

# Getting Schooled in Passive House

$\Delta ABC:$   
 $AB = C \sin 40^\circ \times 1.375$   
 $A = AB + .375 + 1.068$



A-2

TIME	SUBJECT	ROOM
7:30		
9:00	TRIGONOMETRY	37
9:40		
10:30	PRE-FLIGHT	47
10:30		
11:50	RY	11
11:50		
12:50	PRE-FLIGHT	34
12:50		
1:50	ENGLISH	9
1:50		
		18

# PRESENTERS



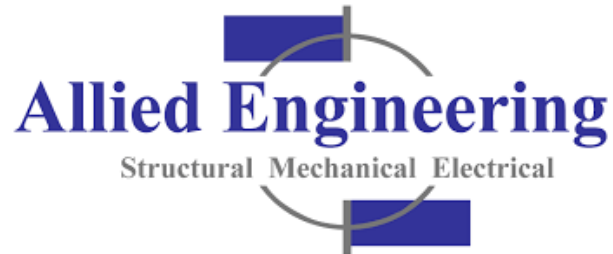
**HARRY HEPBURN, AIA, LEED AP  
BRIBURN  
Principal / Architect**

**CHRIS BRILEY, CPHC, LEED AP  
BRIBURN  
Principal / Architect,  
Certified Passive House  
Consultant**

# TEAM PLAYERS



architecture for life™



CONSTRUCTION GROUP

BARTLETT DESIGN



**MAINE COAST**  
WALDORF SCHOOL



**BECKER**  
STRUCTURAL ENGINEERS

**WALSH**

ENGINEERING ASSOCIATES, INC.

LOWELL SPECIFICATIONS

# MCWS PROJECT GOALS

- © Consolidate campus
- © Energy conservation
- © Sustainable Design
- © Waldorf Principals
  - Anthroposophical Design
  - Flexible Spaces
  - Collaborative Teaching
  - Organic Shaped Spaces
  - High Ceilings
  - Natural Light
  - Use of Chalkboards (Low Tech)
  - Use of Color
  - Use of Natural Materials

# ACCOMPLISHMENTS



## PASSIVE HOUSE - PHIUS + 2015

- Healthy
- Comfortable
- Very Little Energy Needed

## MAINE ADVANCED BUILDINGS CERTIFICATION

- At least 30% more energy efficient than minimum code requirements
- Maintenance and monitoring systems ensure building performs





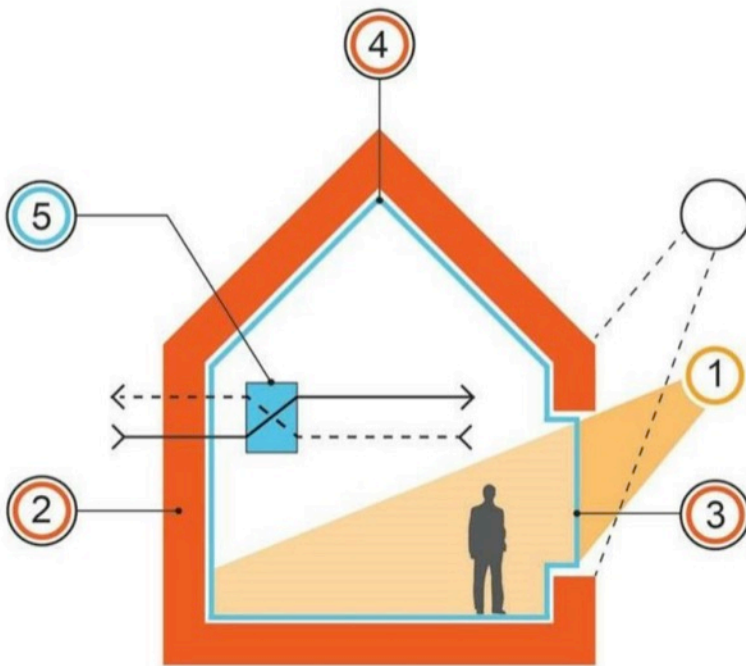




# WHAT'S DIFFERENT

## PASSIVE HOUSE

1. SOLAR ORIENTATION
2. HIGH INSULATION
3. HIGH PERFORMANCE WINDOWS
4. AIRTIGHT ENCLOSURE
5. BALANCED VENTILATION WITH HEAT RECOVERY



# DESIGN CONSIDERATIONS

A hand-drawn site plan for a community center or school. The plan shows a central building with an entrance, surrounded by various rooms like 'HIGH SCHOOL', 'FUTURE', 'OFFICE', 'SERVICE', 'FIRE', 'LOWER SPACES', 'UPPER SPACES', and 'COMMUNITY HALL'. There are also outdoor areas like 'SUMMER SUN' and 'WINTER SUN' patios, and a 'FUTURE ATHLETIC FIELD'. The site is bounded by 'WINTER WINDS' (indicated by blue arrows) and 'DESERT'. A 'PROPERTY LINE' and 'WATER' features are also shown. The plan is overlaid with a vertical sequence of design considerations: SITE PLANNING, BUILDING DESIGN, BUILDING ENVELOPE, BUILDING SYSTEMS, and PERFORMANCE, each in a dashed red box with a red arrow pointing down to the next level.

SITE PLANNING

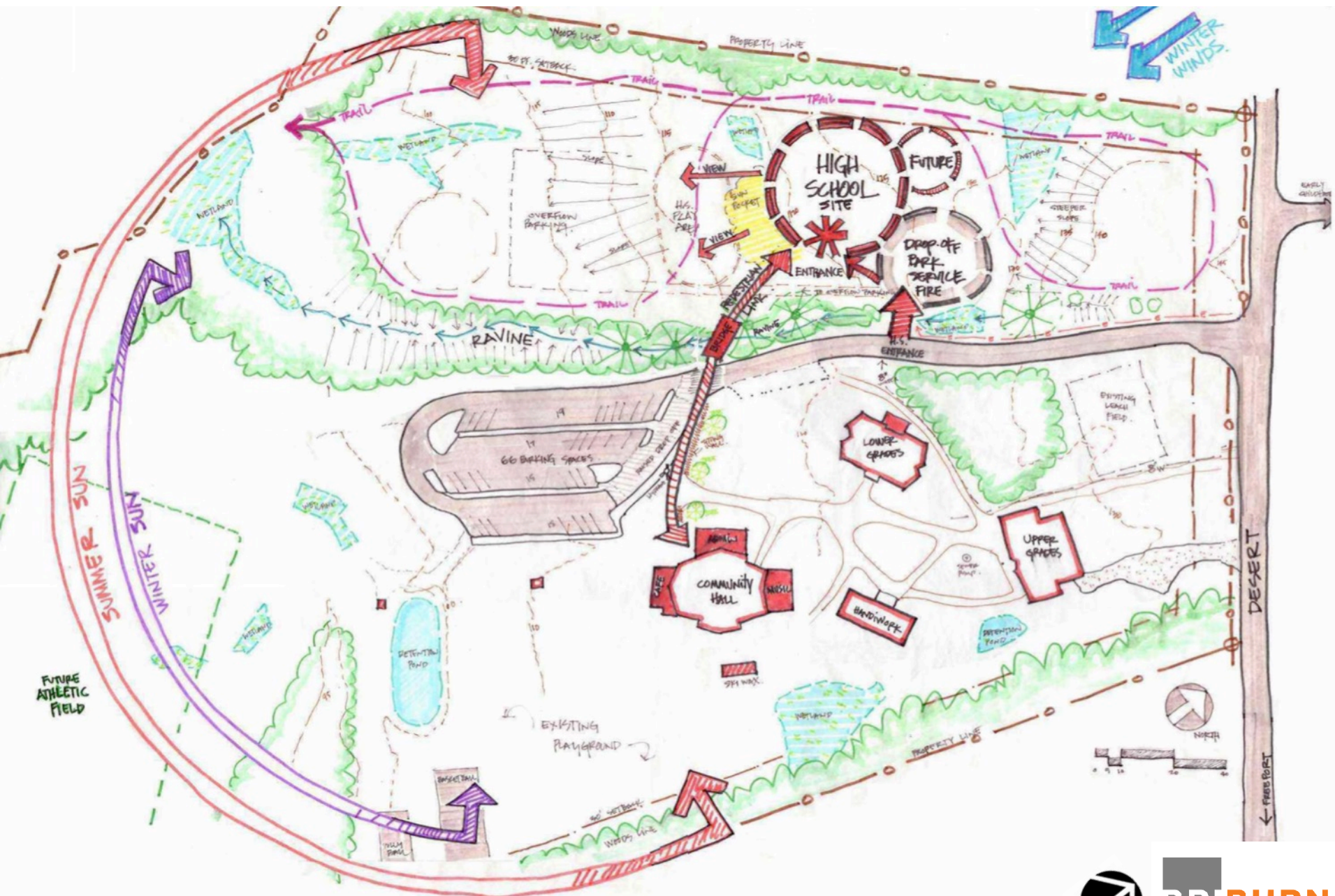
BUILDING DESIGN

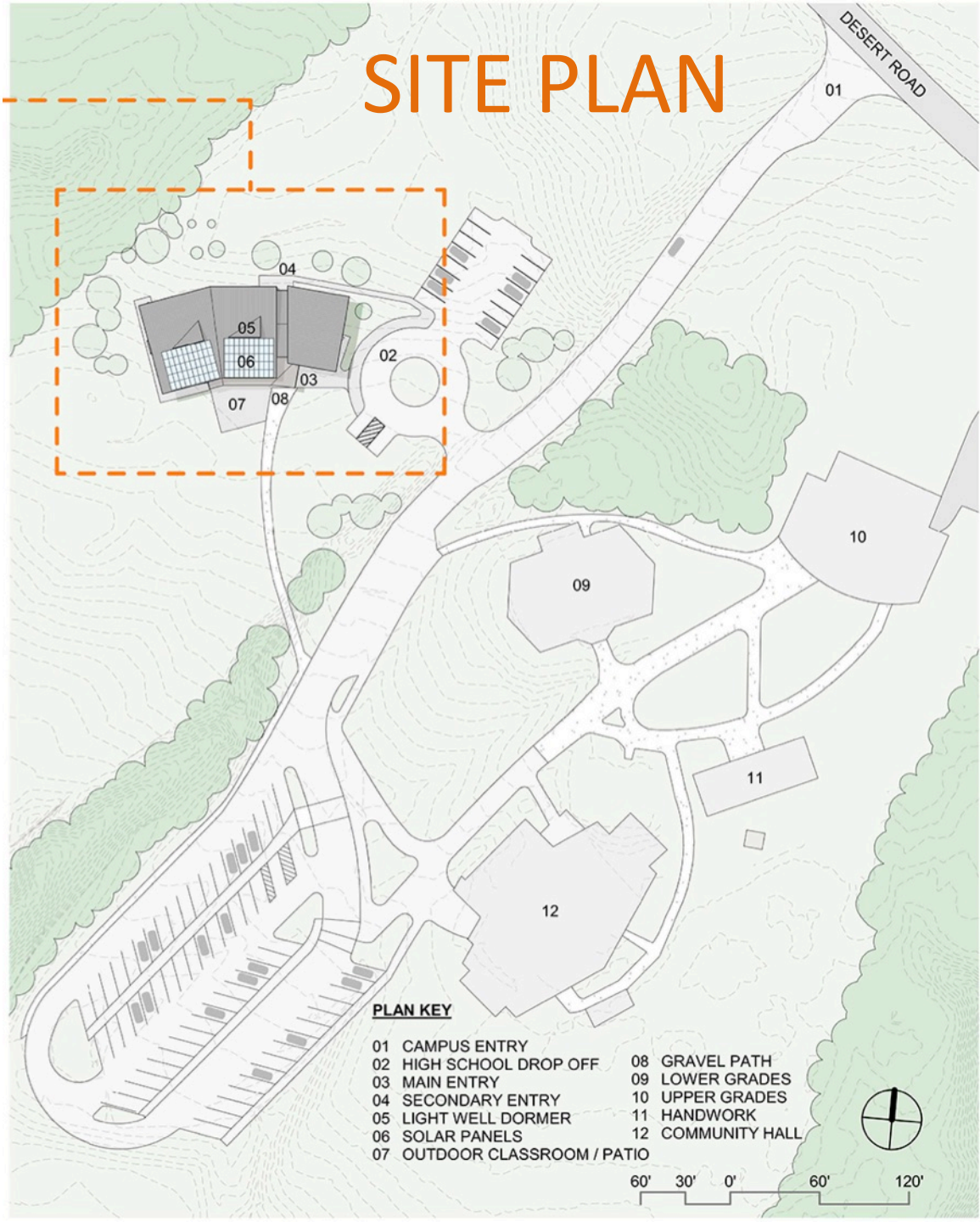
BUILDING ENVELOPE

BUILDING SYSTEMS

PERFORMANCE









A hand-drawn architectural floor plan of a building, rendered in black lines on a dark grey background. The plan shows a complex layout with multiple rooms, corridors, and stairwells. The drawing is surrounded by a textured, greenish-yellow background that resembles a sketch of a landscape or ground. The text "BUILDING DESIGN" is overlaid in the center in a bold, orange, sans-serif font.

