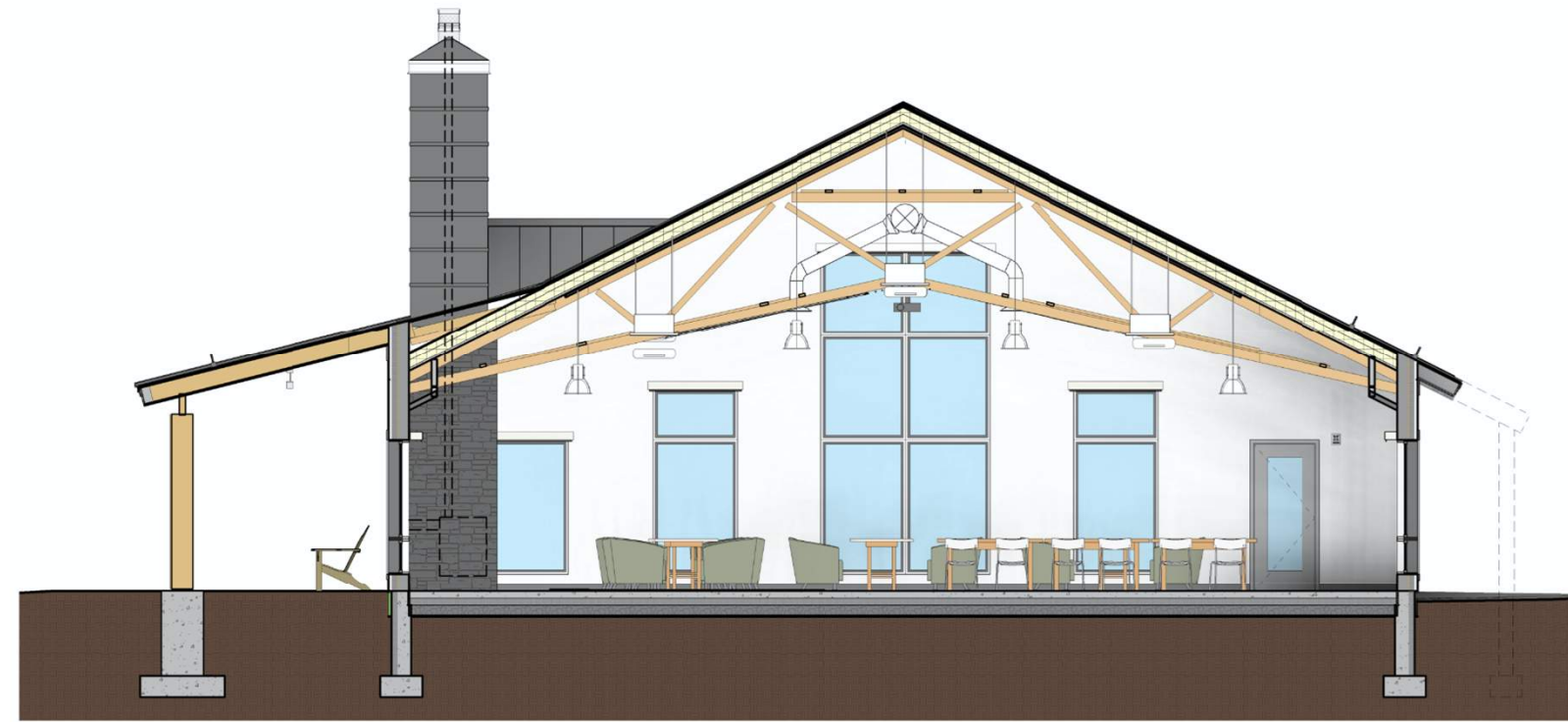
1ST FLOOR



MECHANICAL ATTIC

Different insulation approaches:

- Warm roof

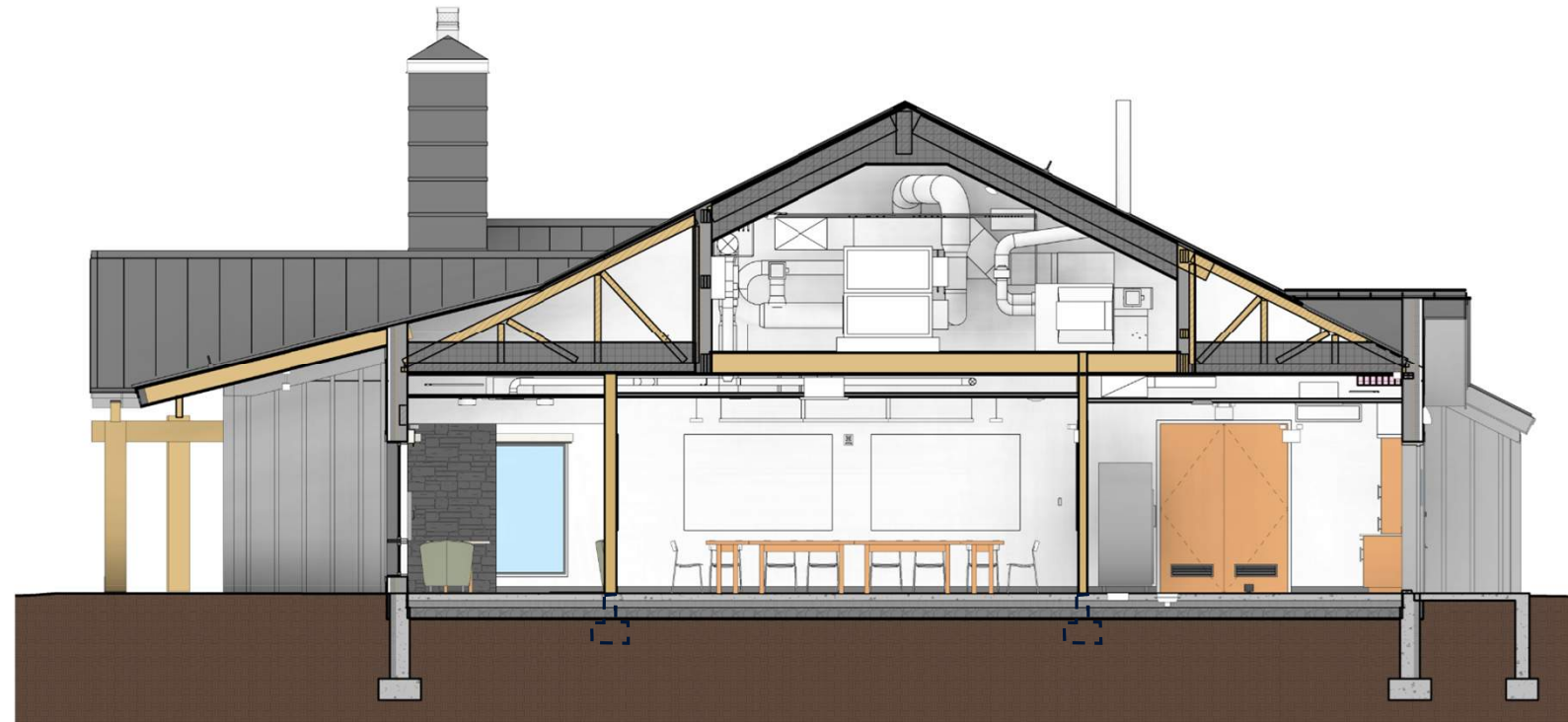


Project & Design

Execution and
Quality Control

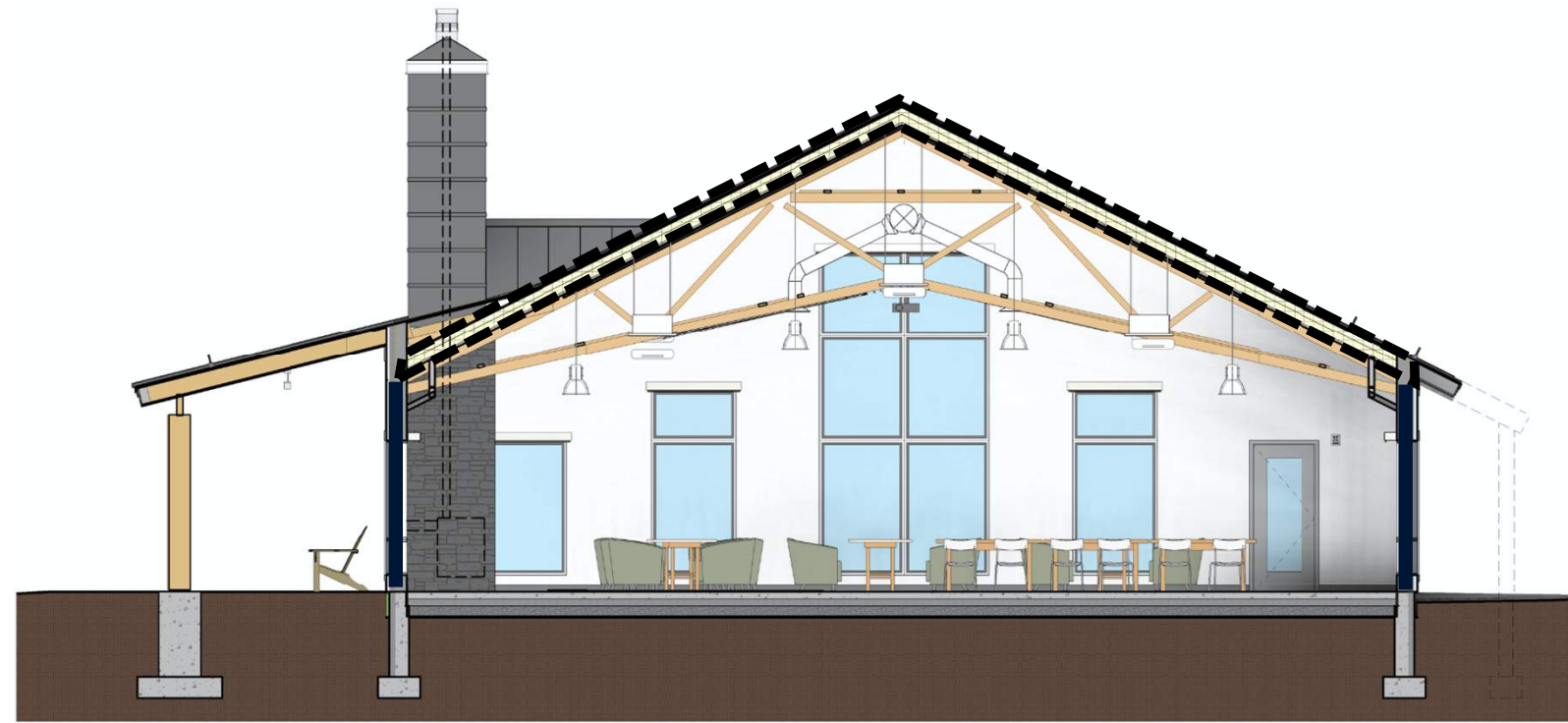
Q&A

- Cold roof



Different insulation approaches:

- **Warm roof**
 - visual appeal

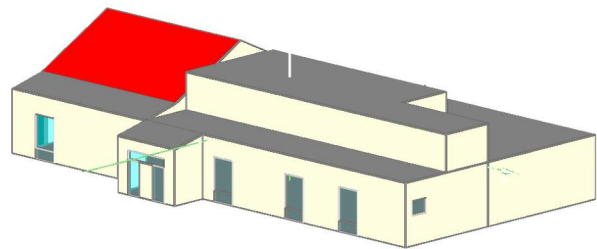


Project & Design

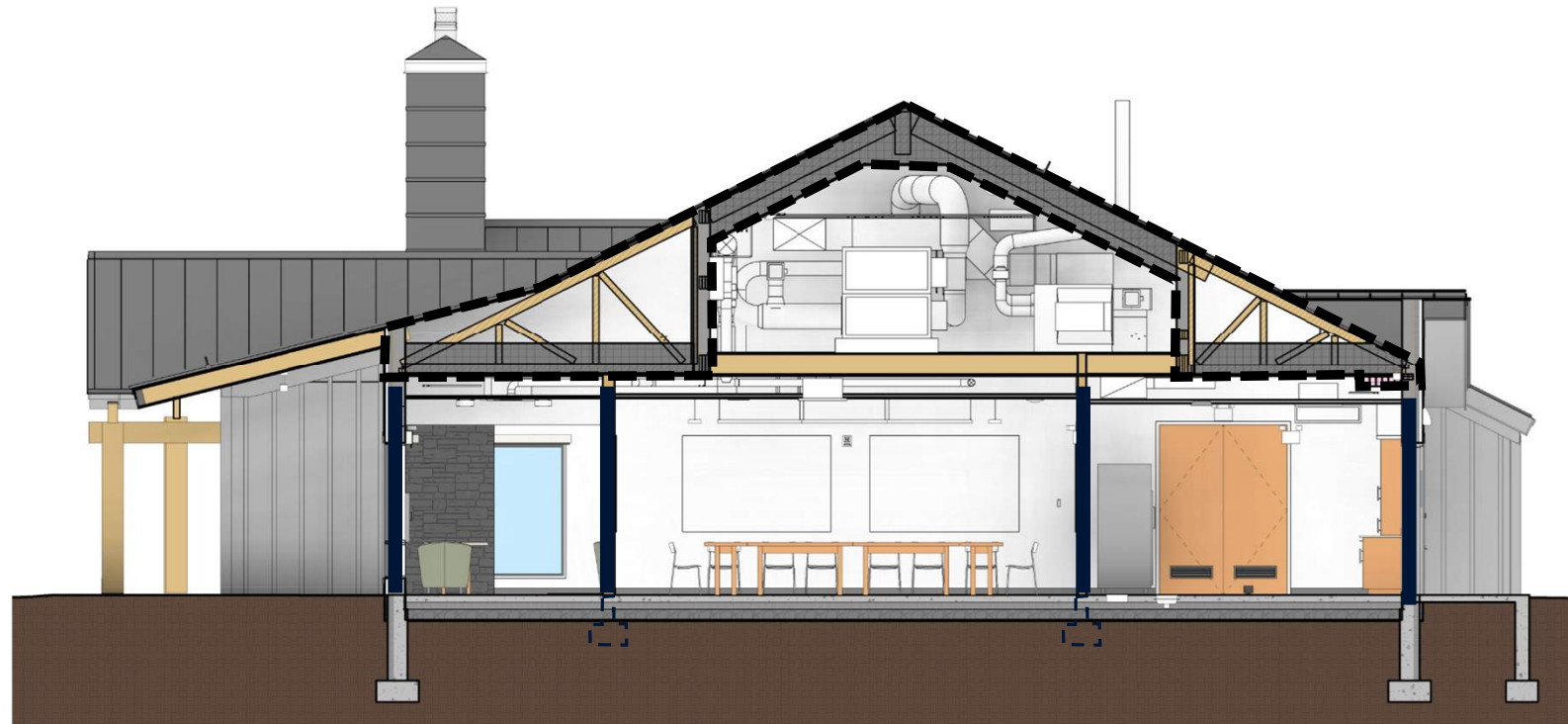
Execution and
Quality Control

Q&A

- **Cold roof**
 - save on conditioned volume
 - shorter structural spans
 - cheaper insulation type