# BUILDING DESIGN



# FIRST FLOOR PLAN





# SECOND FLOOR PLAN

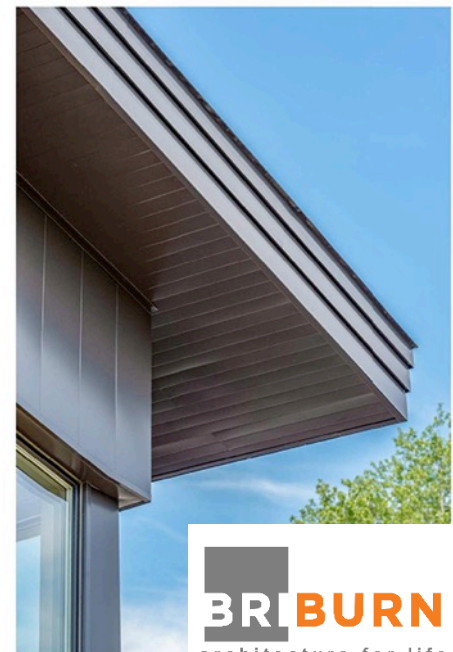


SOUTH ELEVATION

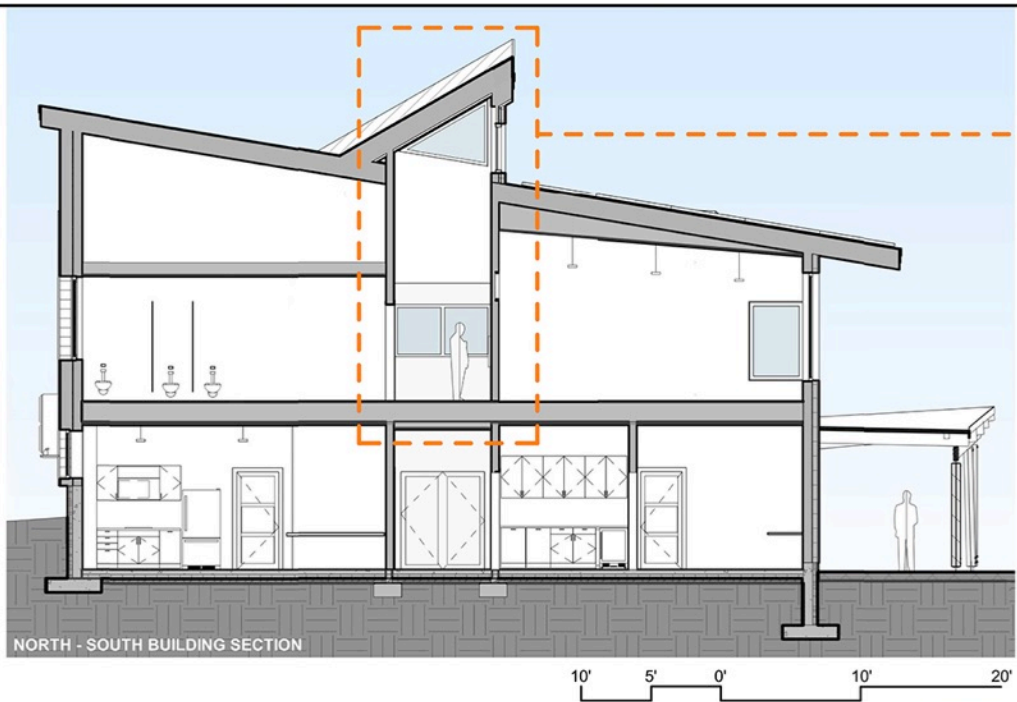
10' 5' 0' 10' 20'



WEST ELEVATION









GREAT ROOM



FIRST FLOOR CORRIDOR & STUDENT CENTER



FIRST FLOOR CORRIDOR, LOCKERS, & ART CLASSROOM



# BUILDING ENVELOPE



FLOOR ASSEMBLY

WALL ASSEMBLY

ROOF ASSEMBLY

WINDOWS & DOORS

# BUILDING ENVELOPE

CONTINUOUS  
AIRTIGHT  
LAYER (RED)

R-61 NORTH  
WALL  
INSULATION

R-17 SLAB  
INSULATION

SOLAR PANELS

R-55 ROOF  
INSULATION

TRIPLE GLAZED  
WINDOWS

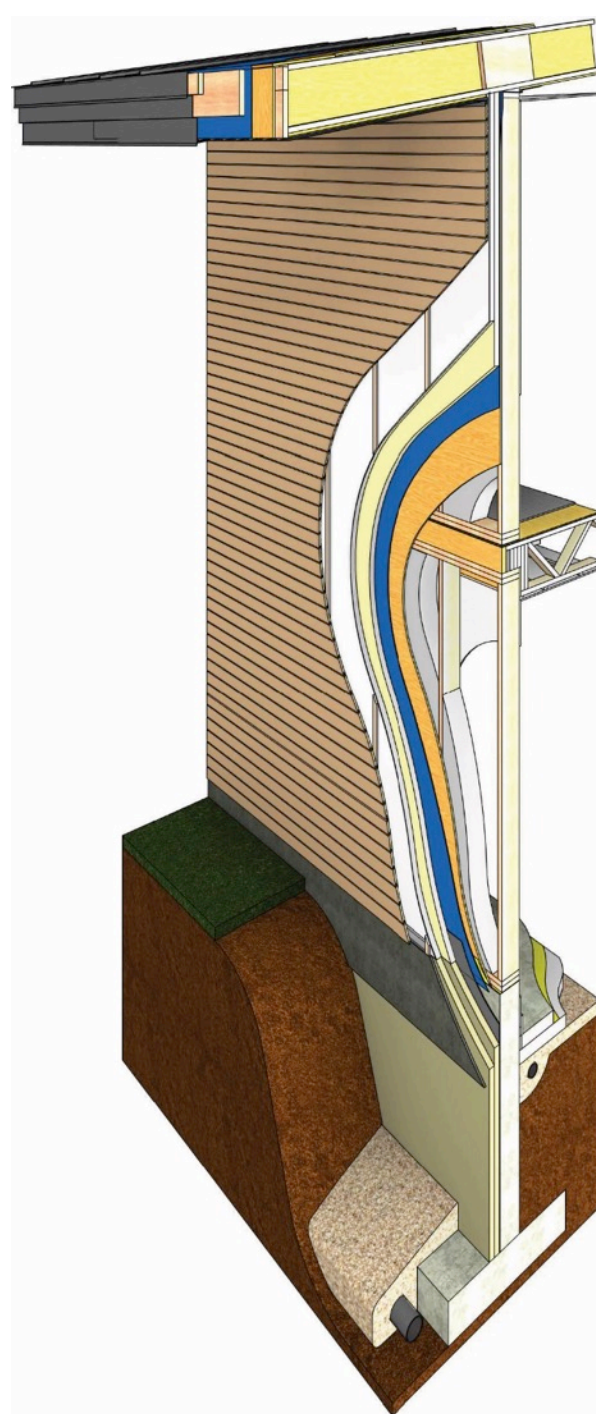
R-51 WALL  
INSULATION

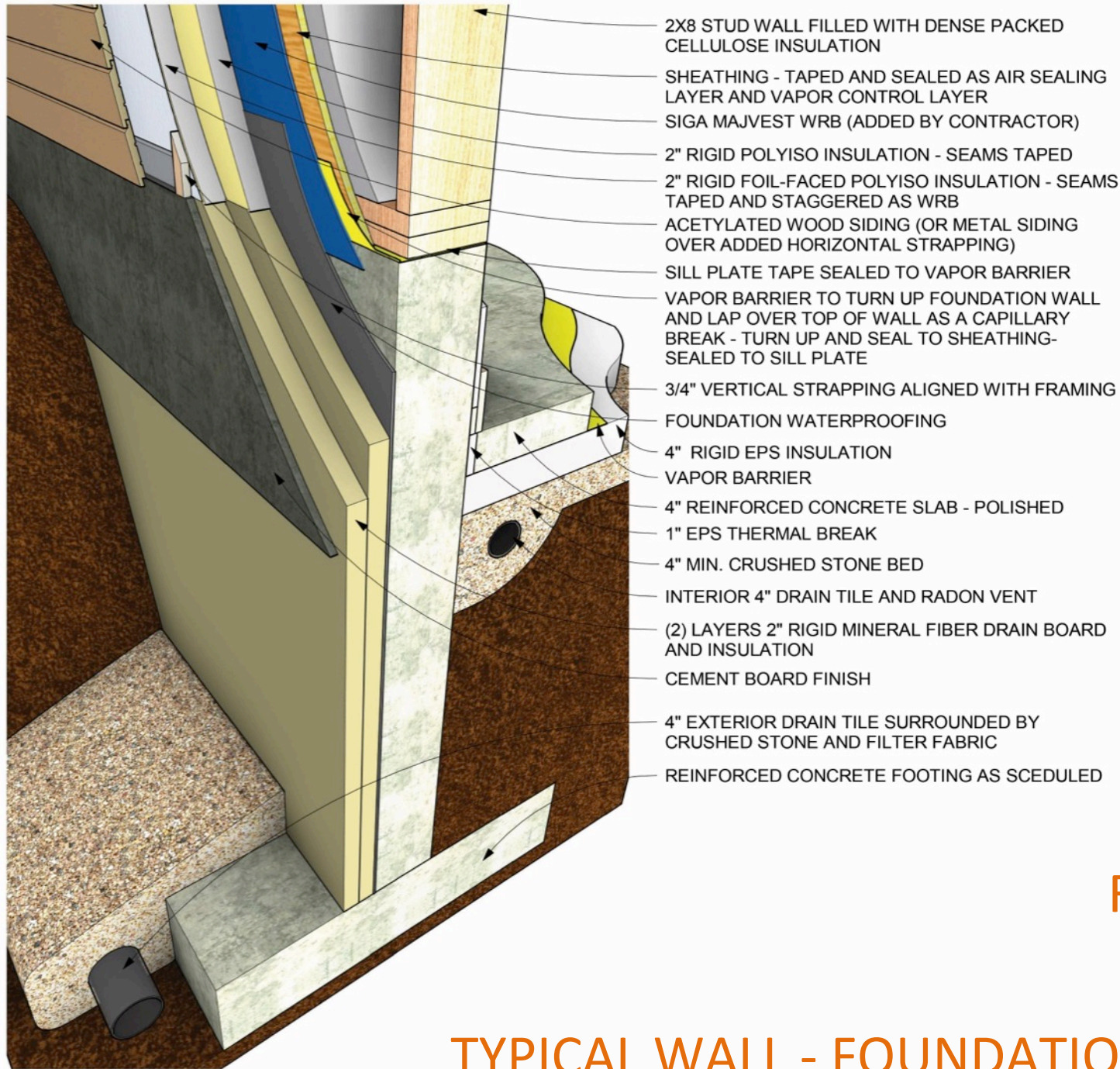




# SOUTH, EAST & WEST WALLS (R-51)

- ◎ siding
- ◎ 3/4" strapping
- ◎ 2" foil faced rigid insulation (taped)
- ◎ 2" rigid insulation
- ◎ weather barrier (majvest by siga)
- ◎ sheathing
- ◎ 2x8 wood stud, Fill cavity with dense-packed cellulose
- ◎ 5/8" gwb