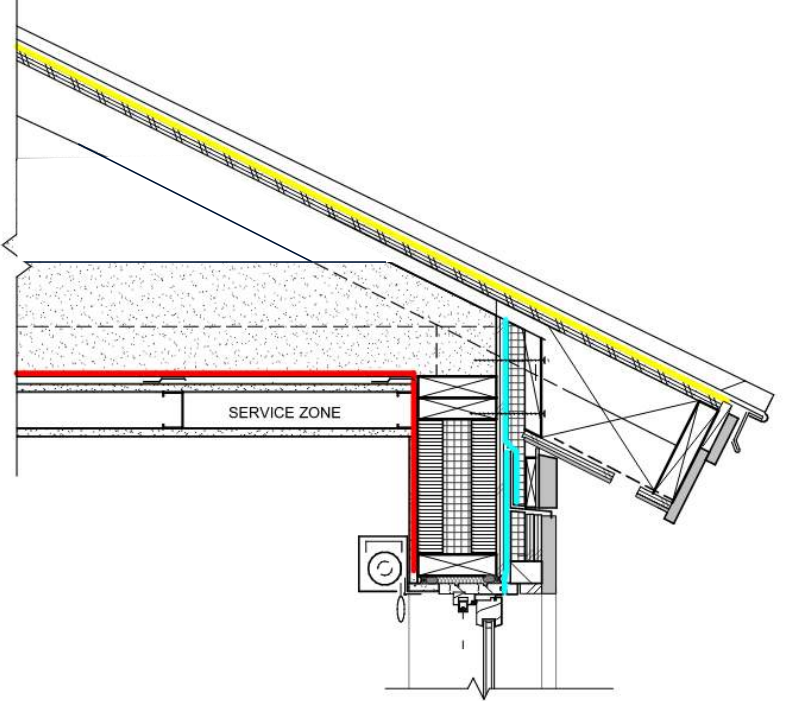


Interior thermal envelope
modeled in WUFI



LLC: THERMAL ENVELOPE

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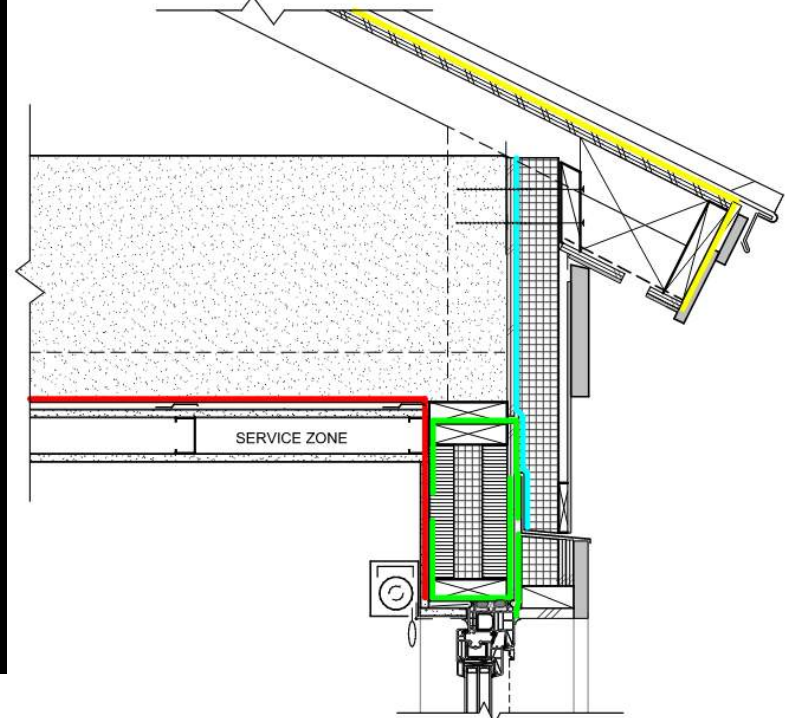
**MAINE 2009
COMMERCIAL IECC CODE ONLY**

ENVELOPE:

ROOF: R38
 WALLS: R13+7.5ci
 FOUNDATION: R7.5ci
 SLAB ON GRADE: R10 FOR 24"

DOUBLE GLAZED uPVC WINDOWS: R3 (40% max area)

AIR TIGHTNESS 7 ACH (1.2 cfm50/ft2) =20x more



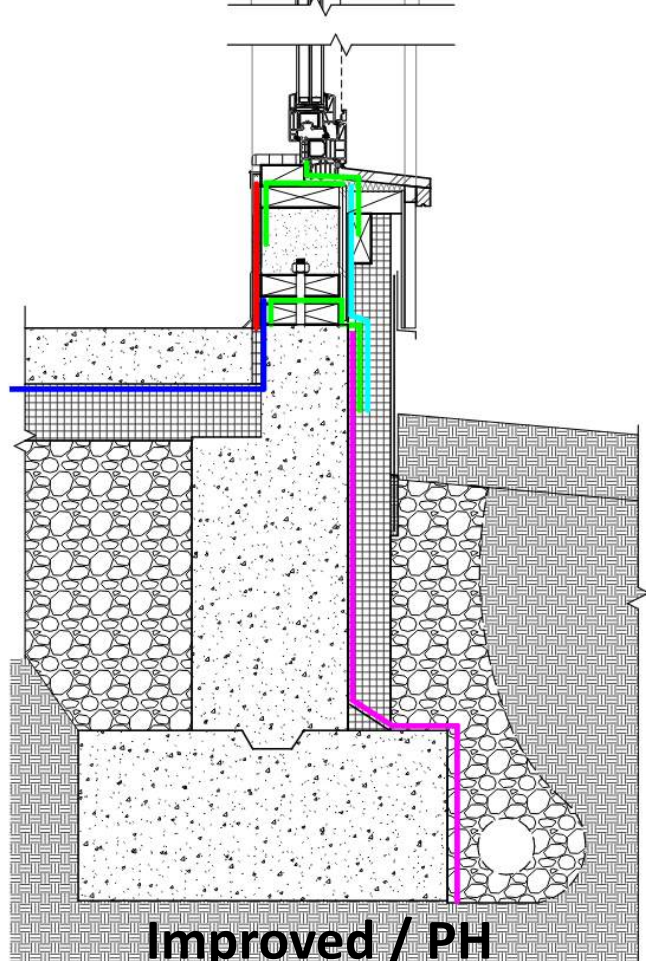
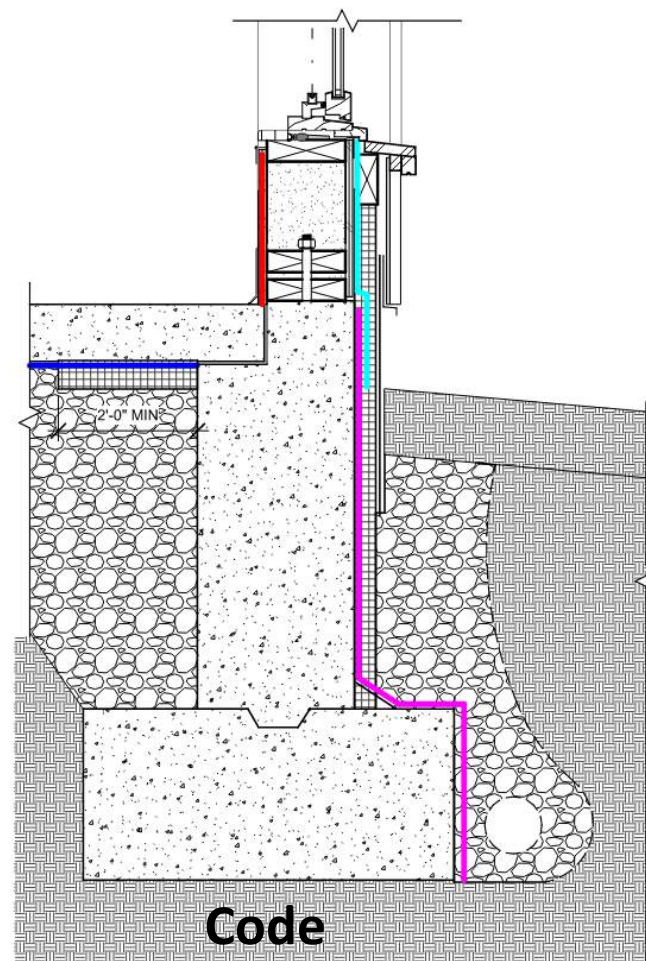
PASSIVE HOUSE PER WUFI MODEL

ENVELOPE:

ROOF: R57 + 50 %
 WALLS: R19+15ci + 66 %
 FOUNDATION: R17ci +227 %
 SLAB ON GRADE: R22 CONTINUOUS +A LOT %

TRIPLE GLAZED THERMALLY BROKEN uPVC WINDOWS: R8 (14% of vertical surfaces) +270%

ALL SEAMS ARE LAPPED AND TAPED
 ALL PENETRATIONS ARE SEALED AND TAPED
 AIR TIGHTNESS: 0.060 cfm50/ft2 5%



- SELF ADHERED UNDERLAYMENT
- AIR WEATHER BARRIER WITH DRAINAGE PLANE
- SELF ADHERED ASPHALT FLASHING
- VAPOR BARRIER
- 15 MILL UNDER SLAB VAPOR BARRIER
- FLUID APPLIED DAMP PROOFING

Code

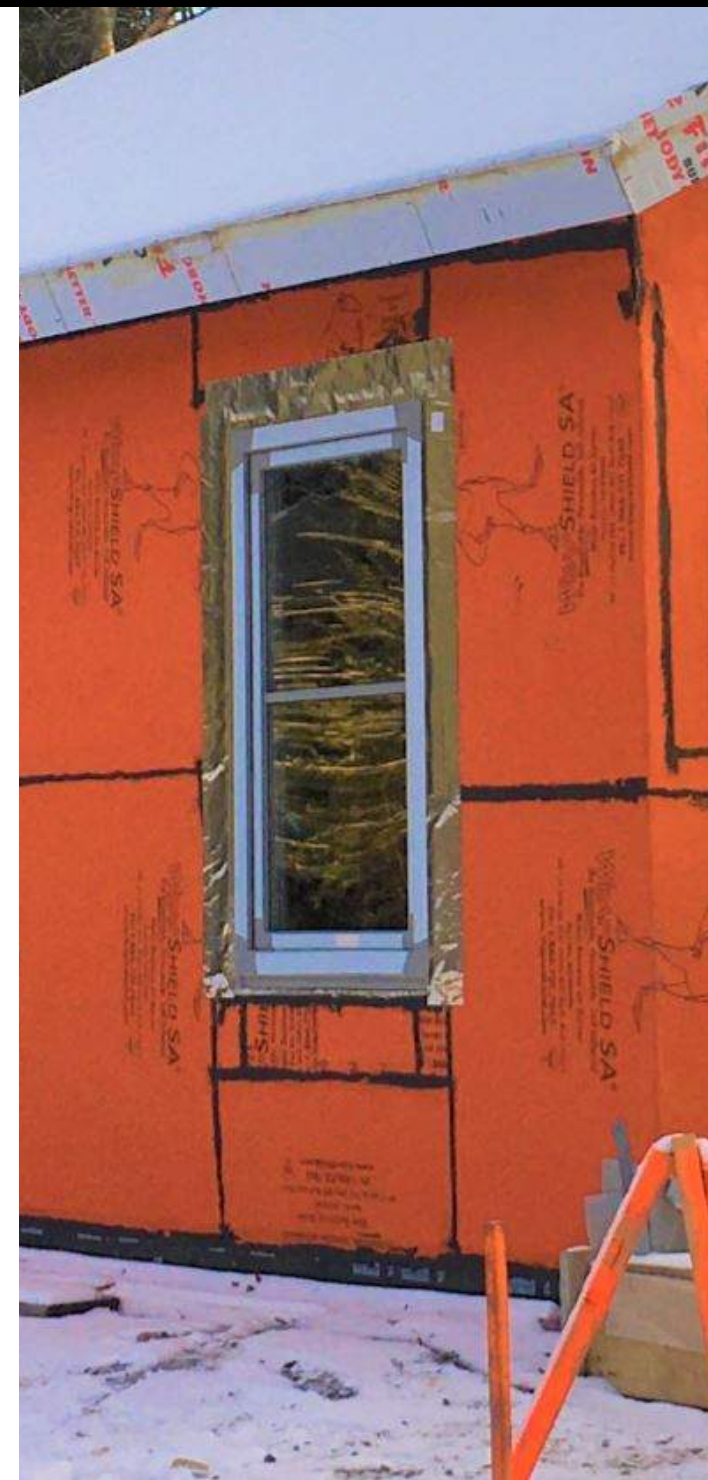
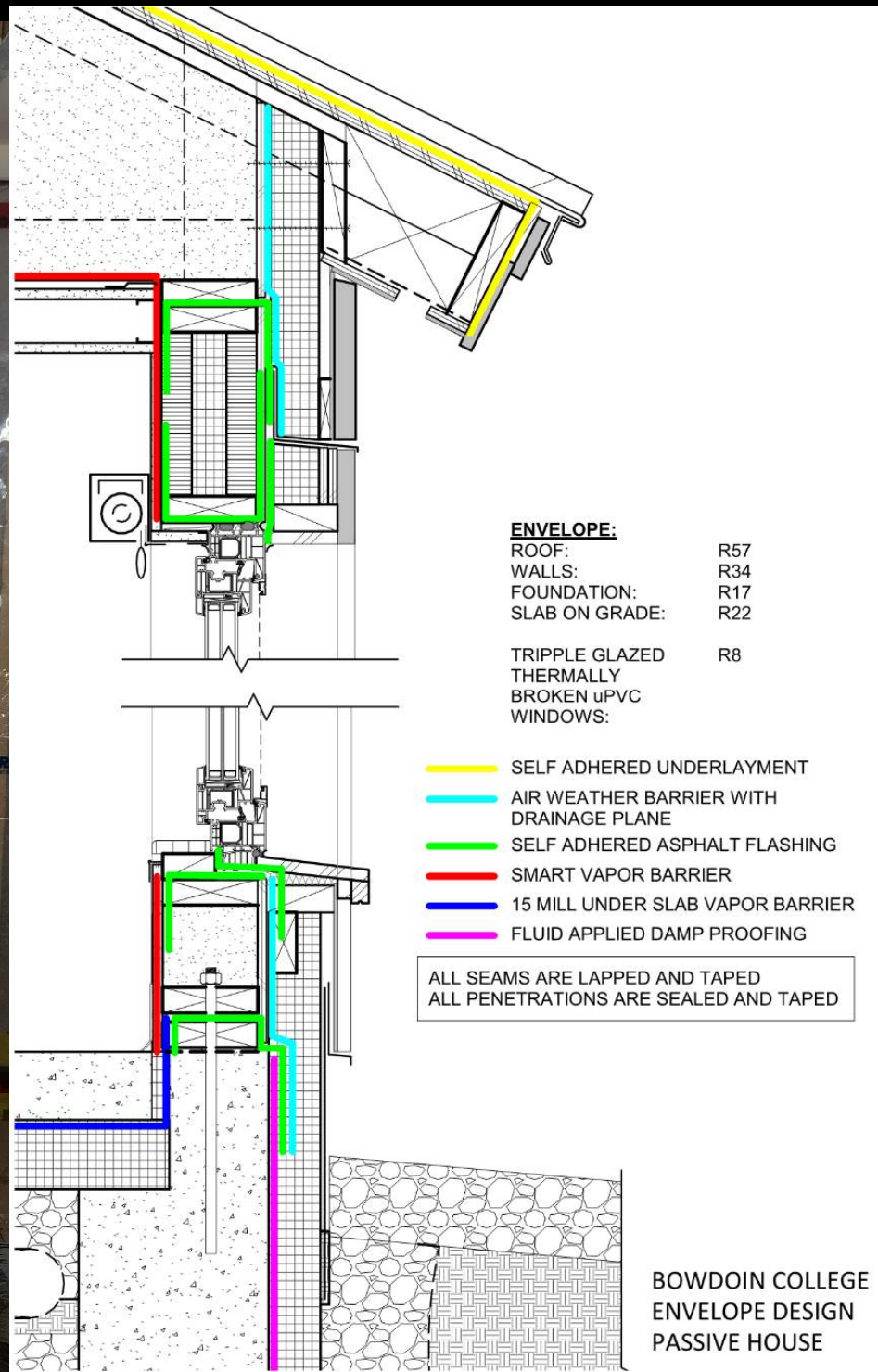
Improved / PH

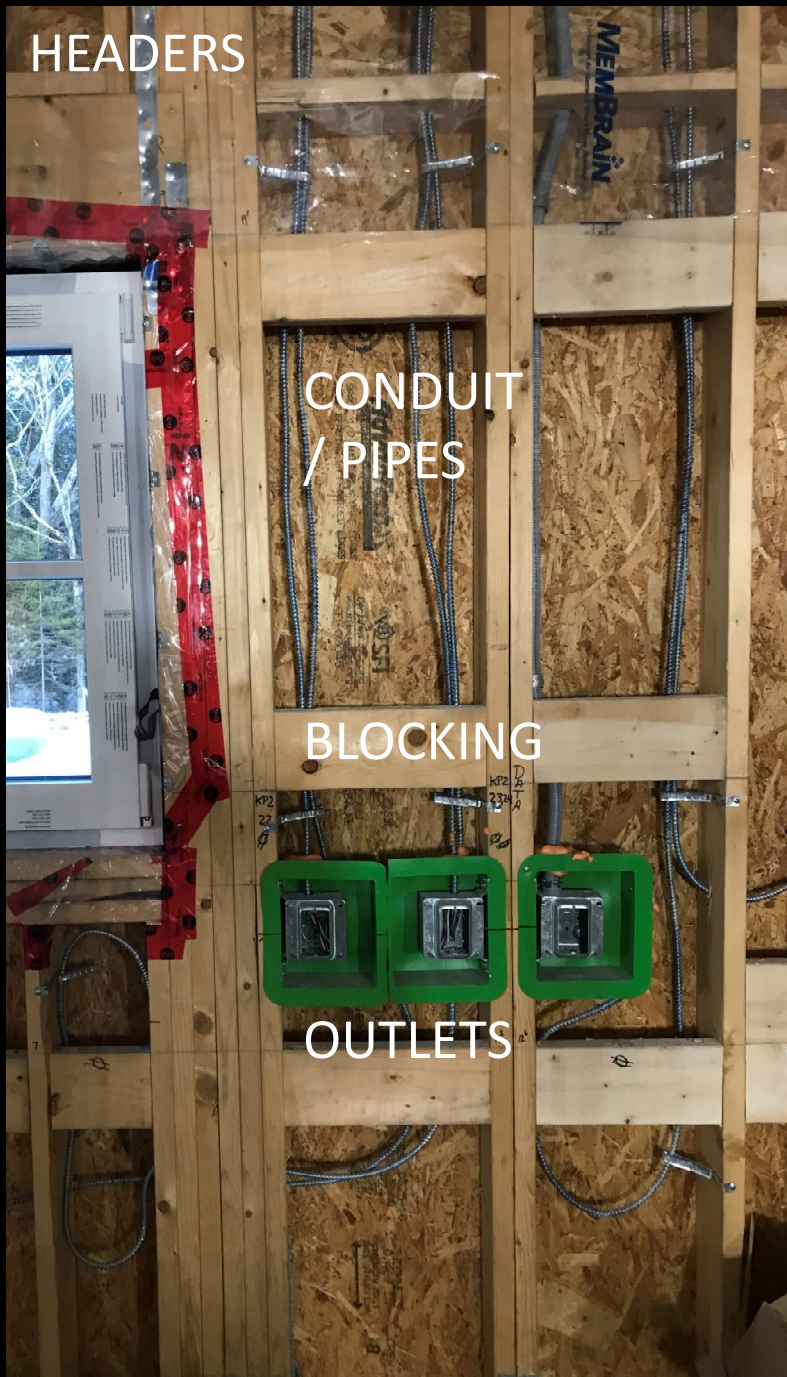
Project & Design

Execution and
Quality Control

Q&A

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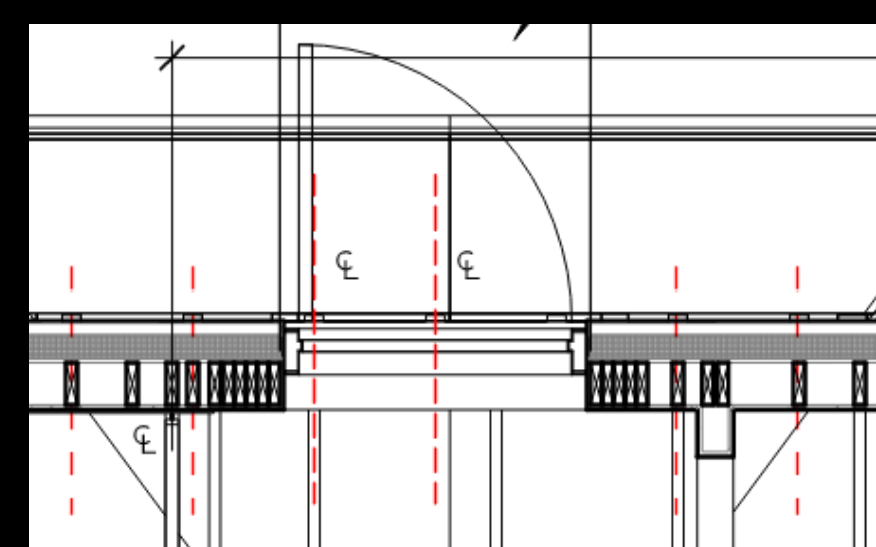




HEADER SCHEDULE

MARK	SIZE	JACK STUDS	KING STUDS
H-1	(2) 1 3/4" X 9 1/2" LVL	2	3
H-2	(2) 2X10	2	3
H-3	(2) 2X8	1	2

TYPICAL WOOD STUD WALL DETAIL
N.T.S.



Project & Design
 Execution and
 Quality Control
 Q&A

REALITY W/ STRUCTURE

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R-39.3

Thermal resistance [hr ft² °F/Btu]: 39.332 / 41.899 (EN ISO 6946 / homogenous layers)

Nr.	Material / Layer (from outside to inside)	Color	λ [Btu/hr ft °F]	Thickness [in]	R [hr ft² °F/Btu]
1	Composite Wood Siding		0.0543	0.75	1.151
2	Polystyrene, extruded		0.01667	3	14.997
3	vapor retarder (10perm)		1.3289	3.9E-2	0.002
4	Plywood (USA)		0.0485	0.625	1.073
5	cellulose		0.019	5.5	21.008
6	Gypsum Board (USA)		0.0942	0.625	0.553

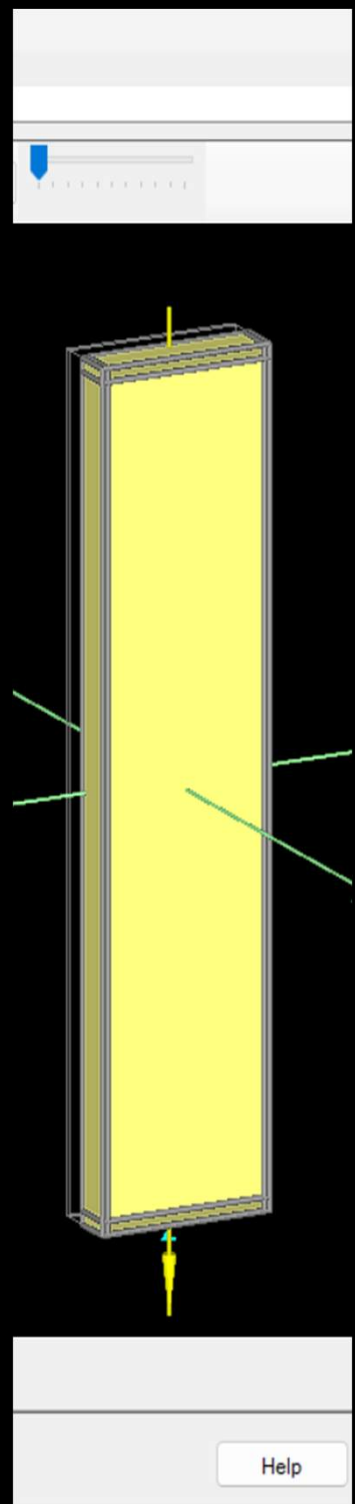
Subdivision [in] (Layer 5)

Vertical	Horizontal
1.5	.75
93	22.5
1.5	.75

Filling with materials

22.5

@24" OC = **7%**
WOOD VS INSULATION



**6%
LESS**

**220%
MORE**

R-37.0

Thermal resistance [hr ft² °F/Btu]: 39.332 / 41.899 (EN ISO 6946 / homogenous layers)

Nr.	Material / Layer (from outside to inside)	Color	λ [Btu/hr ft °F]	Thickness [in]	R [hr ft² °F/Btu]
1	Composite Wood Siding		0.0543	0.75	1.151
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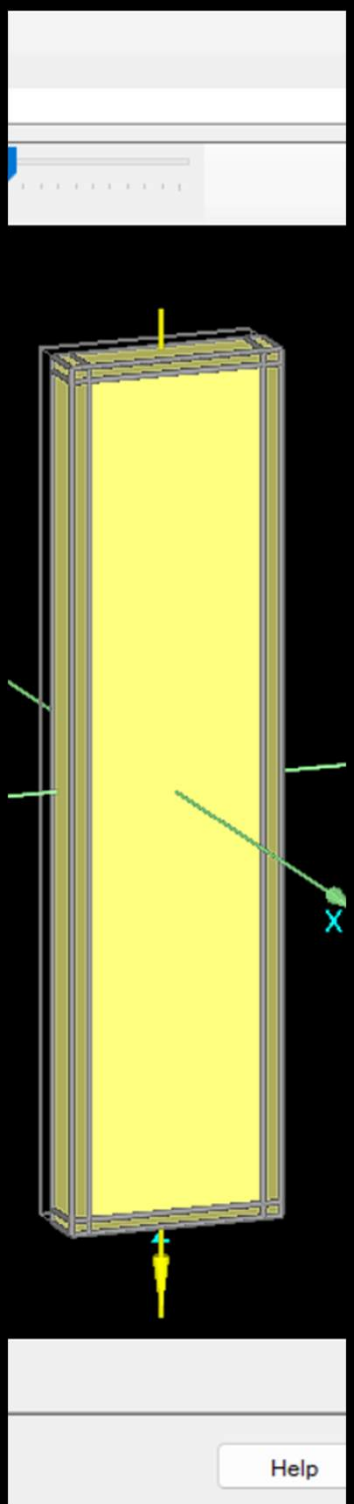
Subdivision [in] (Layer 5)