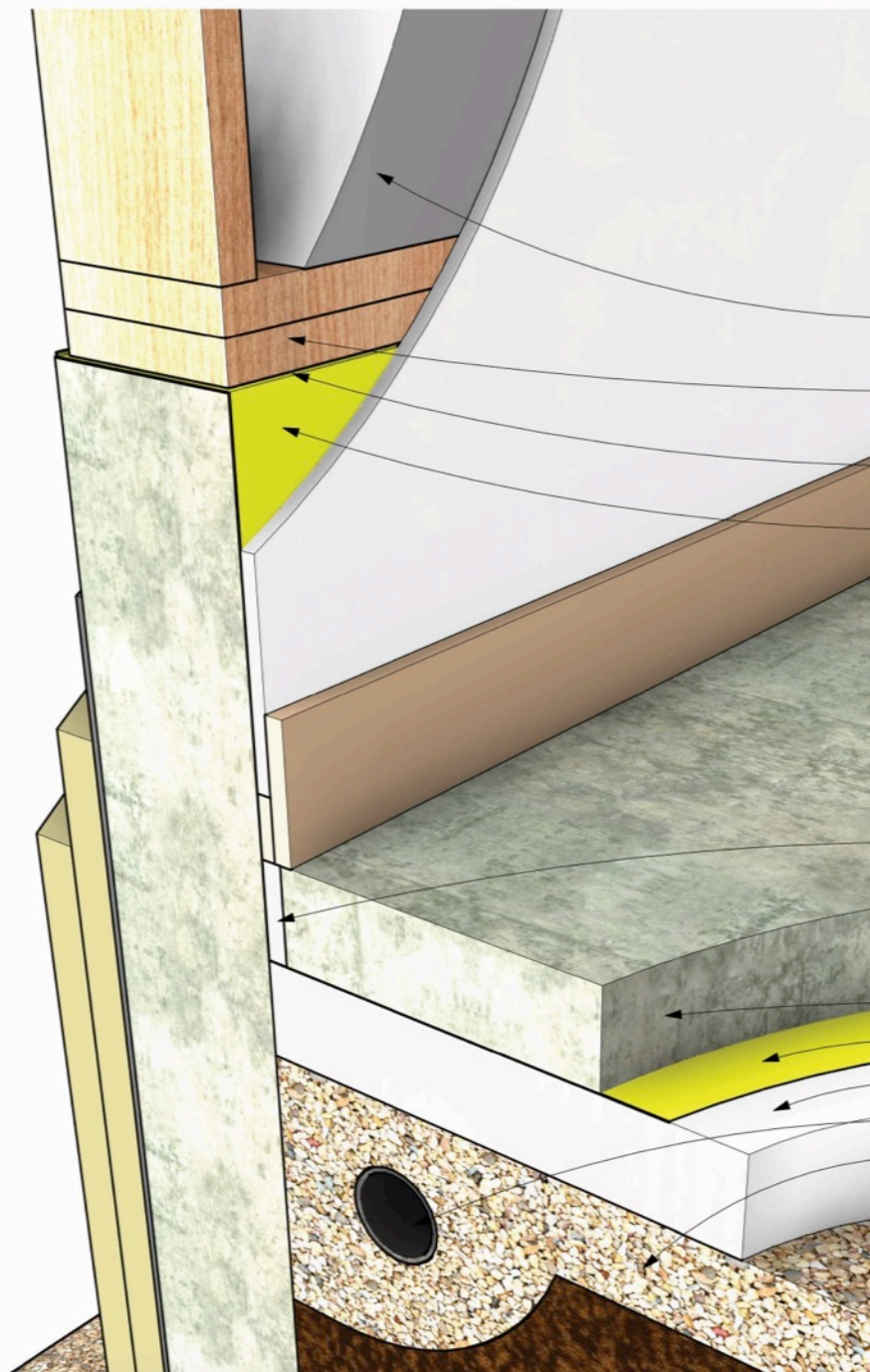


- 2X8 STUD WALL FILLED WITH DENSE PACKED CELLULOSE INSULATION
- SHEATHING - TAPED AND SEALED AS AIR SEALING LAYER AND VAPOR CONTROL LAYER
- SIGA MAJVEST WRB (ADDED BY CONTRACTOR)
- 2" RIGID POLYISO INSULATION - SEAMS TAPED
- 2" RIGID FOIL-FACED POLYISO INSULATION - SEAMS TAPED AND STAGGERED AS WRB
- ACETYLATED WOOD SIDING (OR METAL SIDING OVER ADDED HORIZONTAL STRAPPING)
- SILL PLATE TAPE SEALED TO VAPOR BARRIER
- VAPOR BARRIER TO TURN UP FOUNDATION WALL AND LAP OVER TOP OF WALL AS A CAPILLARY BREAK - TURN UP AND SEAL TO SHEATHING-SEALED TO SILL PLATE
- 3/4" VERTICAL STRAPPING ALIGNED WITH FRAMING
- FOUNDATION WATERPROOFING
- 4" RIGID EPS INSULATION
- VAPOR BARRIER
- 4" REINFORCED CONCRETE SLAB - POLISHED
- 1" EPS THERMAL BREAK
- 4" MIN. CRUSHED STONE BED
- INTERIOR 4" DRAIN TILE AND RADON VENT
- (2) LAYERS 2" RIGID MINERAL FIBER DRAIN BOARD AND INSULATION
- CEMENT BOARD FINISH
- 4" EXTERIOR DRAIN TILE SURROUNDED BY CRUSHED STONE AND FILTER FABRIC
- REINFORCED CONCRETE FOOTING AS SCDEDUED

R-17 SLAB

TYPICAL WALL - FOUNDATION

# R-51 WALL



2X8 STUD WALL FILLED WITH DENSE PACKED CELLULOSE INSULATION

SILL PLATE TAPE SEALED TO CAPILLARY BREAK/VAPOR BARRIER

SILL SEAL GASKET - TAPED AND SEALED TO VAPOR BARRIER

VAPOR BARRIER TO TURN UP FOUNDATION WALL AND LAP OVER TOP OF WALL AS A CAPILLARY BREAK - TURN UP AND SEAL TO SHEATHING-SEALED TO SILL PLATE