Vertical	Horizontal
1.5	2
93	20
1.5	2

Filling with materials

20

@16+" OC = **16%**
WOOD VS INSULATION



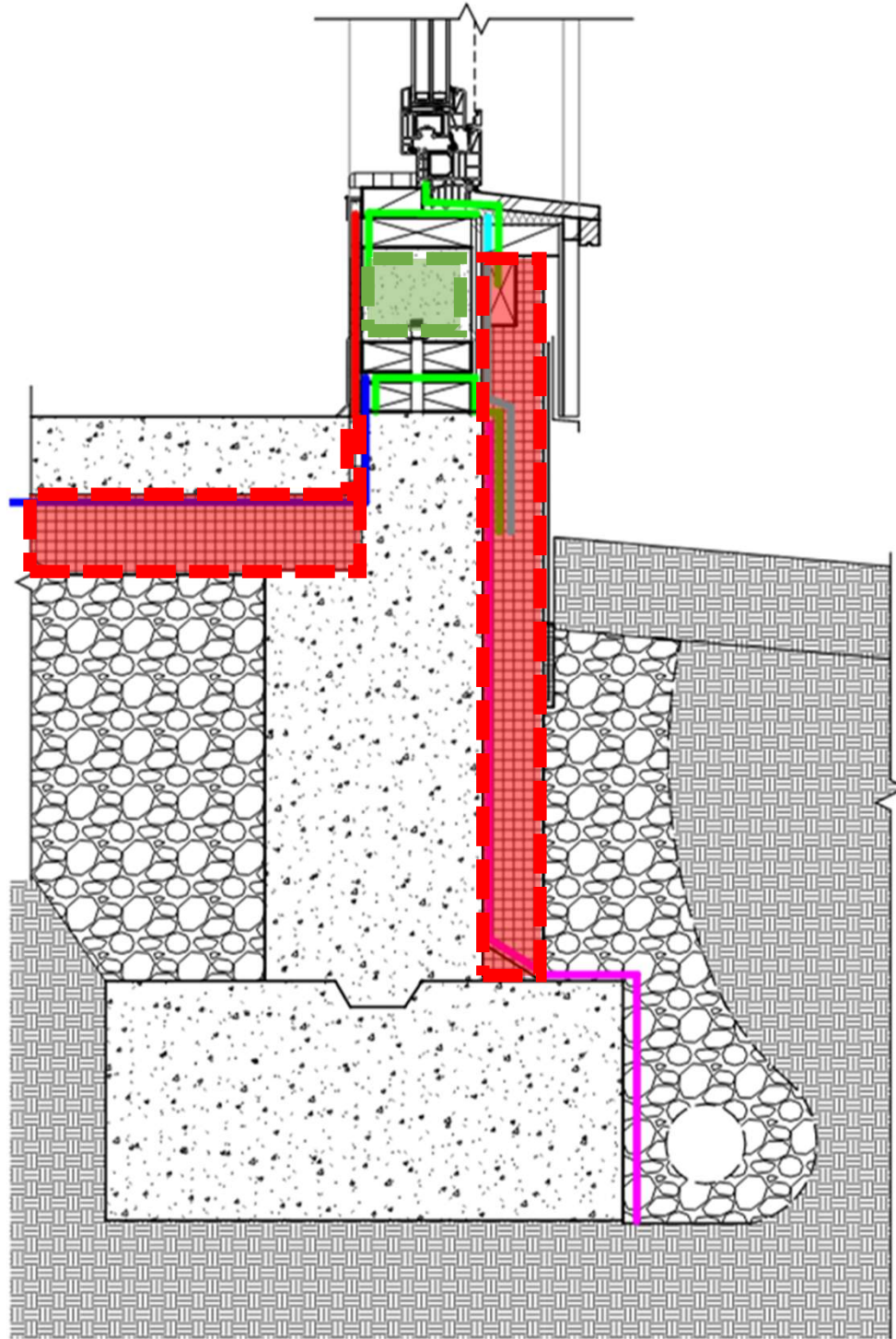
Project & Design

Execution and Quality Control

Q&A

REALITY W/ STRUCTURE

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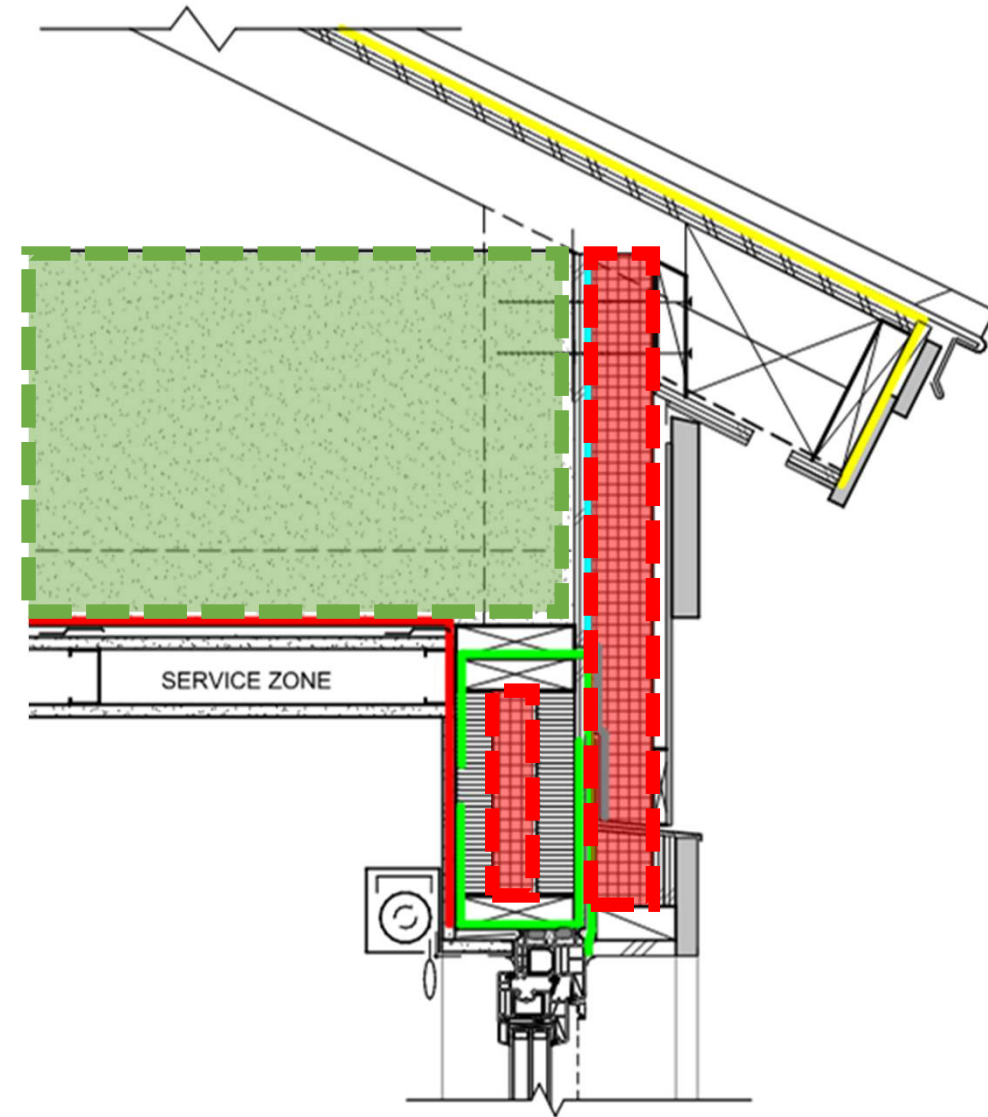


Cellulosic (dense pack insulation)

- ceilings
- cavity walls

XPS

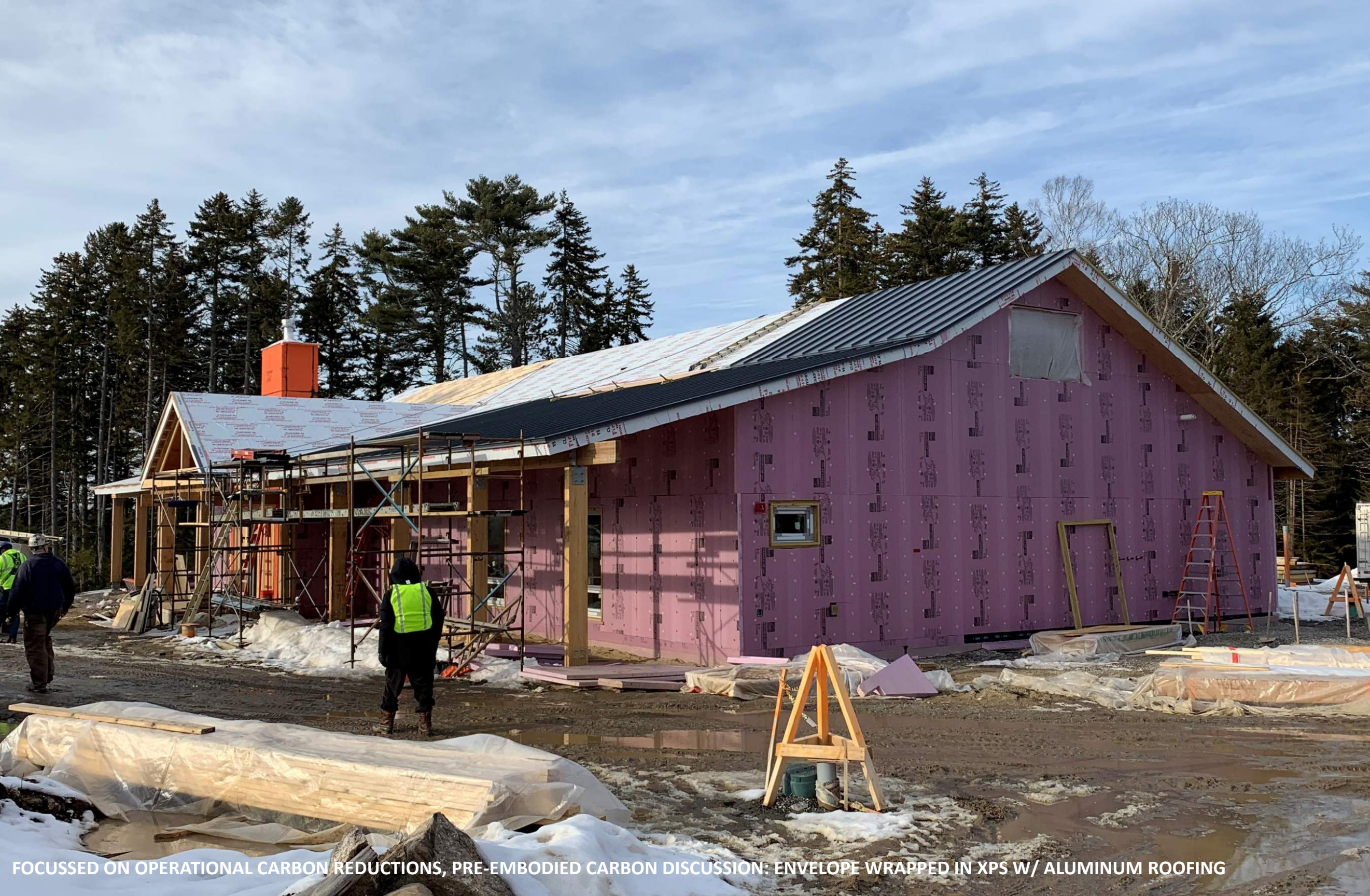
- under slab
- below grade
- continuous ext.



Project & Design

Execution and
Quality Control

Q&A

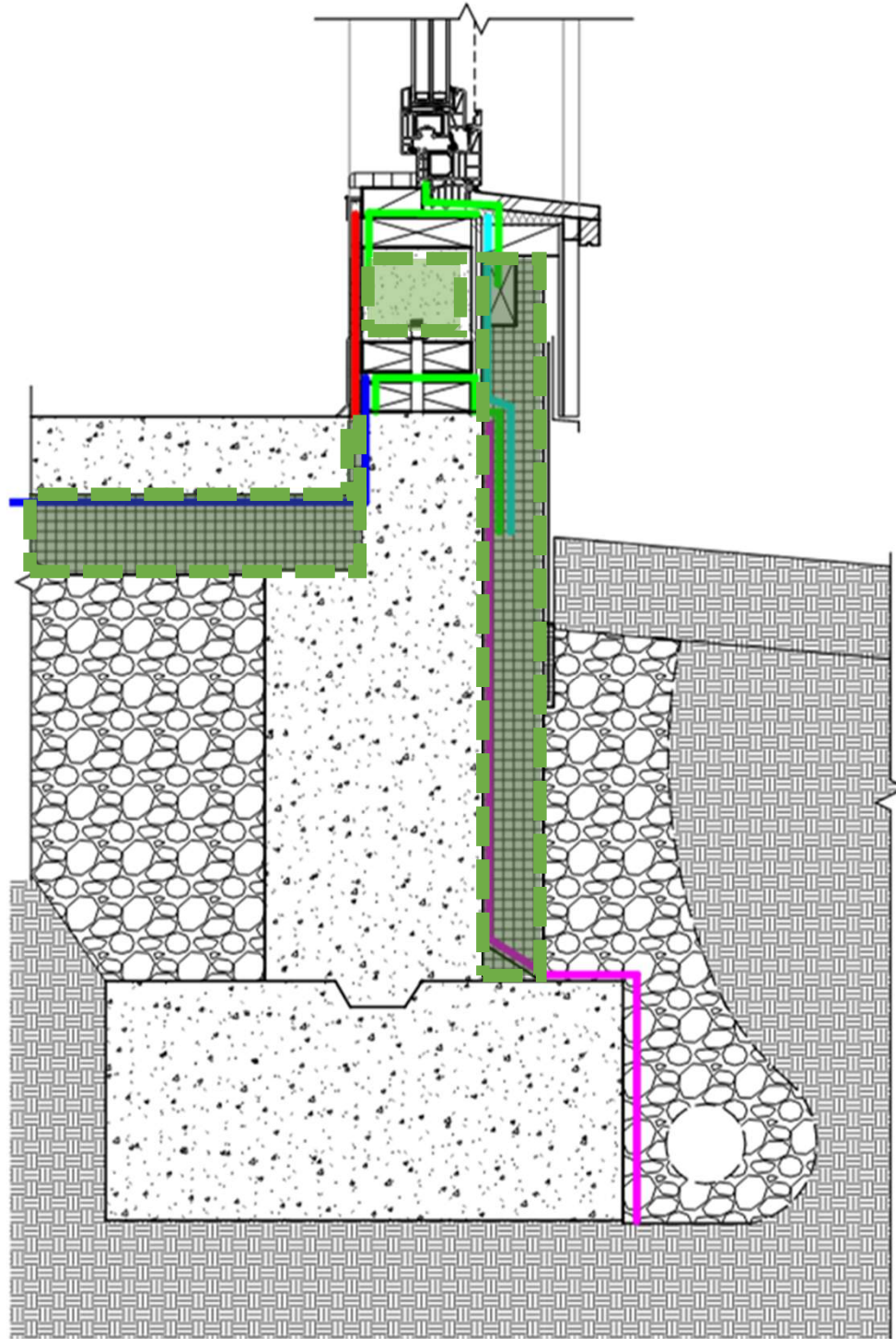


FOCUSED ON OPERATIONAL CARBON REDUCTIONS, PRE-EMBODIED CARBON DISCUSSION: ENVELOPE WRAPPED IN XPS W/ ALUMINUM ROOFING

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Insulation type	Form / variant	GWP average kgCO2e per 1m2 Rsi-1			R-value per inch	\$ per Ft2/R-1*	
		GBA	BEAM	EC3			
Wood fiber	board, unfaced	-7.13	-0.26	5.00	3.5		0.14
Hempcrete	block	-5.67	-0.53		2.1		0.13
Cellulose	densepack 3.55 pcf	-2.16	-0.37	0.30	3.6		0.06
Cellulose	blown / loosefill 1.29 pcf	-0.83	-0.19	0.30	3.4		0.04
Fiberglass	batt unfaced, recycled content	0.68	0.12	1.00	3.6		0.07
Fiberglass	blown / loosefill 1.29 pcf	1.3	0.18	1.30	2.7		0.04
Phenolic foam	board, glass tissue faced	1.54			7.2		0.15
Spray polyurethane foam	spray, open cell	1.59			4.0		0.11
Polyisocyanurate	board, foil faced	2.32	0.72	2.75	6.5		0.15
Mineral wool	batt, unfaced	3.25	0.30	2.50	4.2		0.07
Expanded polystyrene EPS/GPS	board, unfaced, IX-25 psi graphite	3.49	0.84	3.00	4.7		0.22
Cellular glass	aggregate	3.93	0.10		1.5		0.36
Spray polyurethane foam	spray, closed cell HFO	4.00	0.25	2.50	6.6		0.19
Mineral wool	board, unfaced, 'heavy' density	4.06	1.44	2.50	4.0		0.07
Extruded polystyrene XPS/NGX	board, 25psi HFO	8.83		10.00	5.0		0.22
Spray polyurethane foam	spray, closed cell HFC	14.86	3.00	3.50	6.6		0.19
Extruded polystyrene XPS	board, 25psi HFC	46.51	10.70	70.00	5.0		0.22

*note: installed cost varies per region / availability



Cellulosic (dense pack insulation)

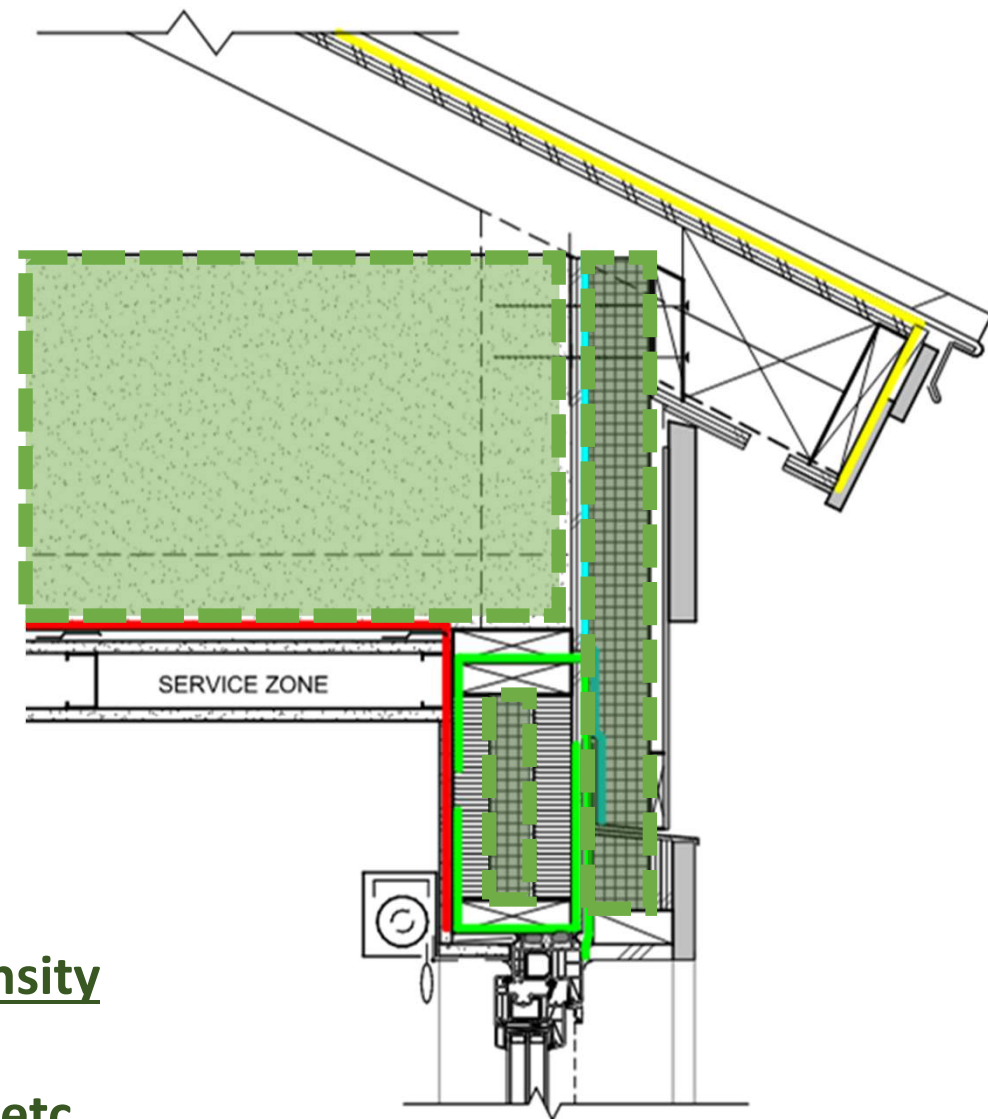
- ceilings
- cavity walls

~~XPS~~

- ~~- under slab~~
- ~~- below grade~~
- ~~- continuous ext.~~

Wood fiber, High density mineral wool, EPS, Phenolic foam, NGX etc.

- under slab
- below grade
- continuous ext.





**RIGID
MINERAL WOOL**

INSULATION: REFERENCE WALLS

**EXTERIOR
SHEATHING**

**PHENOLIC FOAM
THERMALLY
BROKEN Z-GIRTHS**

LIQUID AIR BARRIER

INSULATION: REFERENCE WALLS

Insulation type	Form / variant	GWP average kgCO2e per 1m2 Rsi-1			R-value per inch	\$ per Ft2/R-1*	
		GBA	BEAM	EC3			
Wood fiber	board, unfaced	-7.13	-0.26	5.00	3.5		0.14
Hempcrete	block	-5.67	-0.53		2.1		0.13
Cellulose	densepack 3.55 pcf	-2.16	-0.37	0.30	3.6		0.06
Cellulose	blown / loosefill 1.29 pcf	-0.83	-0.19	0.30	3.4		0.04
Fiberglass	batt unfaced, recycled content	0.68	0.12	1.00	3.6		0.07
Fiberglass	blown / loosefill 1.29 pcf	1.3	0.18	1.30	2.7		0.04
Phenolic foam	board, glass tissue faced	1.54			7.2		0.15
Spray polyurethane foam	spray, open cell	1.59			4.0		0.11
Polyisocyanurate	board, foil faced	2.32	0.72	2.75	6.5		0.15
Mineral wool	batt, unfaced	3.25	0.30	2.50	4.2		0.07
Expanded polystyrene EPS/GPS	board, unfaced, IX-25 psi graphite	3.49	0.84	3.00	4.7		0.22
Cellular glass	aggregate	3.93	0.10		1.5		0.36
Spray polyurethane foam	spray, closed cell HFO	4.00	0.25	2.50	6.6		0.19
Mineral wool	board, unfaced, 'heavy' density	4.06	1.44	2.50	4.0		0.07
Extruded polystyrene XPS/NGX	board, 25psi HFO	8.83		10.00	5.0		0.22
Spray polyurethane foam	spray, closed cell HFC	14.86	3.00	3.50	6.6		0.19
Extruded polystyrene XPS	board, 25psi HFC	46.51	10.70	70.00	5.0		0.22

A LOT

30x

*note: installed cost varies per region / availability

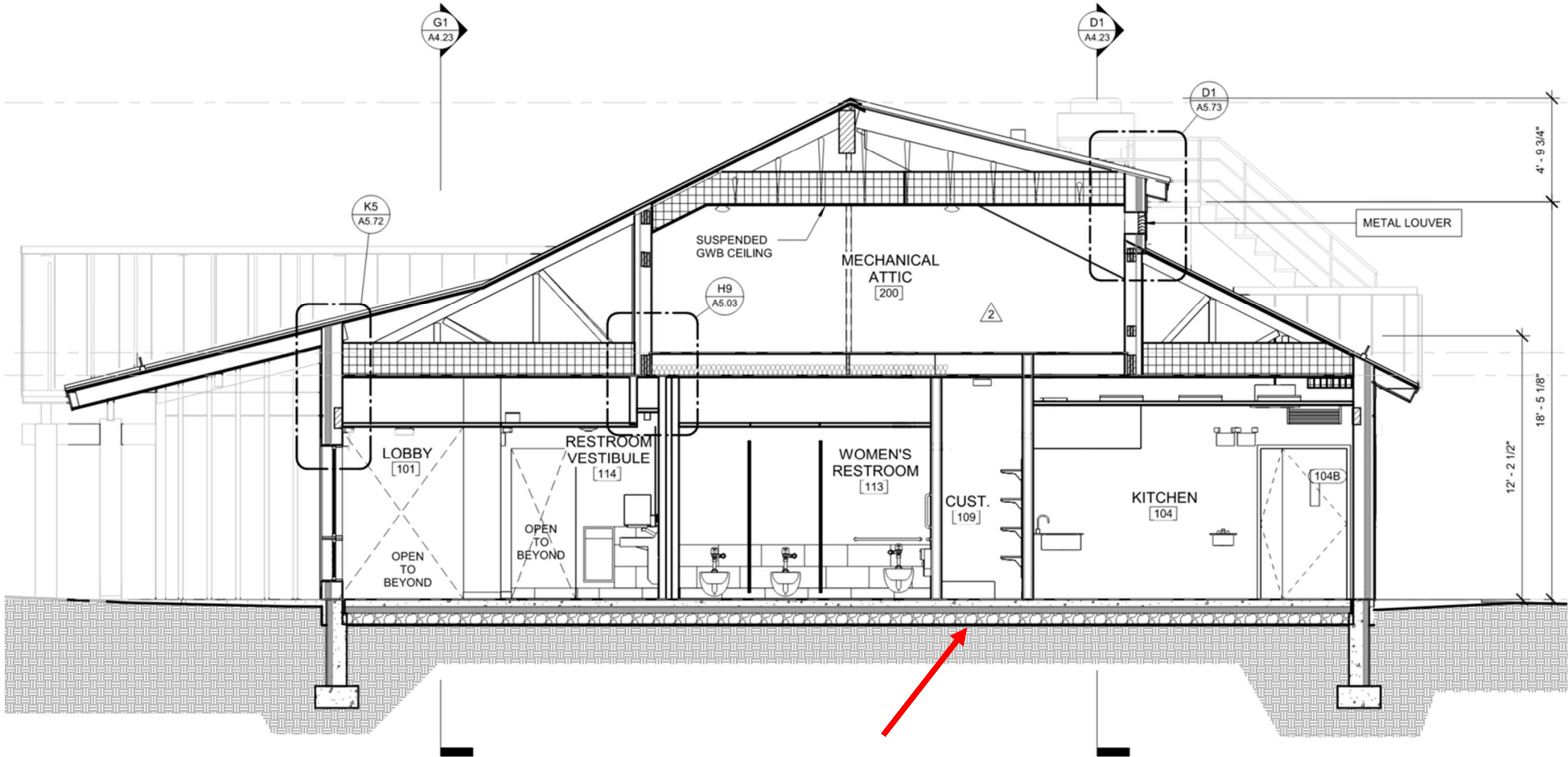


Project & Design *(René Brakels AIA, CPHC, Centerbrook Architects)*
Execution and Quality Control *(Gert Guldentops, P.E., SGH)*
Q&A

Building Enclosure Design

- Enclosure Assemblies
 - Exterior Walls
 - Slab on grade
 - Roofs
 - Windows
- Air Barrier Continuity
- Field Performance Testing
 - Whole building air leakage testing
 - Infrared thermography

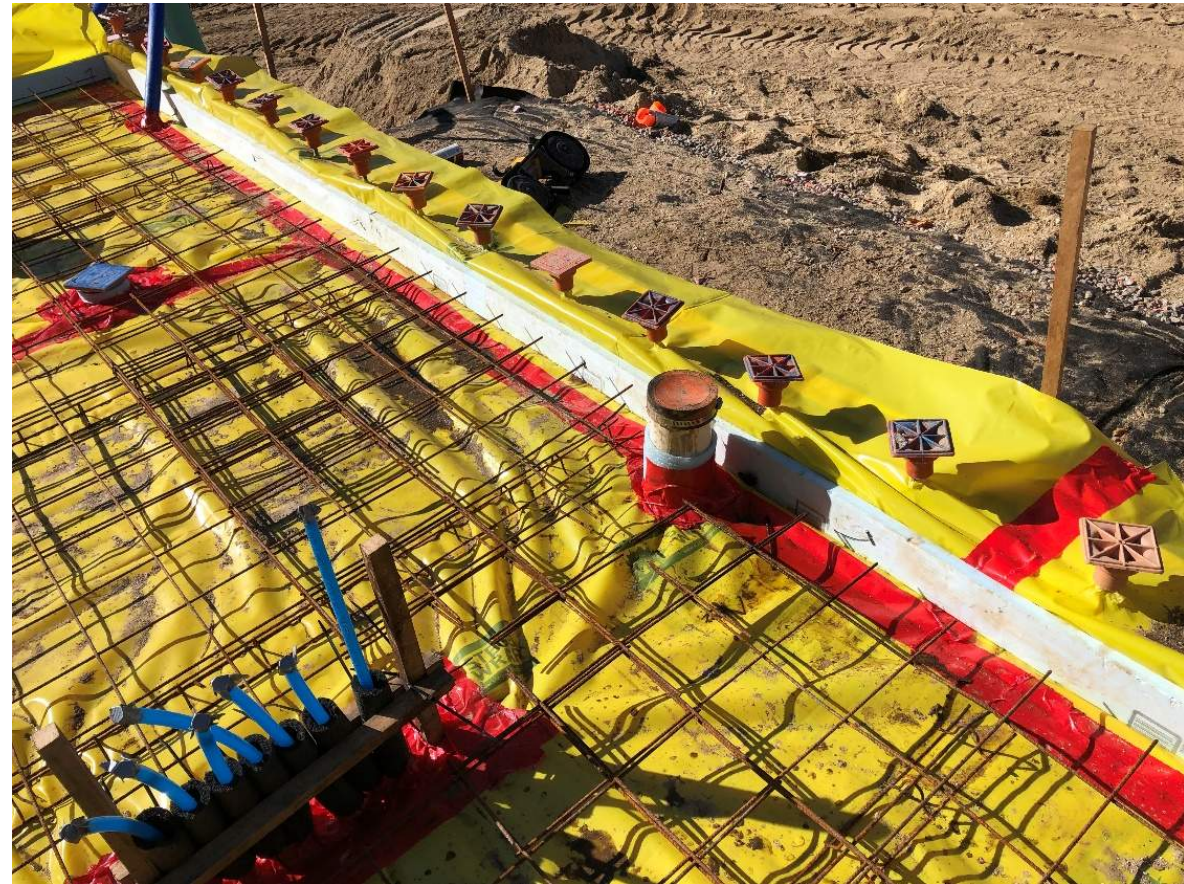






Slab-on-Grade Design:

- Floor finish
- Reinforced concrete slab
- StegoWrap 15 mil reinforced vapor retarder
- 4 in. Extruded polystyrene insulation (R-20)
- Crushed stone with radon mitigation system