1" EPS THERMAL BREAK

4" REINFORCED CONCRETE SLAB - POLISHED

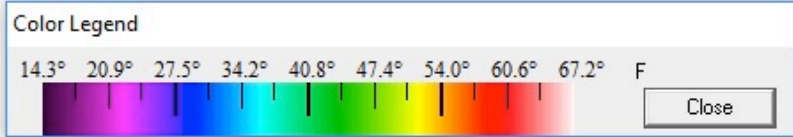
VAPOR BARRIER

4" TYPE IX RIGID EPS INSULATION

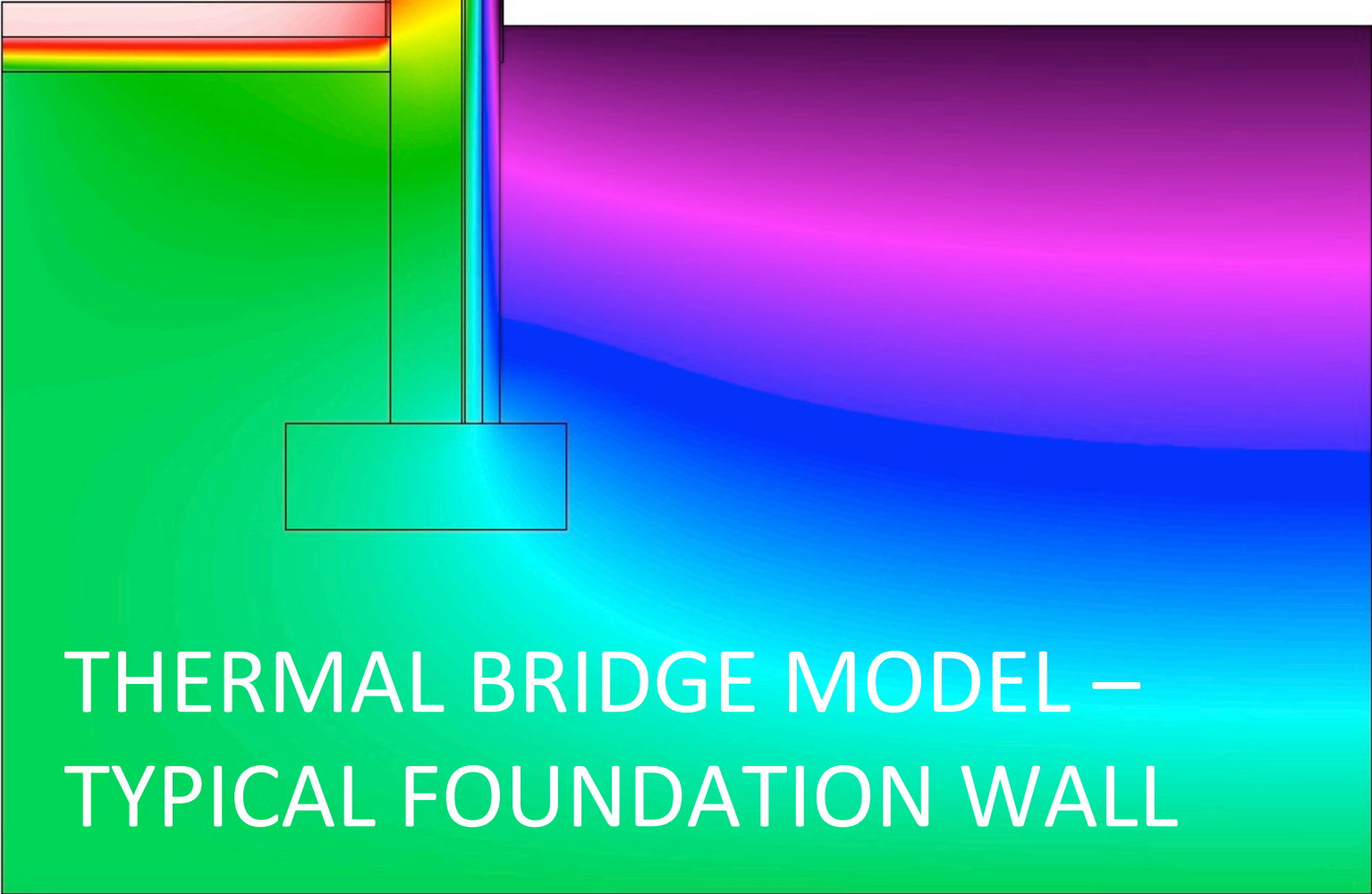
INTERIOR 4" DRAIN TILE AND RADON VENT

4" MIN. CRUSHED STONE BED

## TYPICAL WALL - FOUNDATION



PSI VALUE = 0.077 BTU/HR/FT



# THERMAL BRIDGE MODEL – TYPICAL FOUNDATION WALL



STRUCTURA

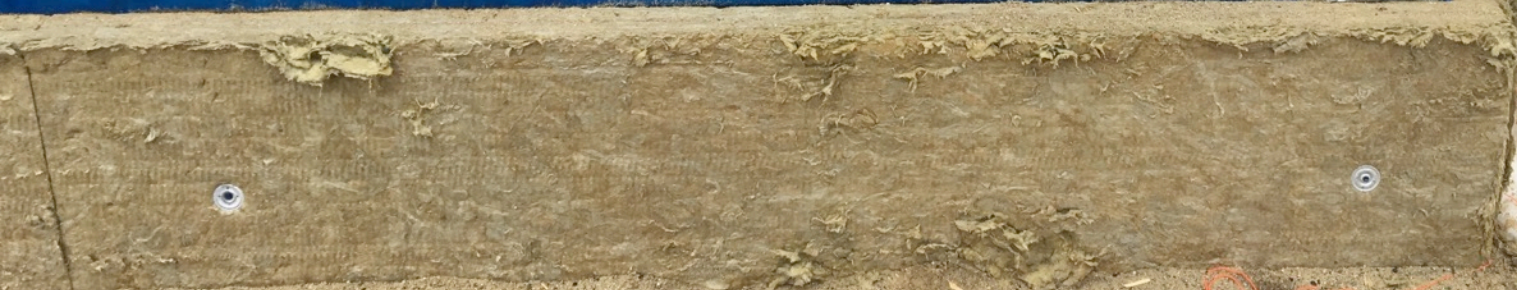
AdvantTech  
CREATING

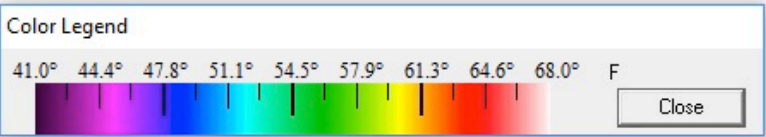
AdvantTech

SIGA-Wigluv

SIGA-Wigluv

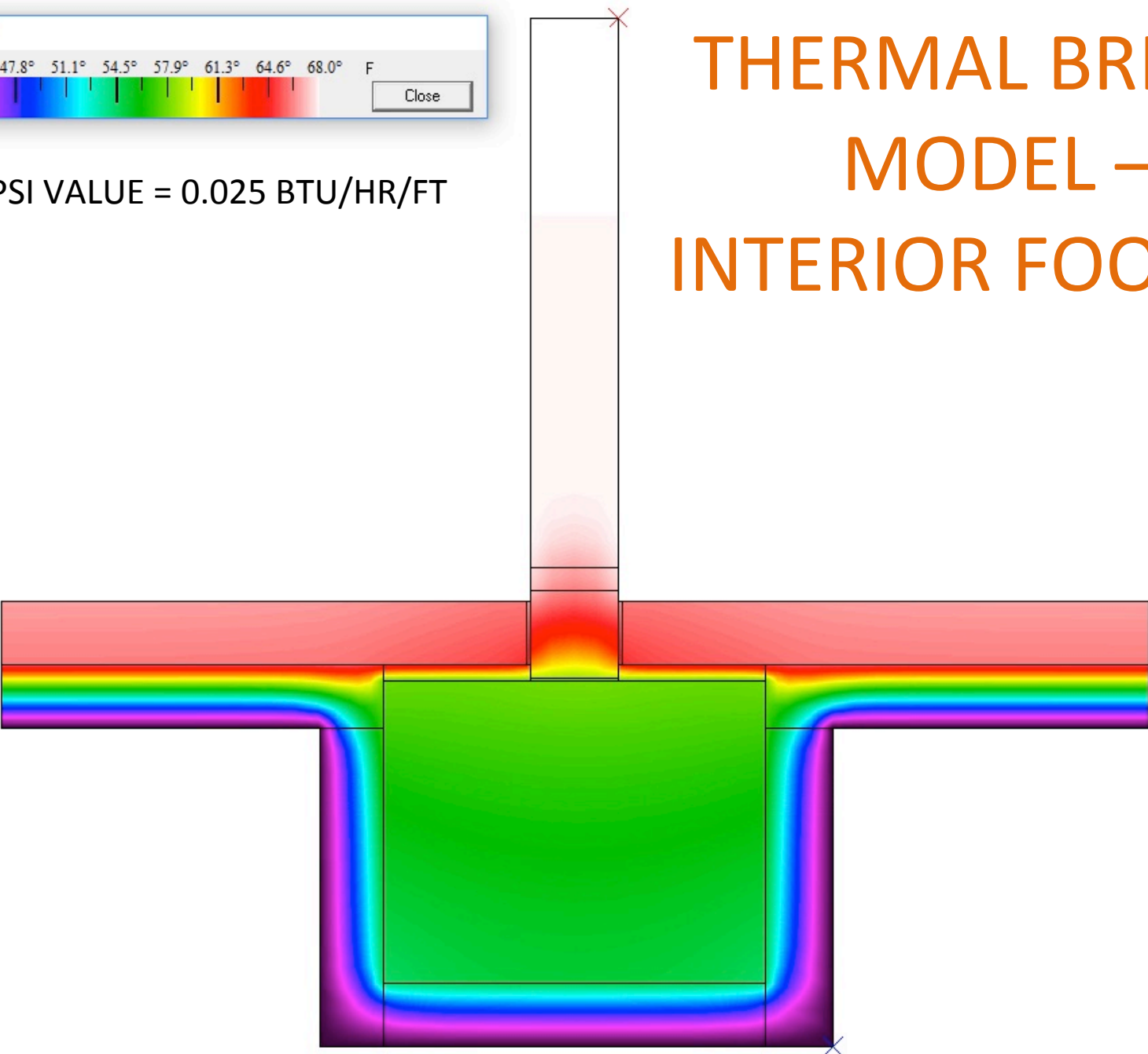
SIGA-Wigluv





PSI VALUE = 0.025 BTU/HR/FT

# THERMAL BRIDGE MODEL – INTERIOR FOOTING













# R-51 WALL

GYPSUM WALL BOARD  
BASE TRIM AS SCHEDULED

2X8 STUD WALL FILLED WITH DENSE PACKED  
CELLULOSE INSULATION

SILL PLATES - SEALED TO DECK

FLOORING FINISH AS SCHEDULED

3/4" FLOOR SHEATHING

1 3/4" X 7 1/4" LVL RIM JOIST

CAVITIES BETWEEN AND AROUND JOISTS FILLED  
WITH DENSE PACKED CELLULOSE

TOP BEARING OPEN WEB WOOD JOISTS

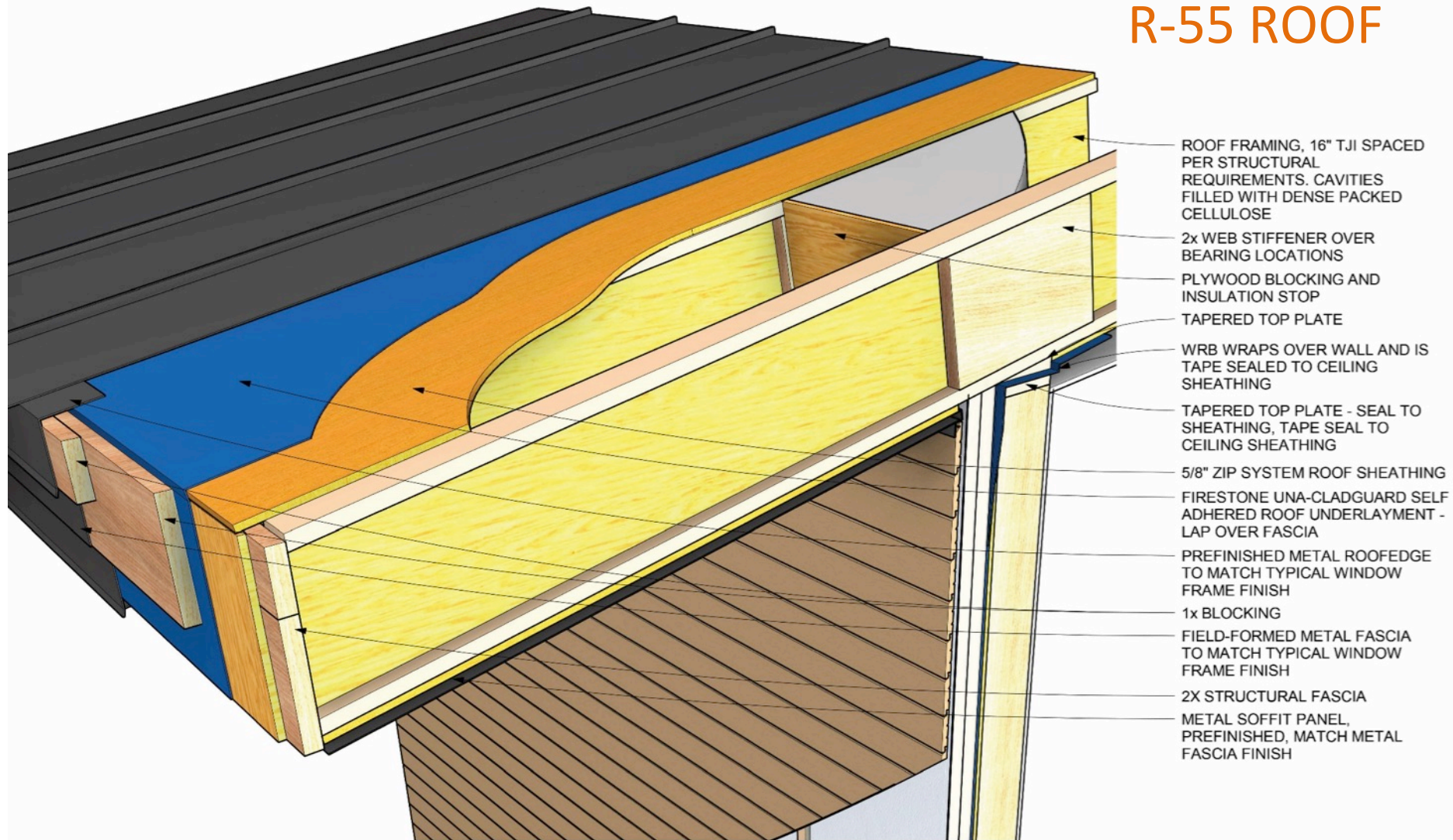
FIELD APPLIED SHEATHING TO CONTAIN CELLULOSE  
AT TOP OF WALL

3/4" STRAPPING

GYPSUM WALL BOARD FINISHED CEILING

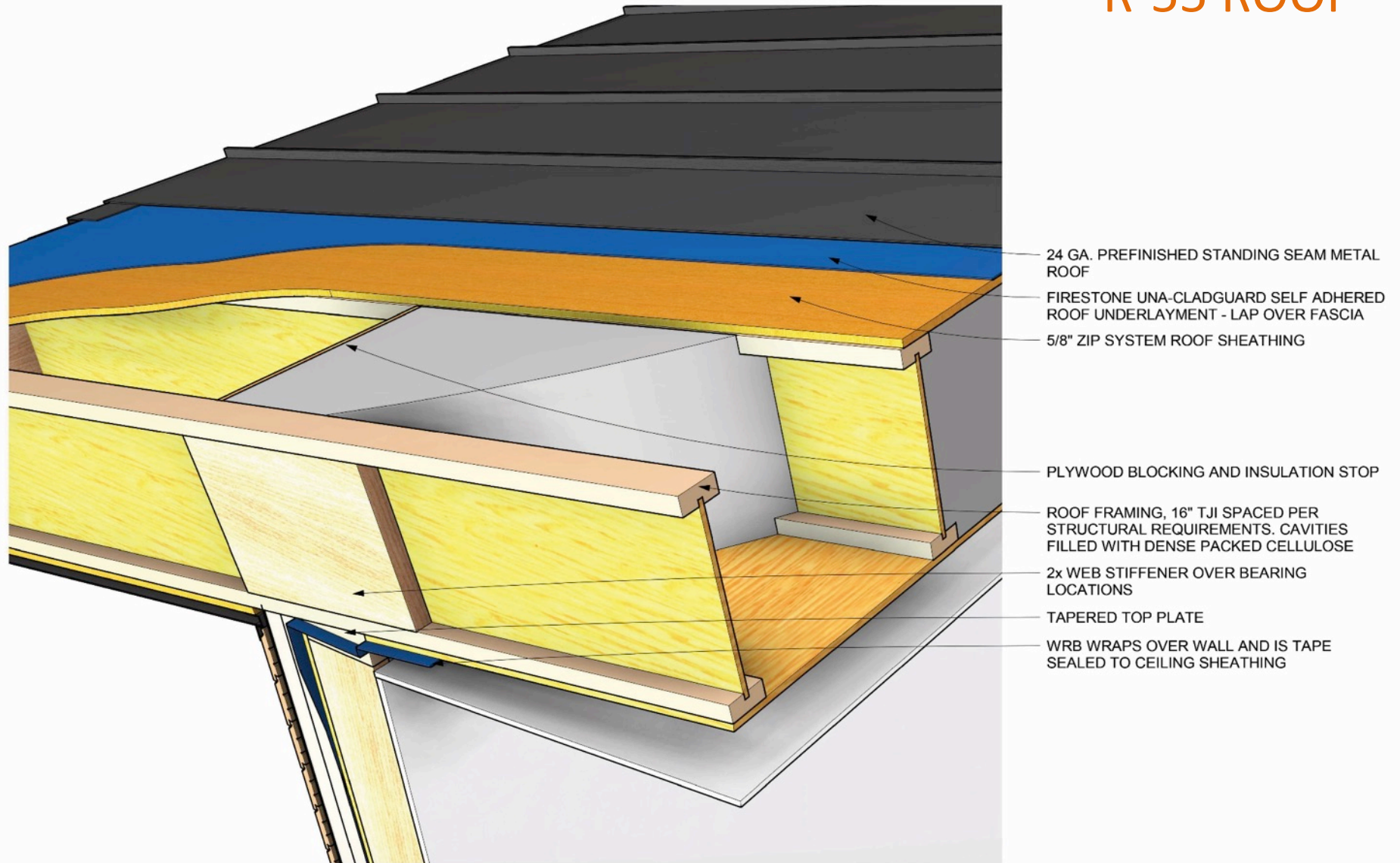
## TYPICAL WALL – AT FLOOR

# R-55 ROOF



TYPICAL WALL – ROOF EXTERIOR

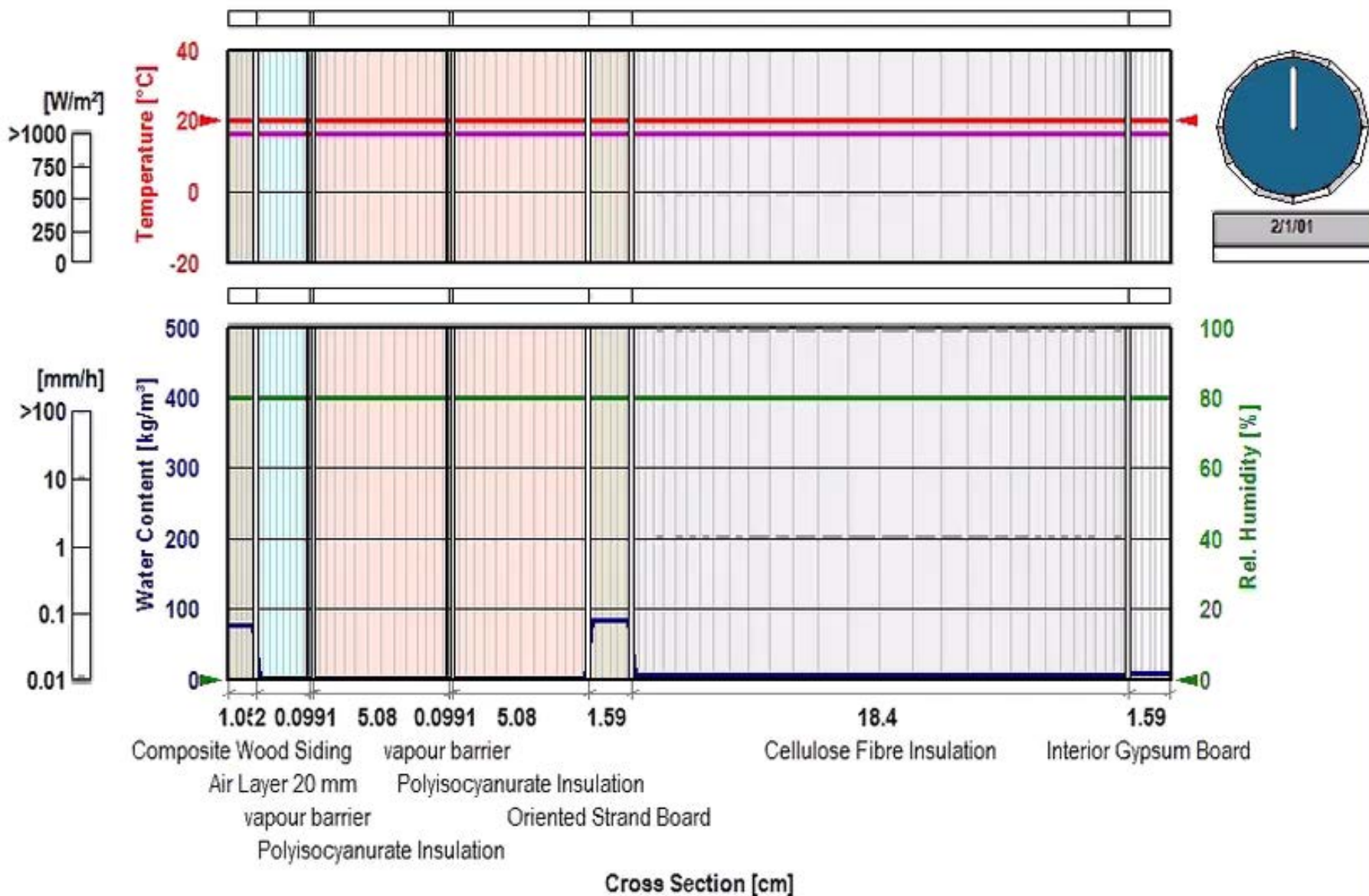
# R-55 ROOF



## TYPICAL WALL – ROOF INTERIOR



WUFI@Passive, Component 20: Walls, North (A350°, 835.27 ft²)



# HYGROTHERMAL WUFI MODEL





STRUCTURAL 1

AdvanTech

AdvanTech

LIFE TIME  
RESISTANCE

STRUCTURAL 1

AdvanTech

STRUCTURAL 1

AdvanTech

STRUCTURAL 1

AdvanTech

AdvanTech

GROVE

60 096





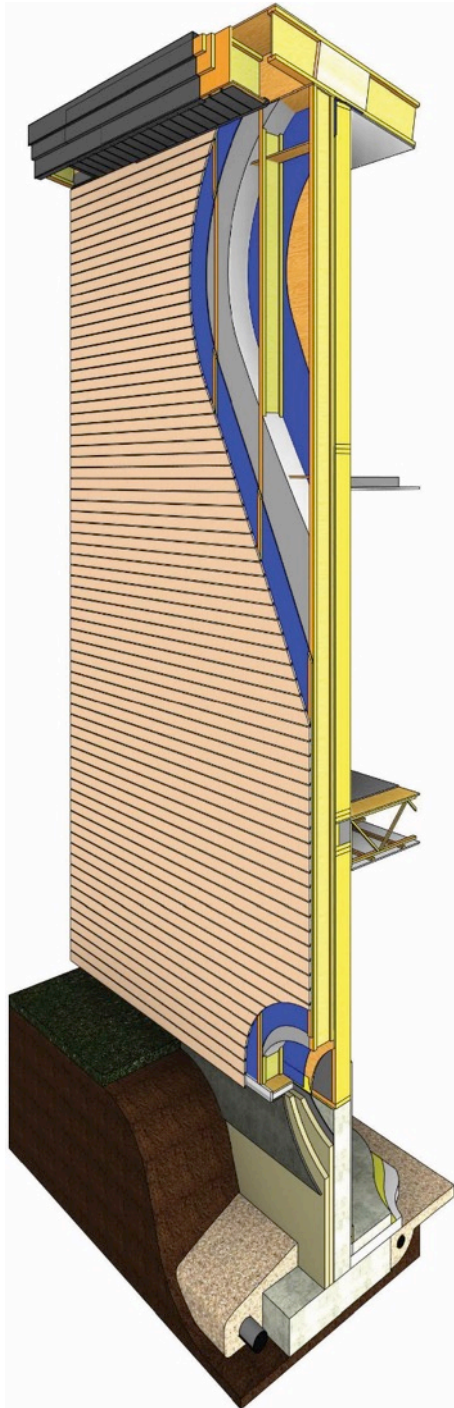




rentals

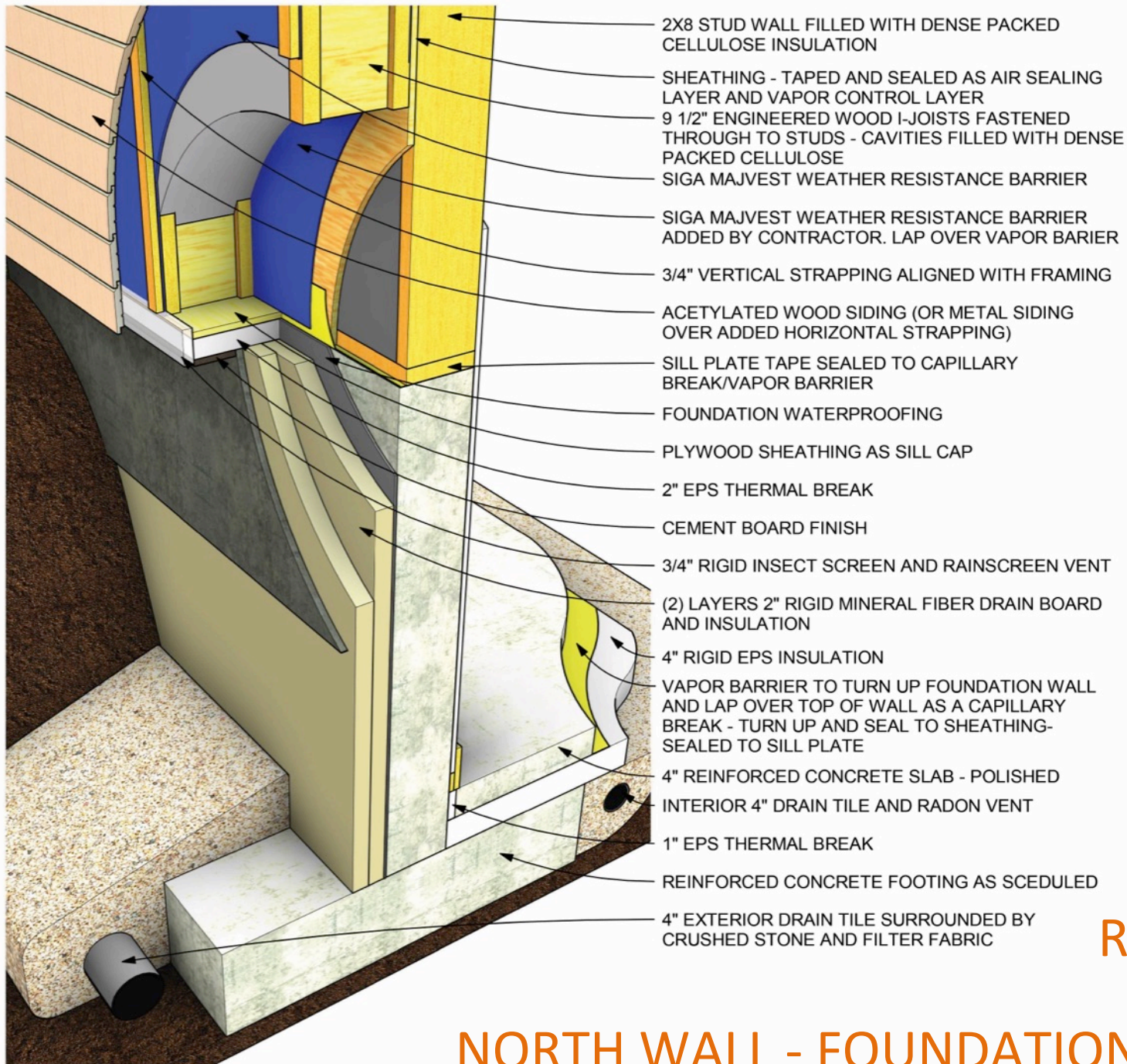
NOTICE





# NORTH WALL

- ◎ siding
- ◎ 3/4" vertical strapping
- ◎ weather barrier (majvest by siga)
- ◎ 9 1/2' I-joist, fill cavity with dense-packed cellulose
- ◎ Weather barrier (majvest by siga)
- ◎ sheathing
- ◎ 2x8 wood stud, fill cavity with dense-packed cellulose
- ◎ 5/8" gwb