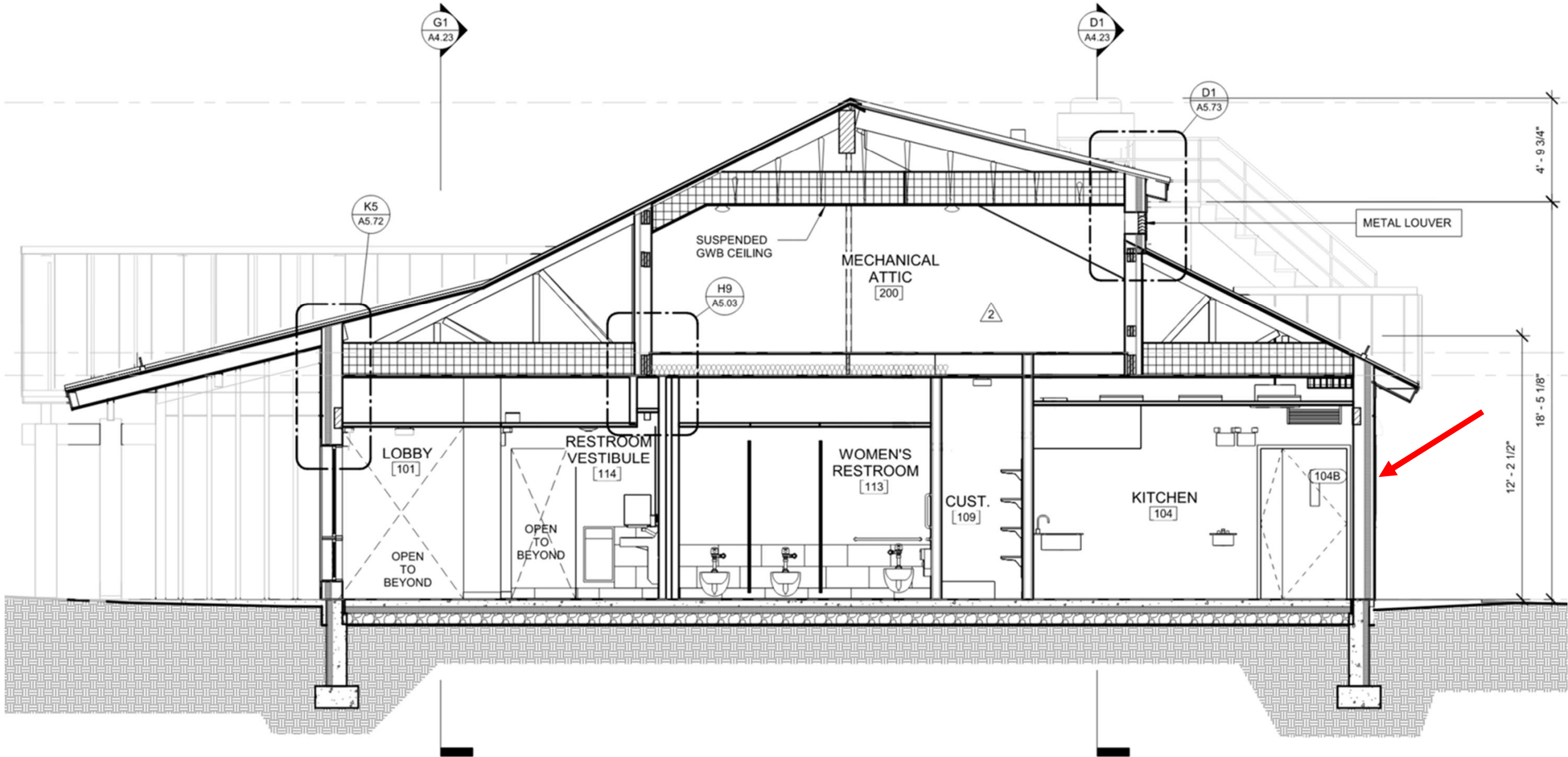
Project & Design

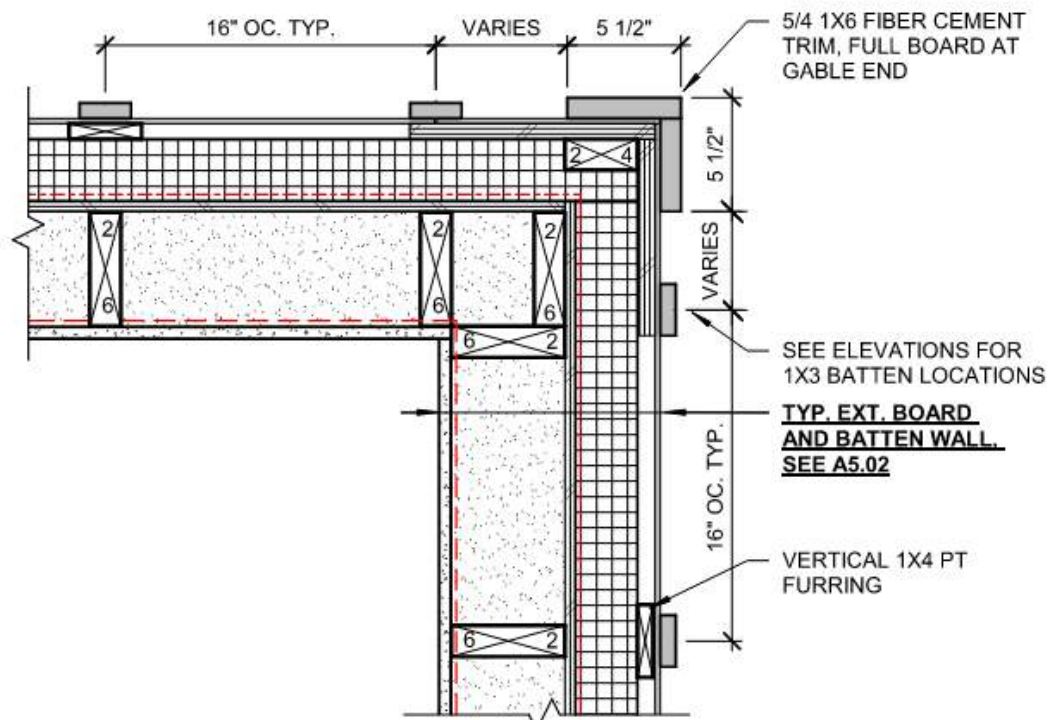
Execution and
Quality Control

Q&A

SLAB ON GRADE







Exterior Wall Design Assembly Components:

- Board and Batten Siding
- Ventilated air space (1x4 PT strapping)
- 3 in. Extruded polystyrene insulation (R-15) over shims
- VaproShield SA (air/water-resistive barrier)
- 1/2 in. Advantech sheathing
- 2x6 wood framing with 5-1/2 in. Dense-Pack Cellulose Insulation (R-19)
- MemBrain (Smart) vapor retarder and air barrier
- Gypsum wallboard; painted.

Project & Design

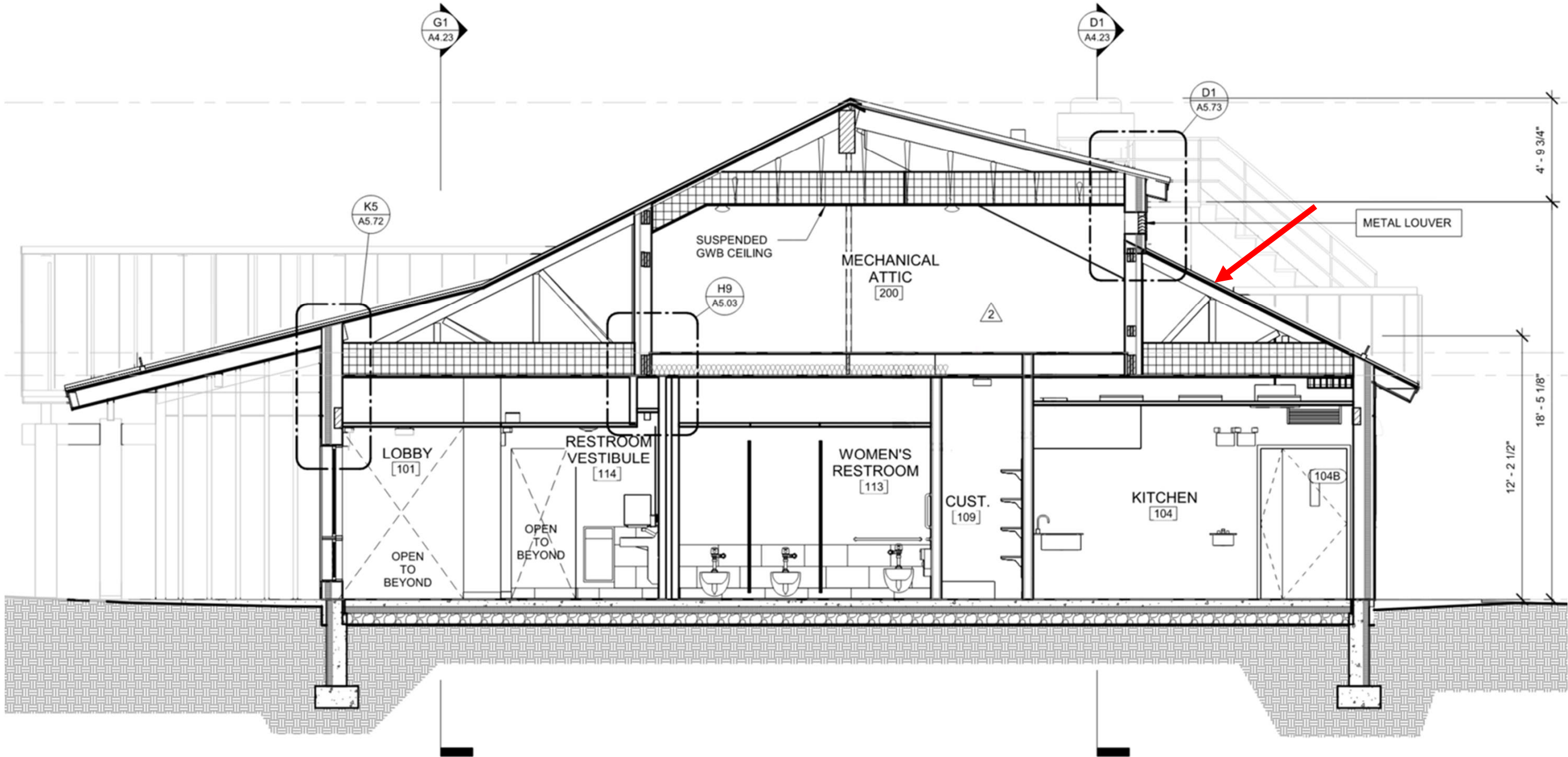
Execution and
Quality Control

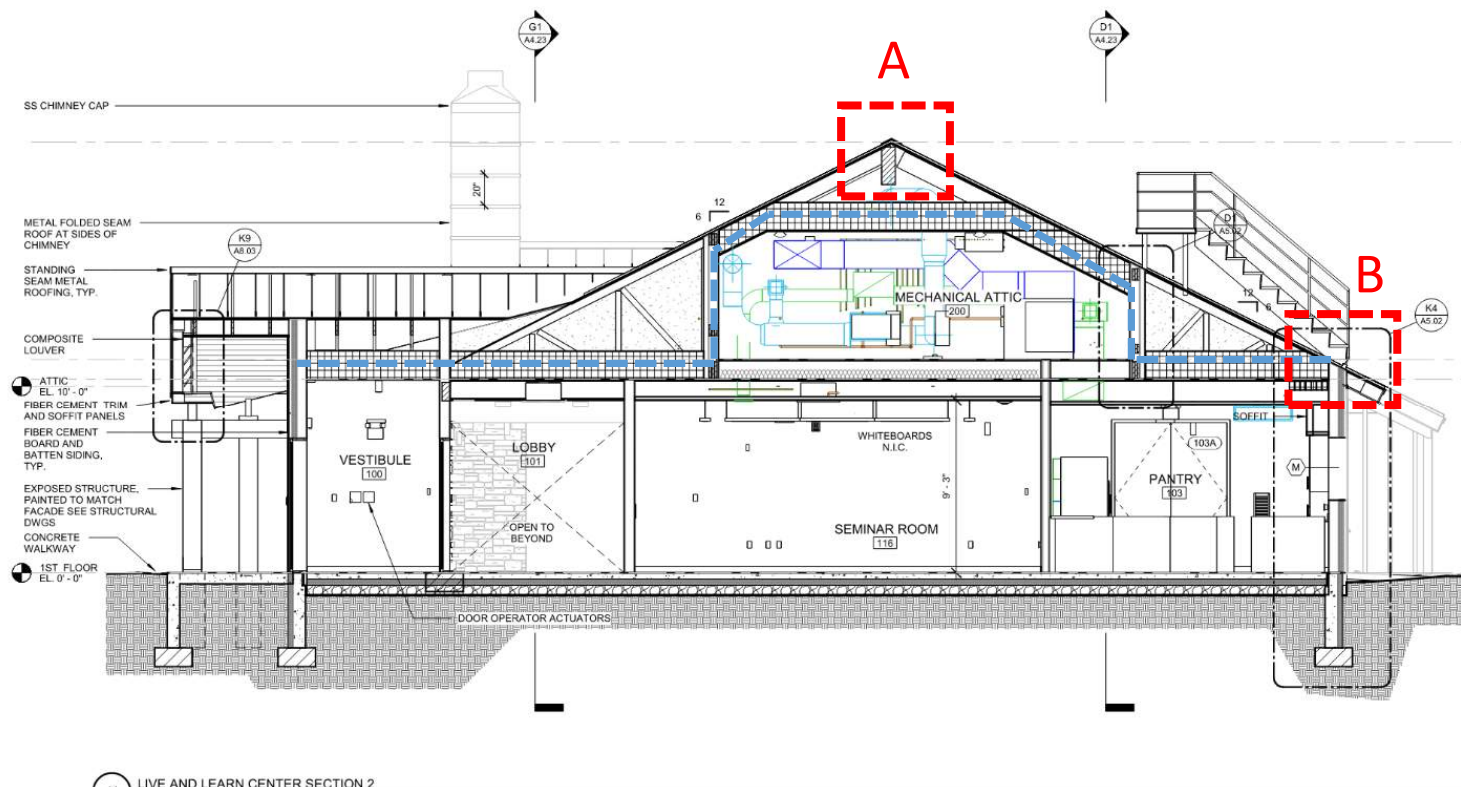
Q&A



EXTERIOR WALL







J1 LIVE AND LEARN CENTER SECTION 2
1/4" = 1'-0"

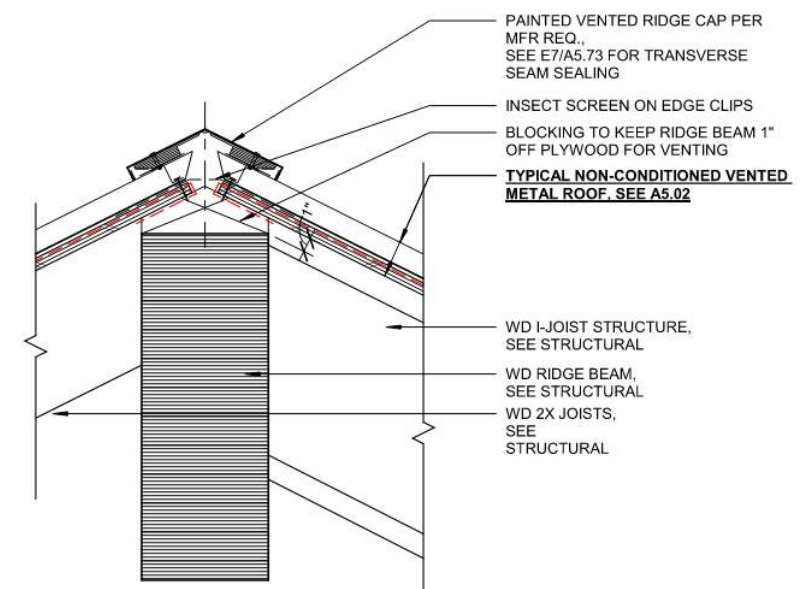
Vented Roof Assembly (Adj Space w/Mech Mezzanine)

- Standing seam metal panels
- Self-adhering roof membrane underlayment
- 5/8 in. plywood
- Wood trusses (ventilated cavity)
- 18 in. Loose-fill cellulose insulation (R-60)
- MemBrain (Smart) vapor retarder
- Gypsum wallboard; painted