**R-17 SLAB**

**NORTH WALL - FOUNDATION**















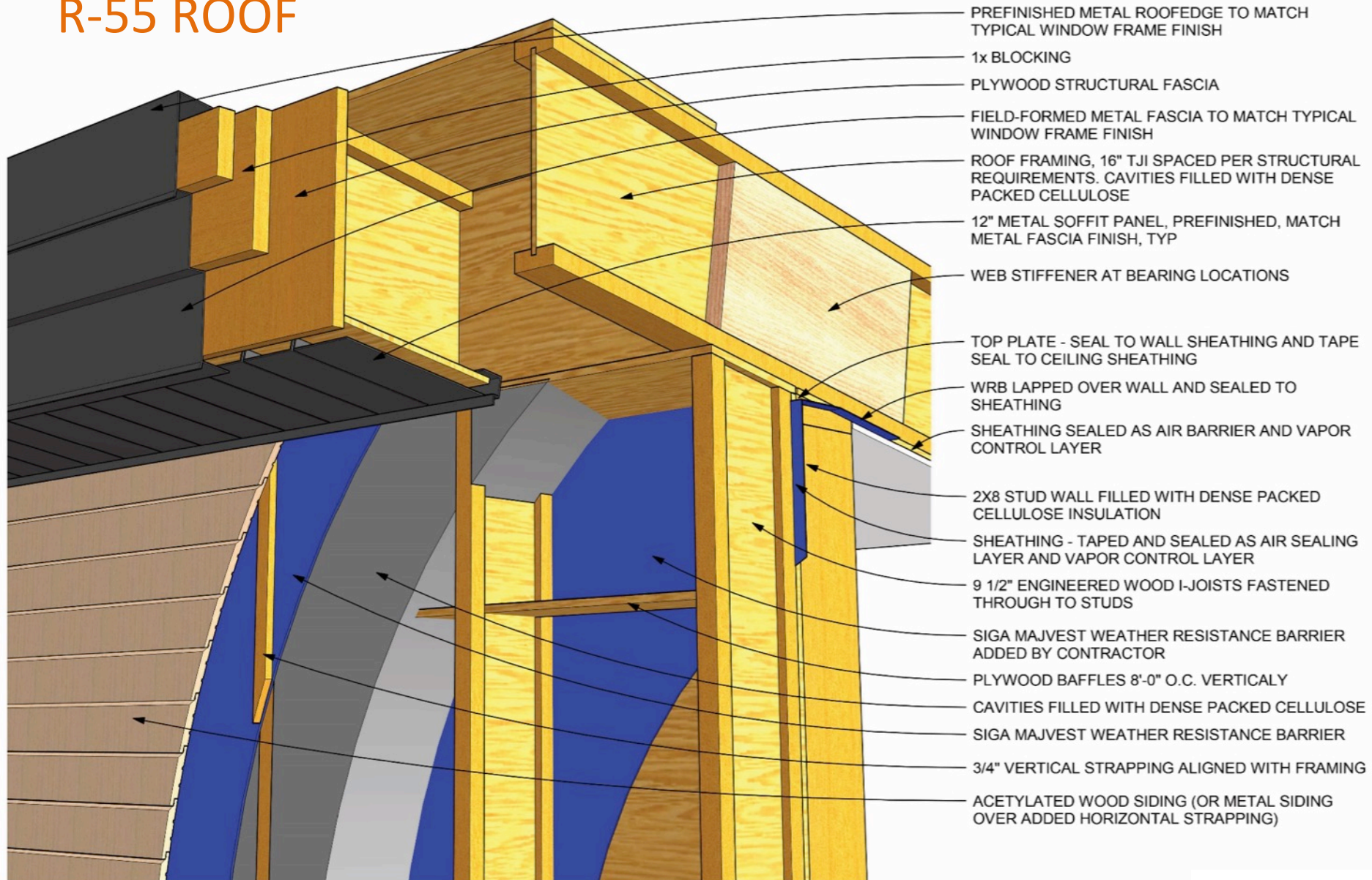








# R-55 ROOF



## NORTH WALL - ROOF

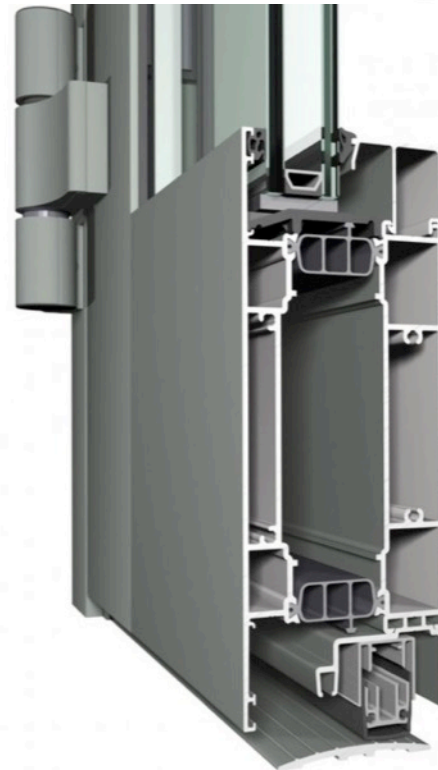
# WINDOWS

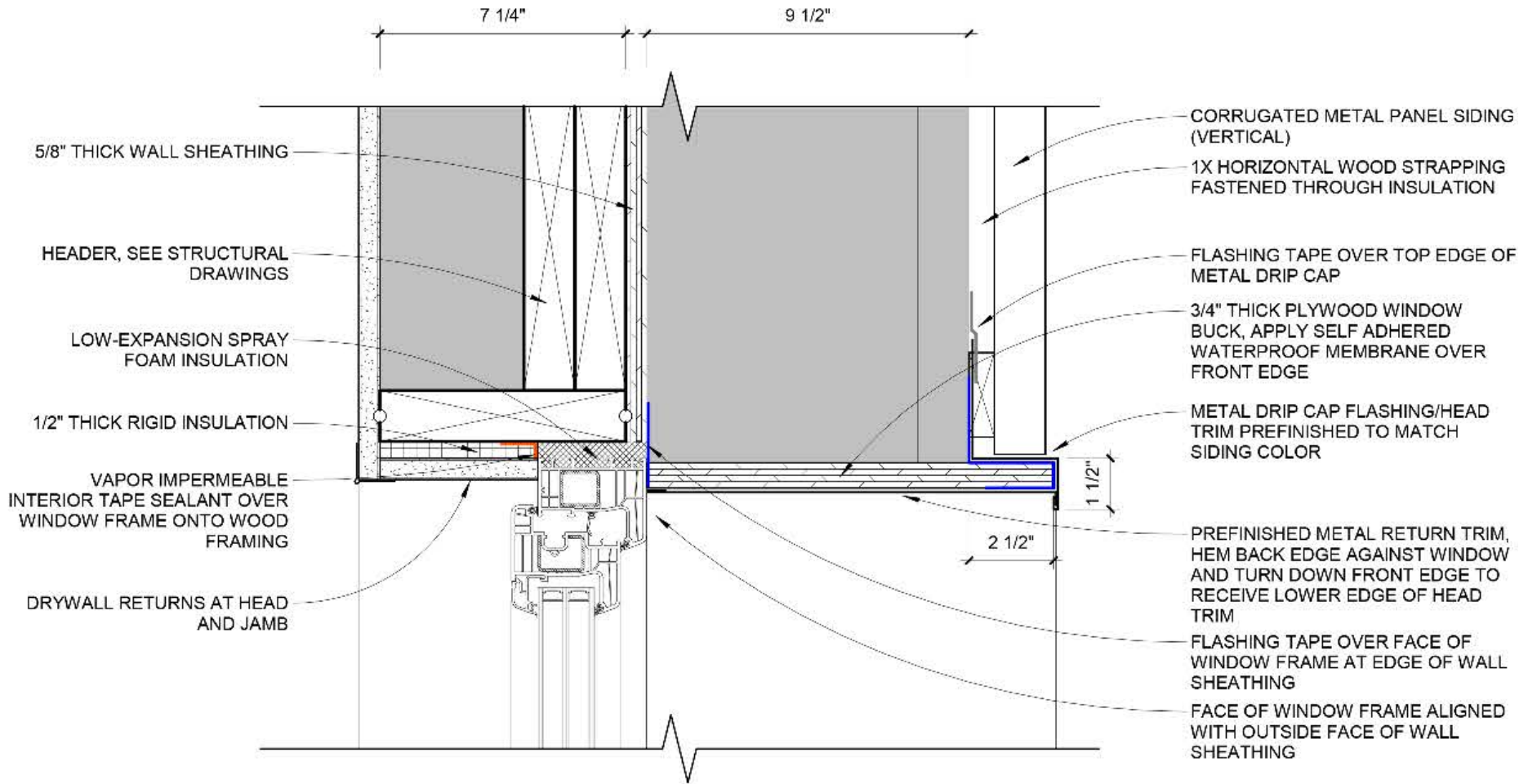
- © INTUS triple glazed European tilt-turn
- © Installed R 6.2, U value = 0.1604