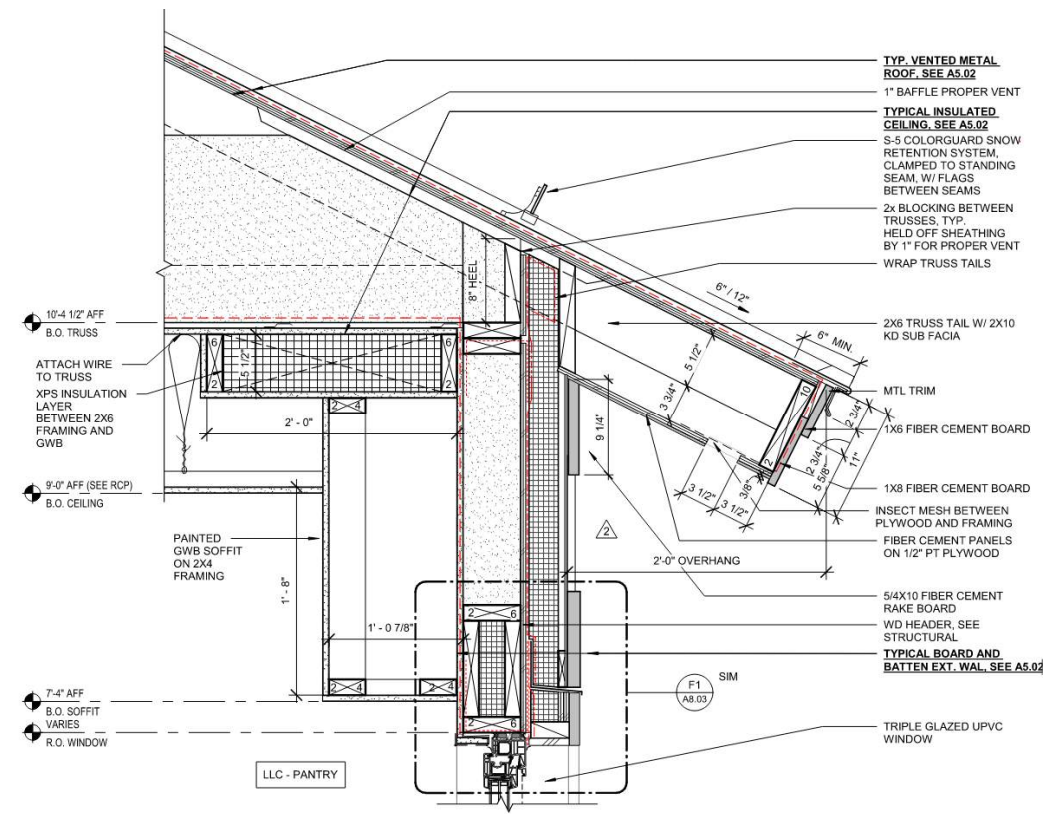
Project & Design

Execution and Quality Control

Q&A



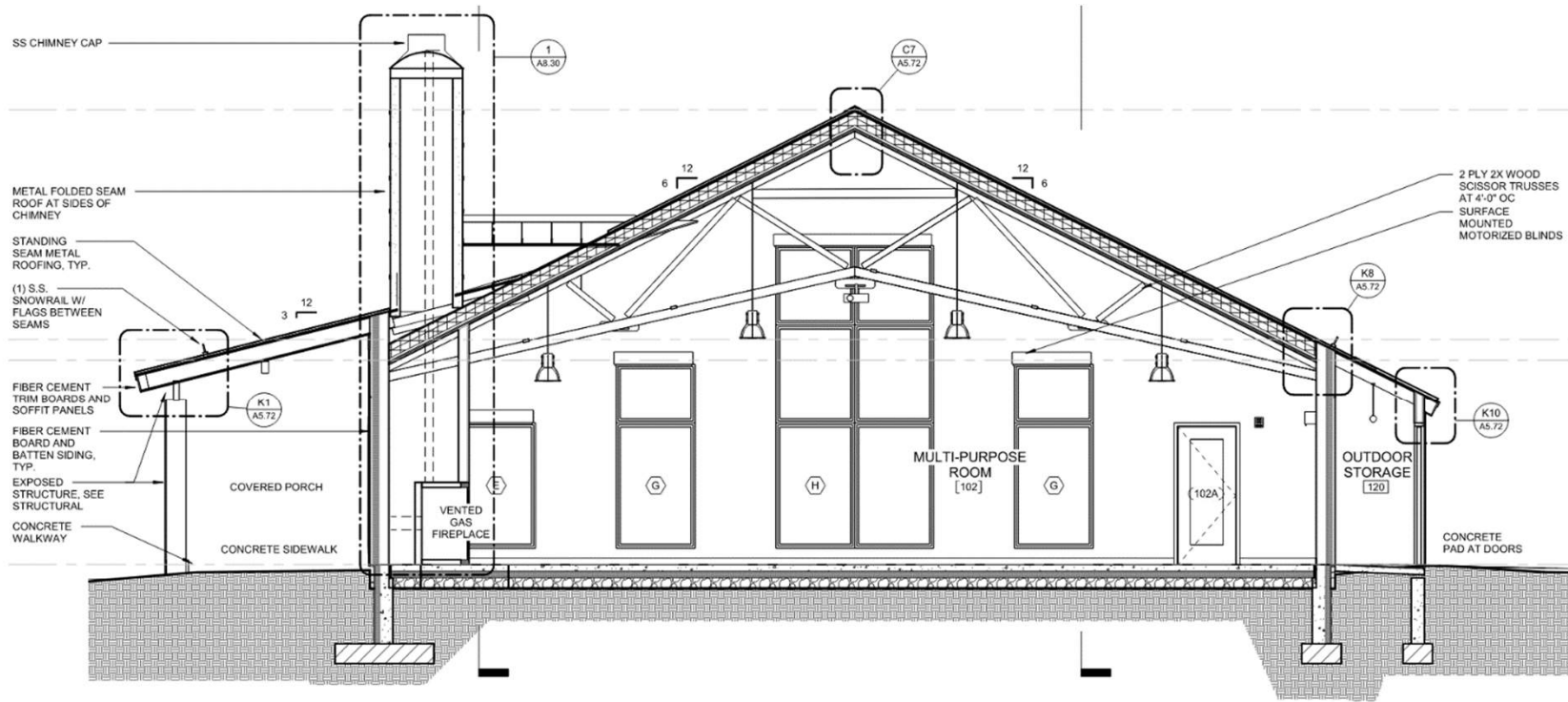
A – Vented Ridge



B – Vented Eave

ROOF ASSEMBLY





Roof Assembly (Multi-Purpose Room)

- Standing seam metal panels
- Clad-Gard SA/MA Metal underlayment
- 4 in. nailboard insulation w/plywood (R-21)
- V-Force Vapor Barrier Membrane
- 5/8 in. T&G Advantech sheathing
- 2 in. nominal T&G wood deck
- Trusses and acoustic panels

Project & Design

Execution and Quality Control

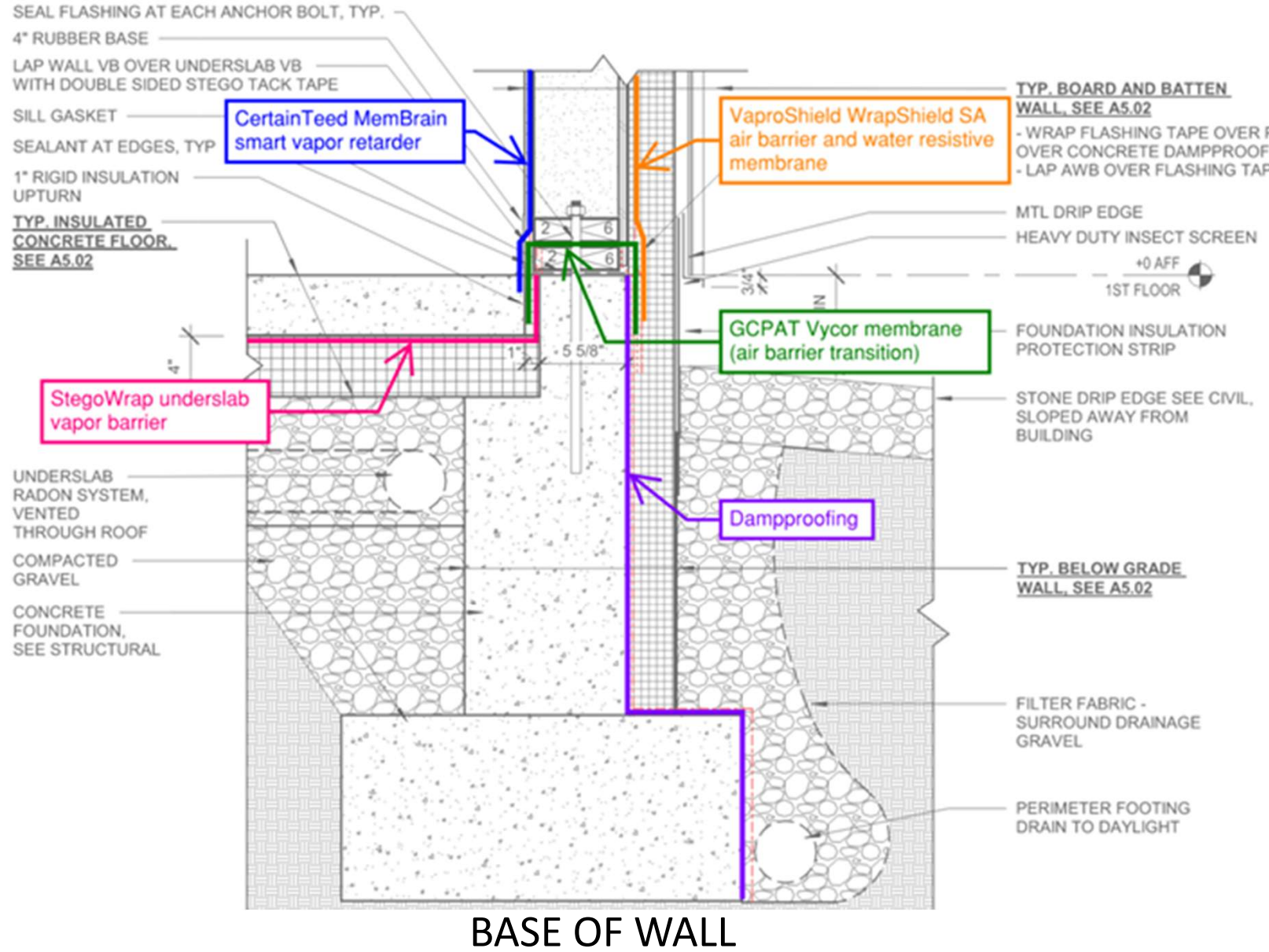
Q&A

E1 LIVE AND LEARN CENTER SECTION 1
1/4" = 1'-0"

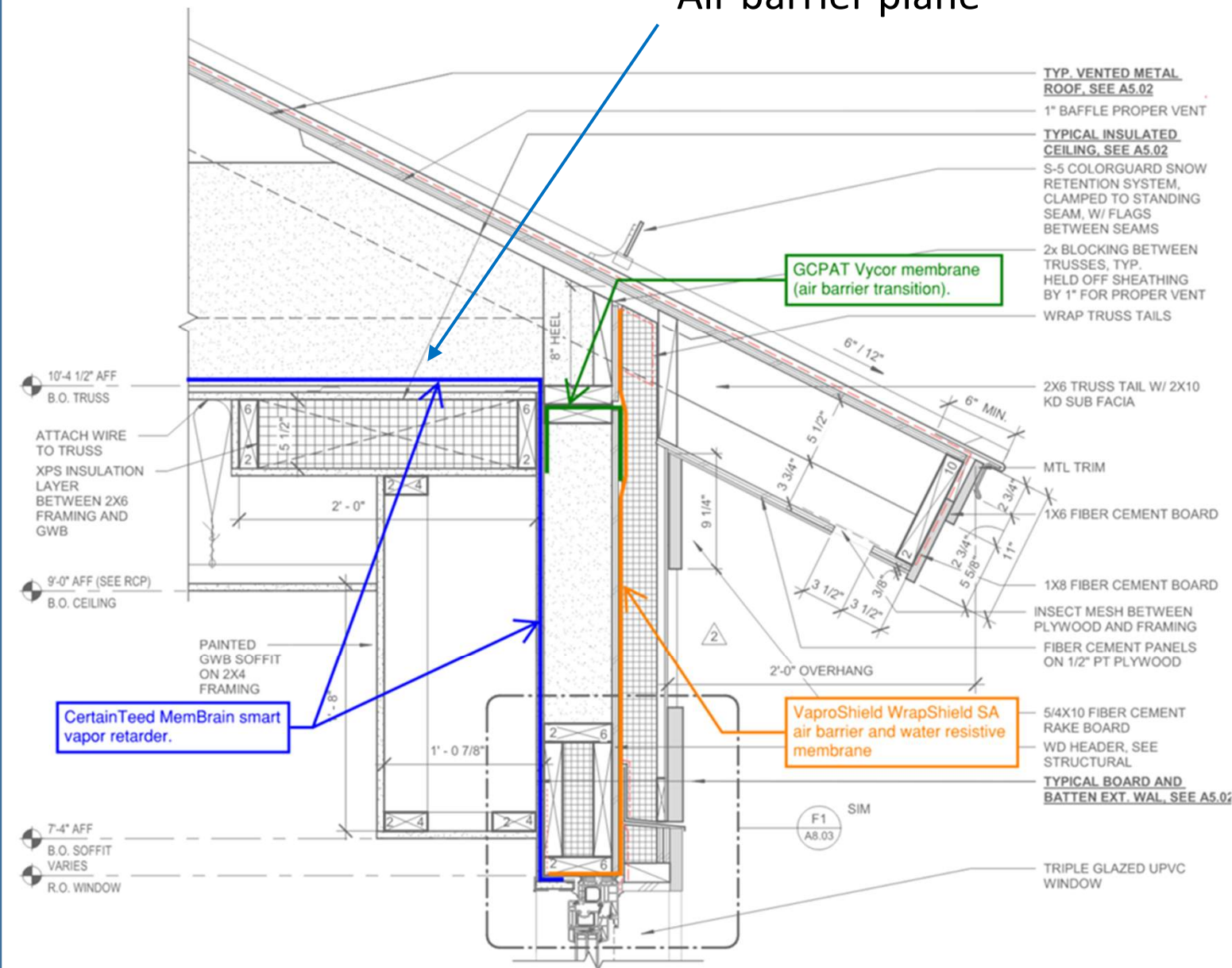


ROOF ASSEMBLY





Air barrier plane



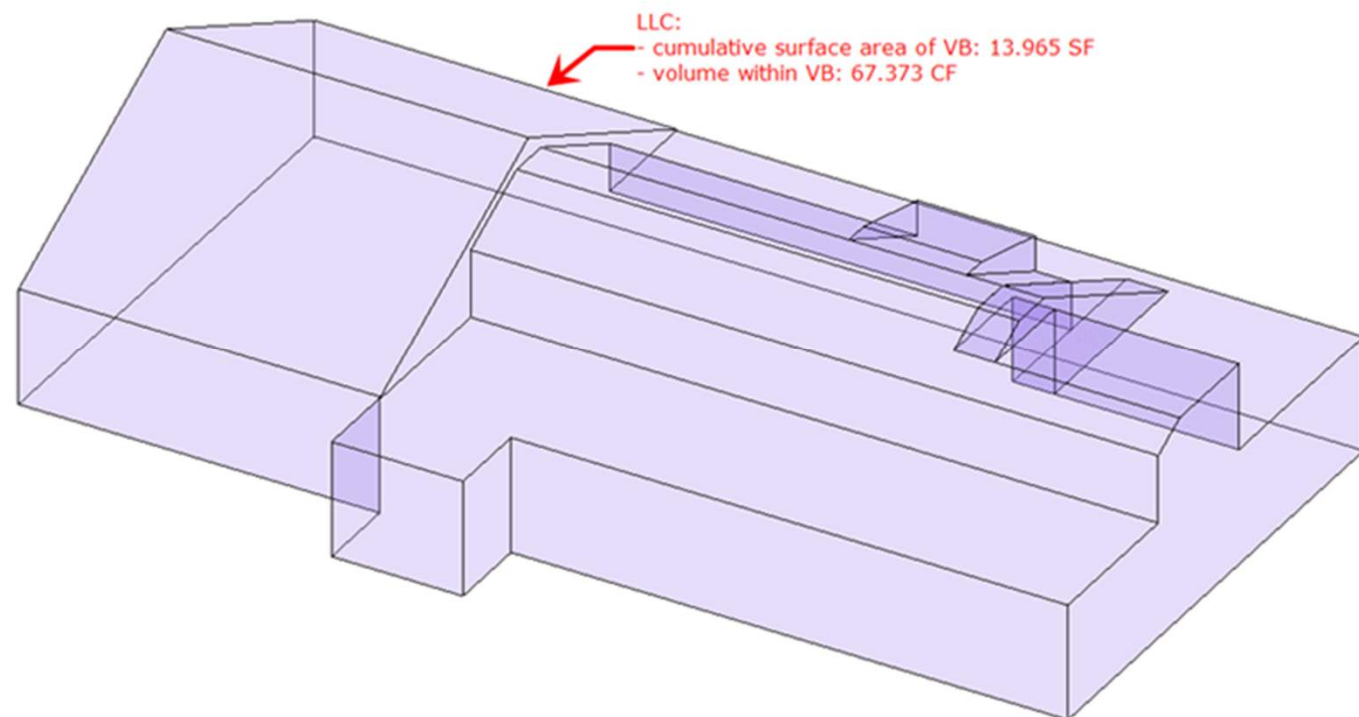


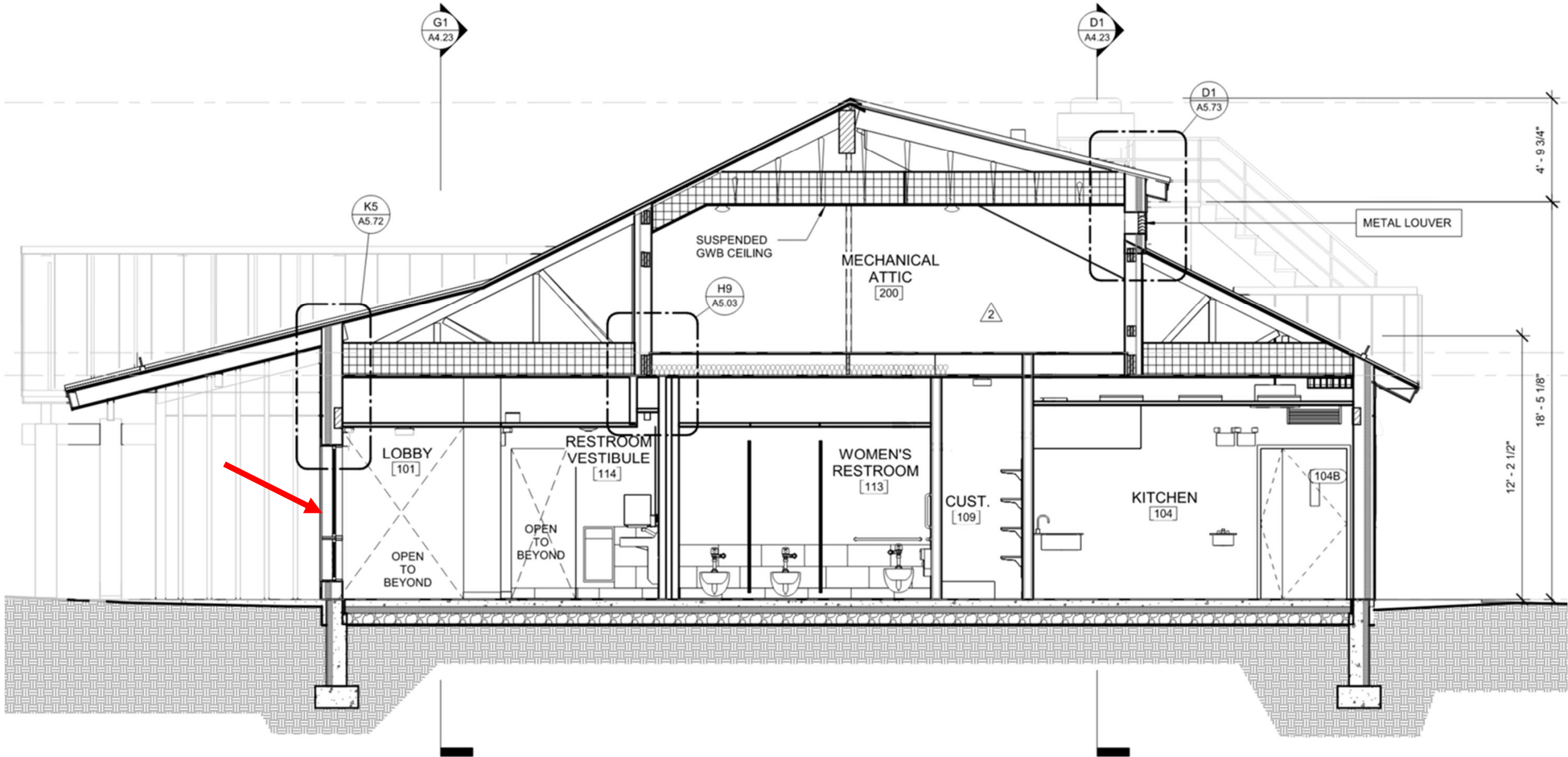


Project & Design

Execution and
Quality Control

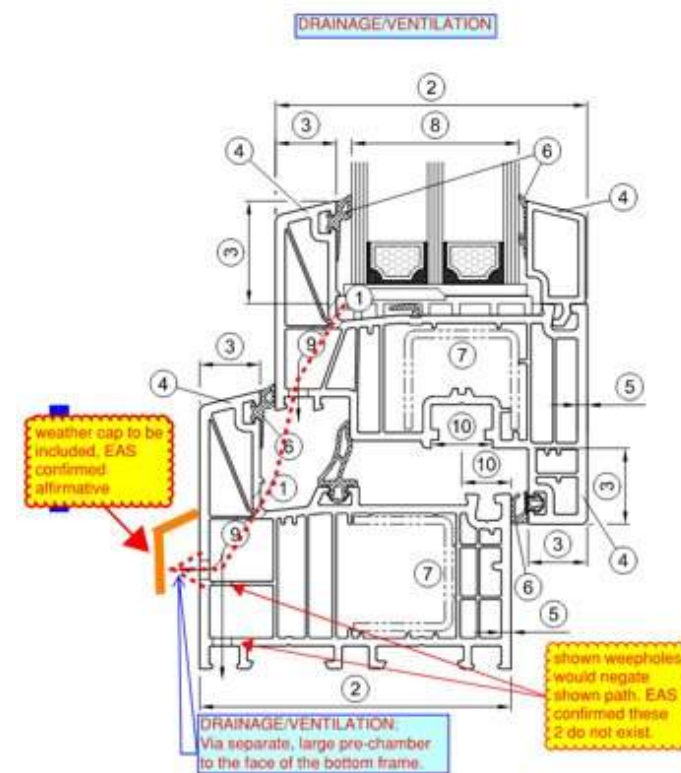
Q&A

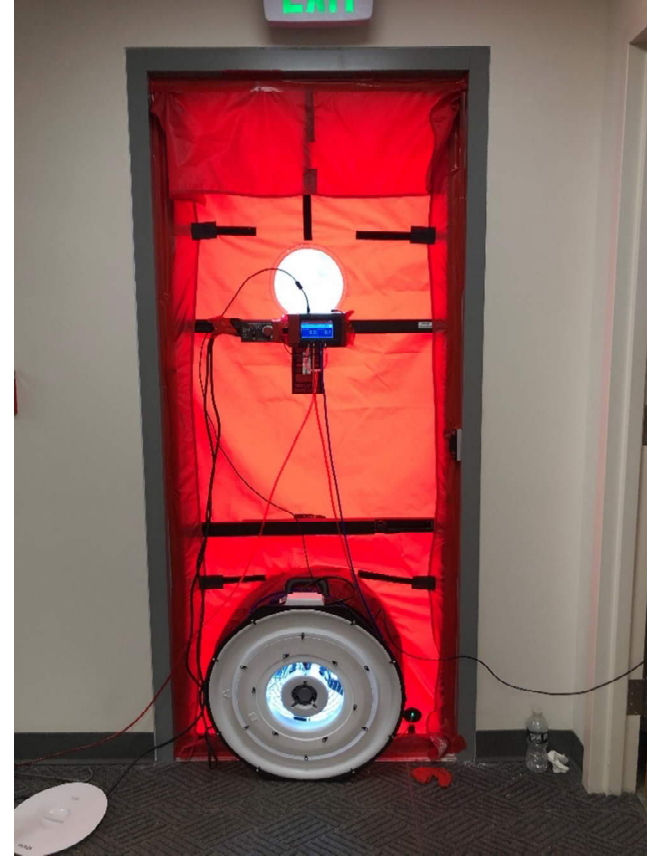




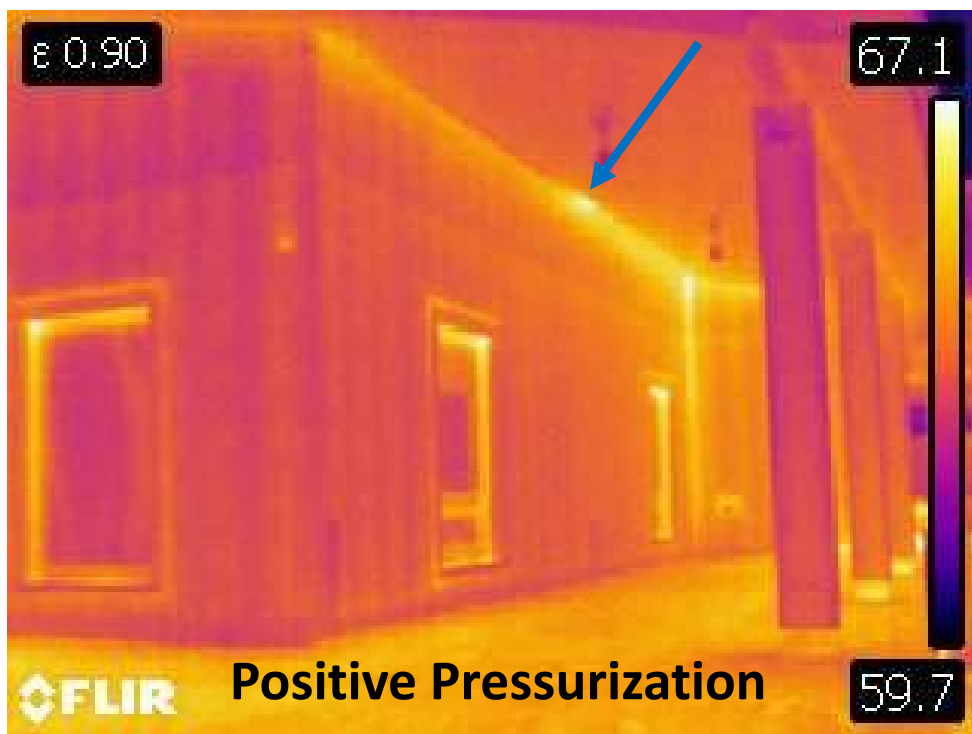
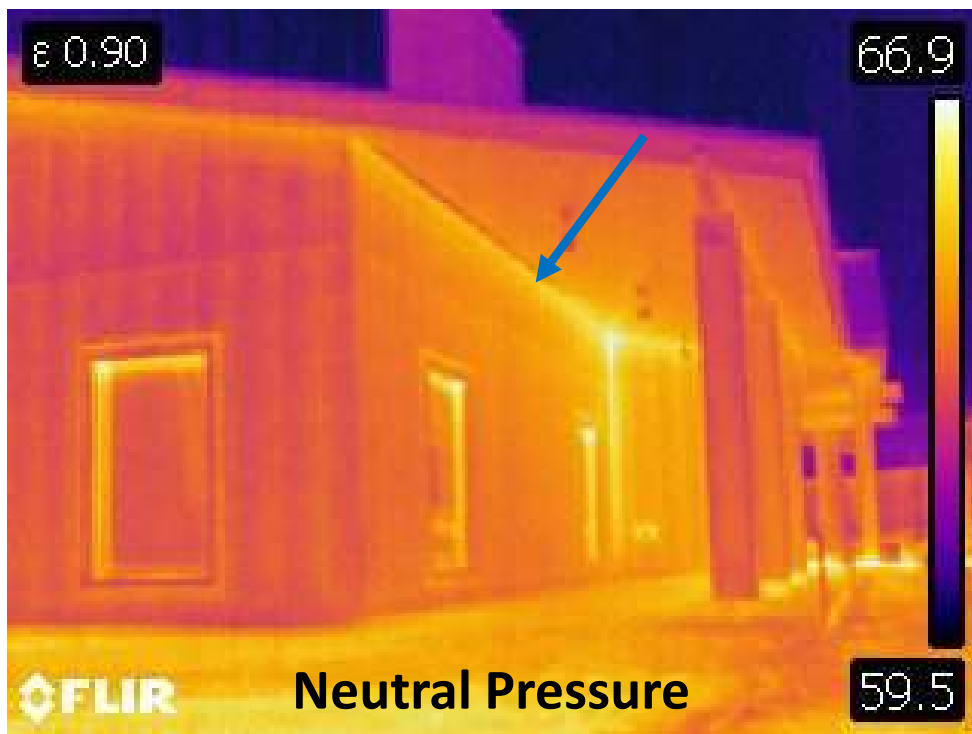
WINDOWS

- Salamander BluEvolution 82 uPVC windows
- Operability: fixed, tilt-turn, tilt
- Triple glazed IGU with applied muntins
 - Double low-e (#2 and #5 surfaces)
 - Argon-filled (90% argon)
 - Thermally-improved spacer (Swisspacer)





- PHIUS+ 2018 requirements for airtightness: 0.06 cfm/sq ft @ 50 Pa
 - Test 1: 0.088 cfm/sq ft @ 50 Pa (January 2020)
 - Test 2: 0.084 cfm/sq ft @ 50 Pa (March 2020)
 - Test 3: 0.066 cfm/sq ft @ 50 Pa (June 2020)
 - **Test 4 (final): 0.053 cfm/sq ft @ 50 Pa (July 2020)**
- We recommend preliminary tests during construction, when repairs are easier.



Project & Design

Execution and
Quality Control

Q&A

FIELD PERFORMANCE TESTING (AIR LEAKAGE)





Project & Design *(René Brakels AIA, CPHC, Centerbrook Architects)*
Execution and Quality Control *(Gert Guldentops, P.E., SGH)*
Q&A