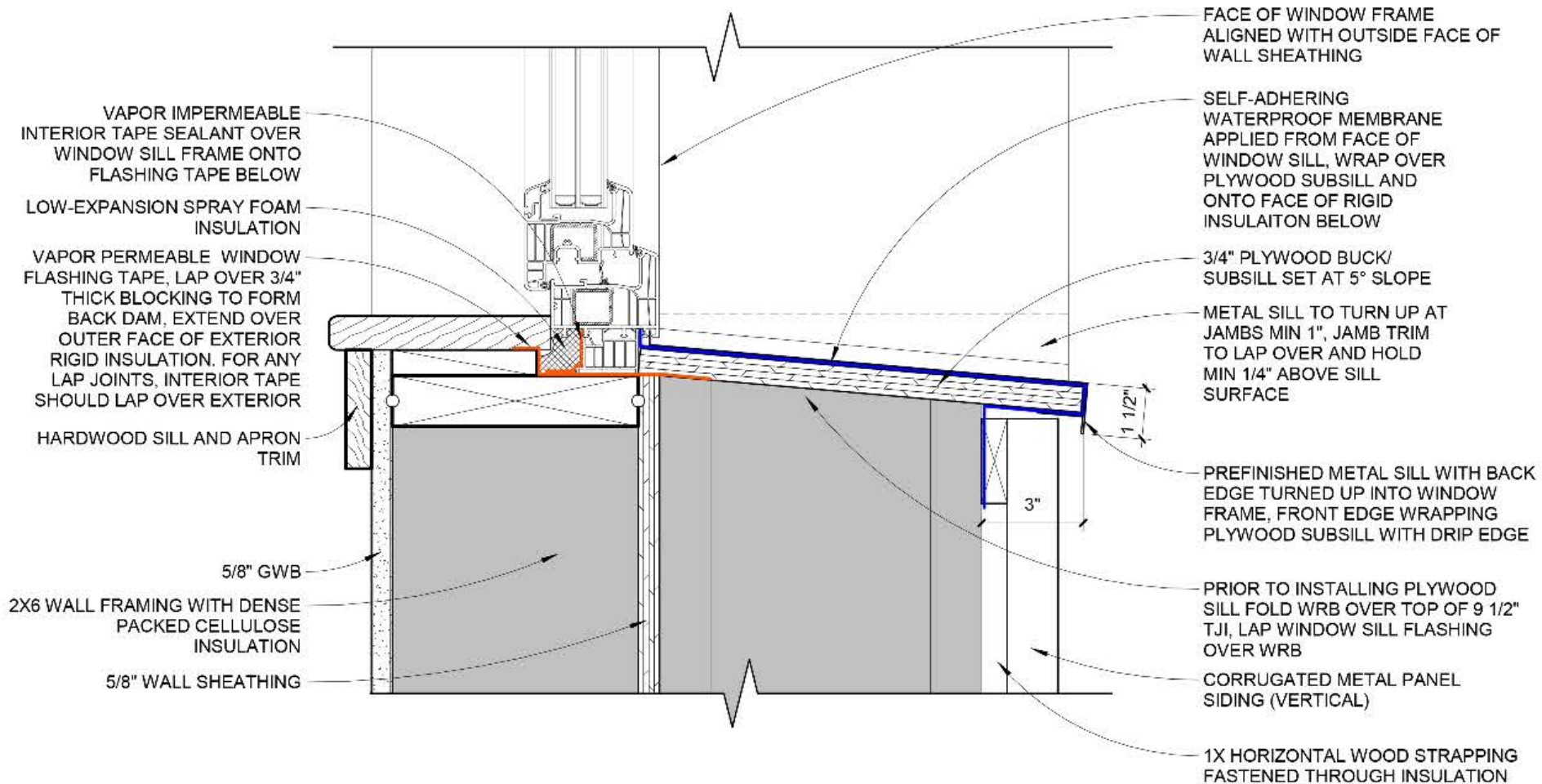
# DOORS

- © REYNAERS triple glazed European
- © Installed R 5.0, U value = 0.1995

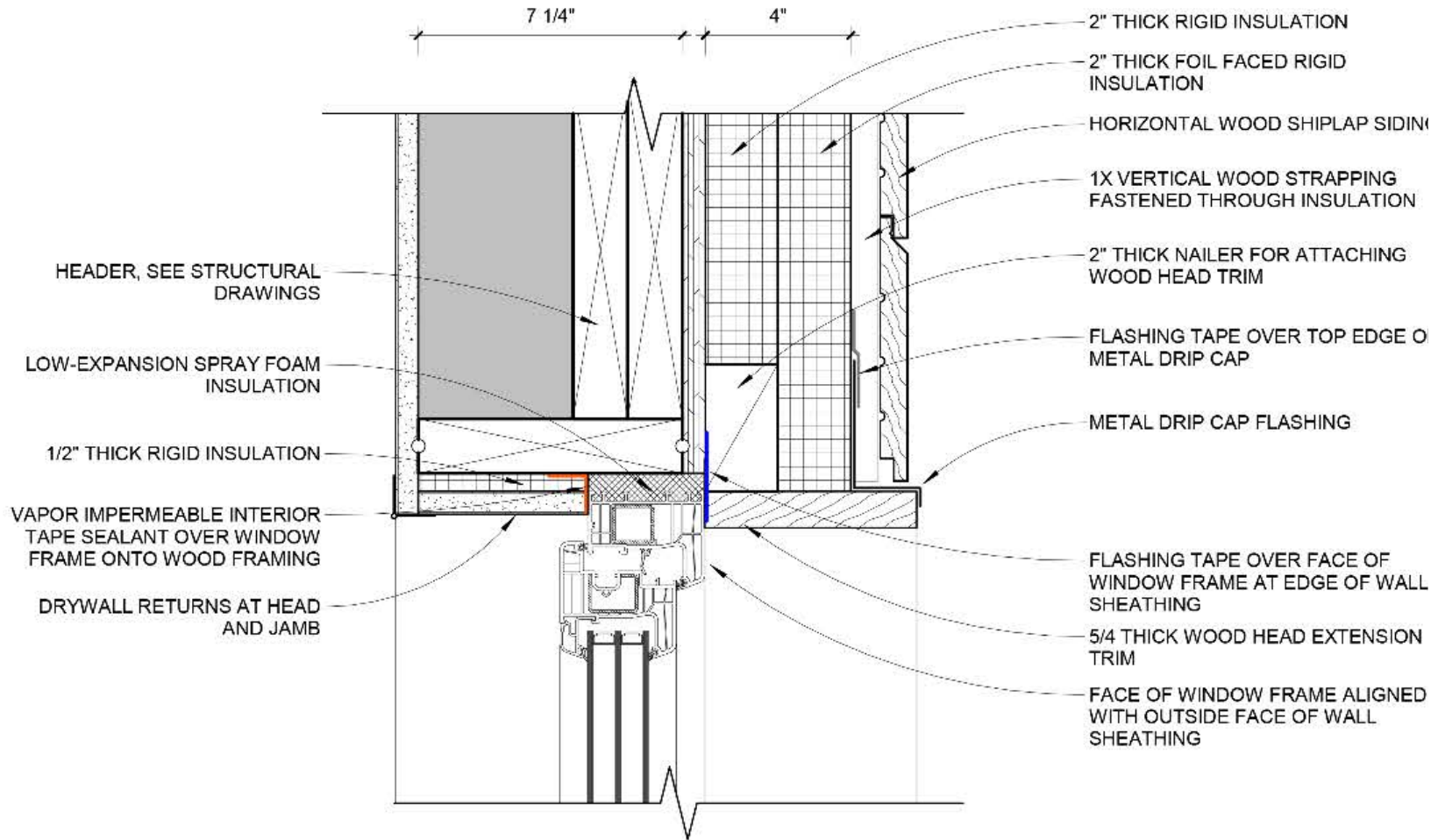




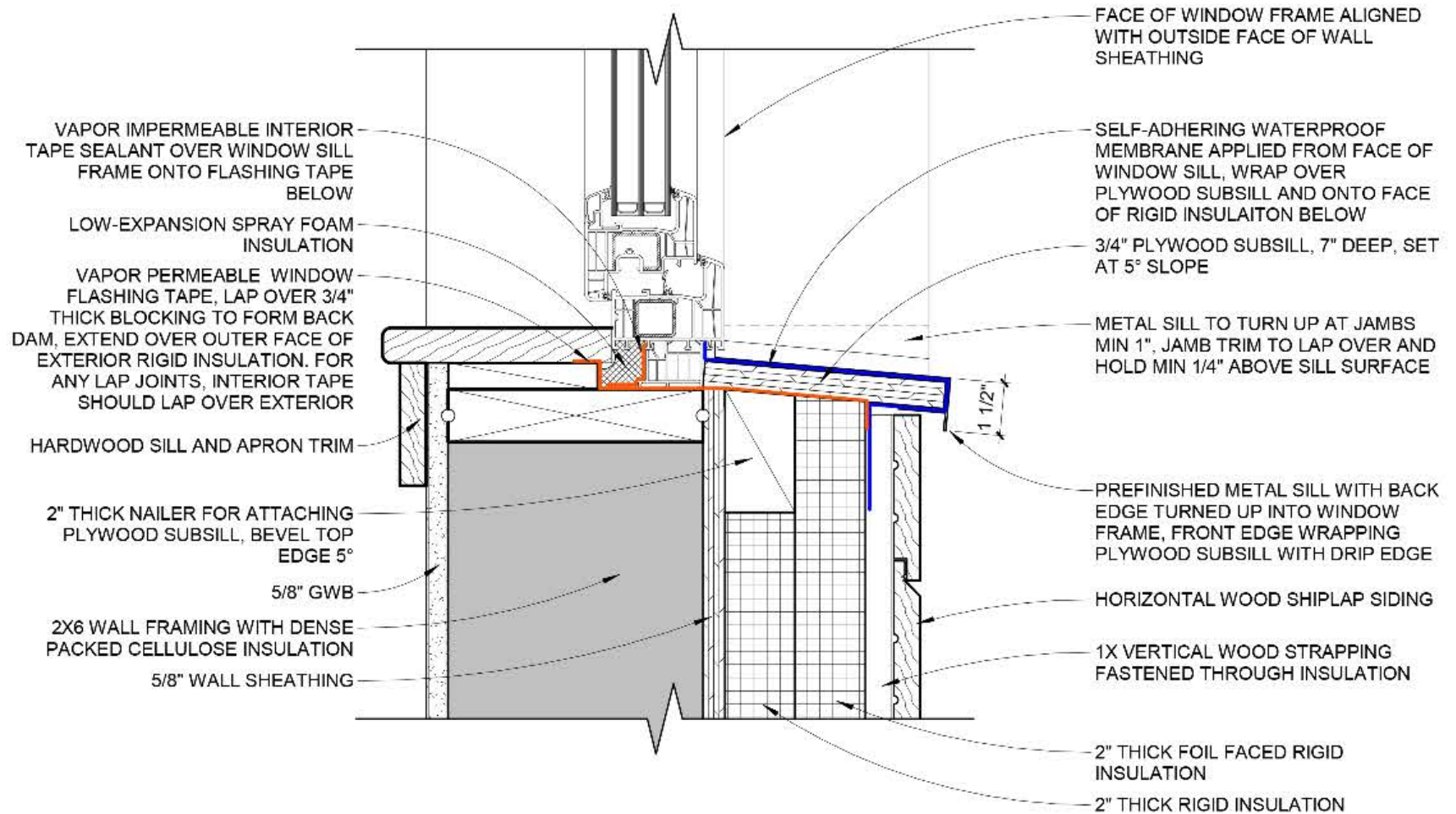
# TYPICAL WINDOW HEAD - NORTH WALL



# TYPICAL WINDOW SILL - NORTH WALL



# TYPICAL WINDOW HEAD - SOUTH WALL



# TYPICAL WINDOW SILL - SOUTH WALL









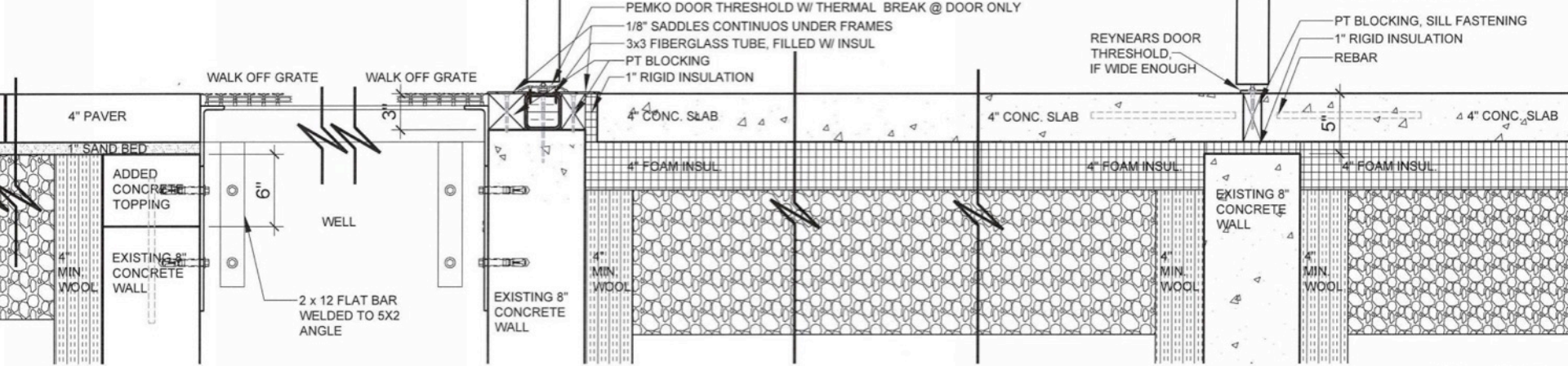
DOOR / STOREFRONT 101A  
DOORS 109D, 108A & 121D SIM.

**EXTERIOR**

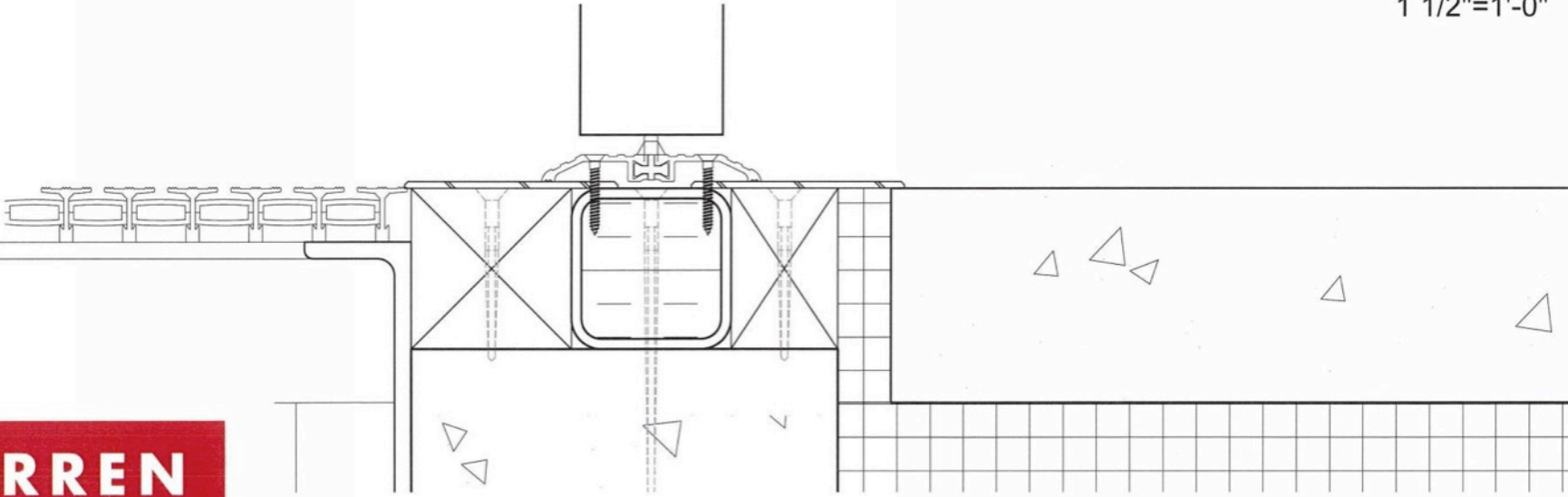
**VESTIBULE**

DOOR / STOREFRONT 102A

**INTERIOR**



1 1/2"=1'-0"



**WARREN**

CONSTRUCTION GROUP

FRONT ENTRY DOOR TRANSITIONS  
7/17/17



system  
STRUCTURAL I  
1/2" X 2" X 1/2" WALL SHEETING

SIGA-Majvest  
www.siga.ch

SIGA-Majvest  
www.siga.ch

SIGA-Majvest  
www.siga.ch

SIGA-Majvest  
www.siga.ch

PUSH



A hand-drawn architectural floor plan of a building, rendered in white lines on a dark grey background. The plan shows a complex layout of rooms, corridors, and structural elements. A prominent feature is a large, irregularly shaped room on the right side. The drawing includes various details such as doors, windows, and structural columns. The text "BUILDING SYSTEMS" is overlaid in a bold, orange, sans-serif font across the center of the plan. The background of the drawing is filled with light green and yellowish scribbles, suggesting an outdoor or landscaped area.

# BUILDING SYSTEMS



# ELECTRICAL & LIGHTING

- © LED lighting
- © Occupant sensors
- © Separate switches at exterior walls







# HVAC FUNDAMENTALS

## *Reduce the load !*

- ◎ Super insulation, air tight construction, high performance windows
- ◎ Fault detection & diagnostics
- ◎ Extra insulation – piping and water heater (3” non-CFC foam)
- ◎ LED lighting
- ◎ No process exhaust (kitchen, science)
- ◎ All HVAC inside the thermal envelope

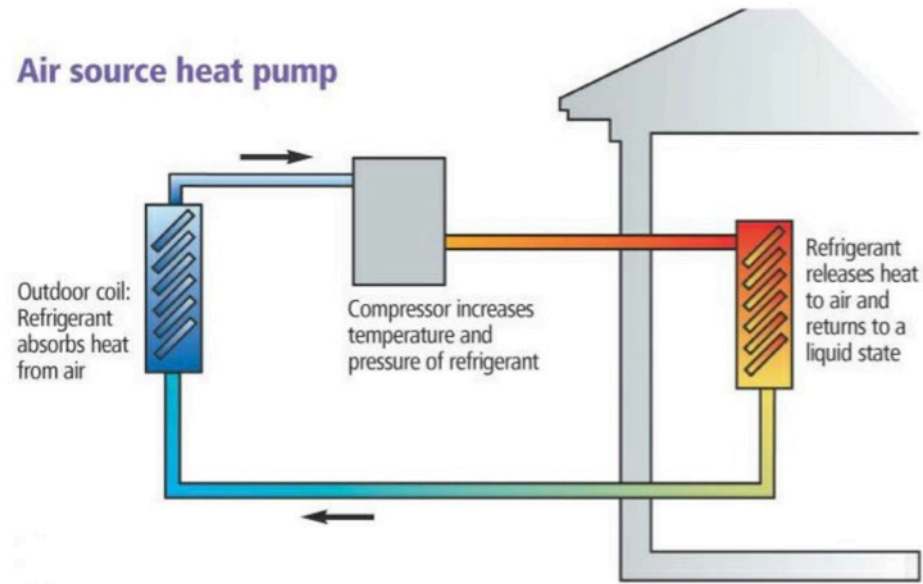
# HEATING & COOLING

*Little “h” and Little “c”*

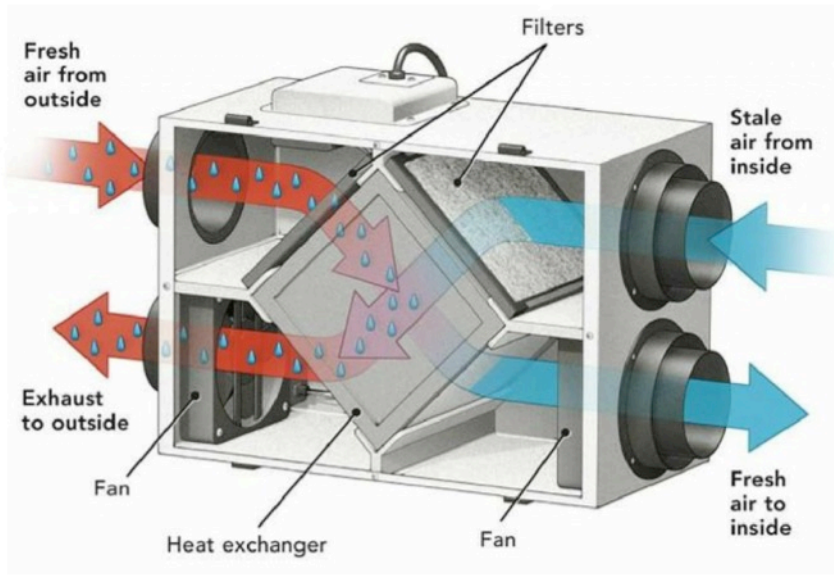
- © Mitsubishi MXZ H2i “hyper heat”
- © 19.0 SEER, 3.75 COP @ 47F, 2.7 COP @ 17f
- © Variable speed compressors
- © Full heating to -13°
- © 20 zones; grouped by exposure
- © Wall mounted indoor units – less friction



Air source heat pump







# VENTILATION

*The big “V”*

- © Balanced ventilation that delivers fresh air and removes stale air
- © Three energy recovery units, 1<sup>st</sup> fl, 2<sup>nd</sup> fl & great room
- © Ventilation per ASHRAE 62.1-2013
- © Air diffusion – thermal core high induction – no heat in ERV system





# DIDN'T MAKE THE CUT

## *IDEAS CONSIDERED BUT NOT AFFORDABLE*

- ◎ ERU for each classroom for better demand control
- ◎ Higher efficiency ERU's, such as Zehnder
- ◎ Building automation system
- ◎ Heat recovery VRF (multi-splits were more affordable)
- ◎ Geothermal
- ◎ Daylighting controls

# PLUMBING

- © Low flow / low water use fixtures
- © automatic sensors
- © Insulated piping
- © 120 gallon storage tank, insulated



# RENEWABLES

- © Designed to be Net Zero
- © 110 Q-Cell solar panels 300W each
- © 33 kW system
- © Projected use = 34,000± kWh/yr.
- © Installed by Maine Solar Solutions

*Building use = 3 houses, 5X less than a high school of same size*







## Periodic AC Energy Report for Site Maine Coast Waldorf High School

**Report Period:** From 09/20/2017 to 09/19/2018  
**Location:** Freeport, United States  
**Peak Power:** 33 kWp  
**Installation Date:** 09/19/2017  
**Revenue calculation:** Flat rate

Inverter	Serial Number	AC Energy()	Total Revenue()
Inverter 1	7D113648-0C	14678.19	2,201.73
Inverter 2	7311DD4E-AF	4716.29	707.44
Inverter 3	7D1132D3-93	16235.55	2,435.33
<b>Total for site</b>		35630.03	5,344.50

### Overview

Current Power	Energy today	Energy this month	Lifetime energy	Lifetime revenue
<b>15.48 kW</b>	<b>31.8 kWh</b>	<b>2.43 MWh</b>	<b>38.19 MWh</b>	<b>\$5,356.17</b>

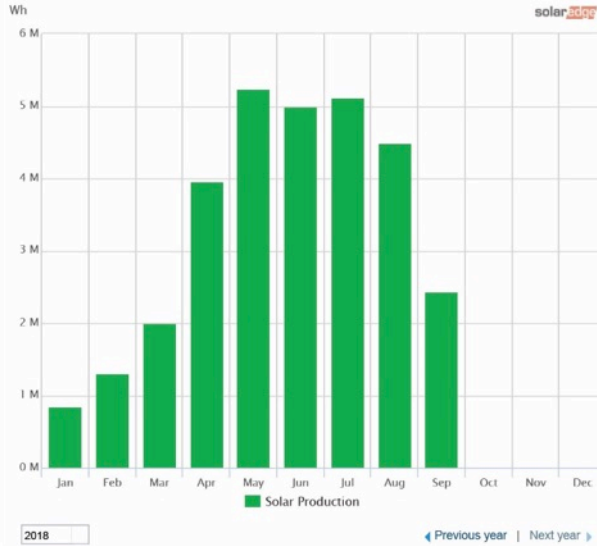


### Power and Energy

Day Week Month **Year**

01/01/2018 - 12/31/2018

System Production: **30.36 MWh**



2018

◀ Previous year | Next year ▶

### Comparative Energy

Month Quarter Year



### Site summary

Site status:

ID	552374
Name	Maine Coast Waldorf High ...
Country	United States
State	Maine
City	Freeport
Address	Desert Road 57
Installed	09/19/2017
Last updated	09/20/2018 11:46
Peak power	33 kWp

### Weather

Cloudy  
58 °F  
Feels like 58 °F  
Wind ENE, 4 MPH  
Humidity 82 %  
Sunrise at 06:25  
Sunset at 18:41

Thursday	Friday	Saturday
63 - 52 °F Cloudy	64 - 61 °F Mostly Cloudy	66 - 46 °F Partly Cloudy

### Site Image



### Environmental Benefits

CO2 Emission Saved  
**59,131.97 lb**

Equivalent Trees Planted  
**1,489.32**



Choose a site (insert at least 3 letters to search):

Maine Coast Waldorf High School

Show playback | Total | Physical layout



359.88 kWh	355.77 kWh	353.62 kWh	360.62 kWh	352.32 kWh	351.17 kWh	335.78 kWh	331.74 kWh	334.37 kWh	337.11 kWh	326.38 kWh	337.86 kWh
2.1.1	2.1.2	2.1.3	2.1.4	2.1.5	2.1.6	2.1.7	2.1.8	2.1.9	2.1.10	2.1.11	2.1.12
330.95 kWh	328.86 kWh	322.17 kWh	325.43 kWh	326.98 kWh	324.69 kWh	327.6 kWh	330.82 kWh	326.99 kWh	327.63 kWh	357.34 kWh	348.65 kWh
1.1.10	1.1.9	1.1.8	1.1.7	1.1.6	1.1.5	1.1.4	1.1.3	1.1.2	1.1.1	2.1.14	2.1.13
323.92 kWh	322.65 kWh	331.01 kWh	319.38 kWh	322.34 kWh	324.66 kWh	332.86 kWh	326.21 kWh	332.62 kWh	332.9 kWh	334.45 kWh	327.97 kWh
1.1.11	1.1.12	1.1.13	1.1.14	1.1.15	1.1.16	1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6
328.6 kWh	324.7 kWh	324 kWh	323.68 kWh	325.08 kWh	321.48 kWh	327 kWh	328.25 kWh	328.73 kWh	331.02 kWh	331.11 kWh	335.12 kWh
1.3.3	1.3.2	1.3.1	1.2.15	1.2.14	1.2.13	1.2.12	1.2.11	1.2.10	1.2.9	1.2.8	1.2.7
340.01 kWh	330.27 kWh	328.74 kWh	326.4 kWh	329.42 kWh	326.94 kWh	332.75 kWh	332.86 kWh	331.06 kWh	333.86 kWh	333.62 kWh	340.37 kWh
1.3.4	1.3.5	1.3.6	1.3.7	1.3.8	1.3.9	1.3.10	1.3.11	1.3.12	1.3.13	1.3.14	1.3.15

331.33 kWh	335.68 kWh	323.68 kWh	328.61 kWh	327.35 kWh	333.43 kWh	333.93 kWh	347.46 kWh	340.95 kWh	344.83 kWh
3.1.1	3.1.2	3.1.3	3.1.4	3.1.5	3.1.6	3.1.7	3.1.8	3.1.9	3.1.10
336.73 kWh	330.28 kWh	329.24 kWh	329.04 kWh	331.72 kWh	334.52 kWh	338.08 kWh	344.63 kWh	348.08 kWh	350.23 kWh
3.2.4	3.2.3	3.2.2	3.2.1	3.1.16	3.1.15	3.1.14	3.1.13	3.1.12	3.1.11
328.83 kWh	327.13 kWh	325.56 kWh	332.36 kWh	333.82 kWh	333.68 kWh	336.82 kWh	340.41 kWh	337 kWh	343.78 kWh
3.2.5	3.2.6	3.2.7	3.2.8	3.2.9	3.2.10	3.2.11	3.2.12	3.2.13	3.2.14
333.03 kWh	326.12 kWh	329.7 kWh	335.02 kWh	334.91 kWh	332.53 kWh	335.94 kWh	332.41 kWh	335.34 kWh	338.04 kWh
3.3.7	3.3.6	3.3.5	3.3.4	3.3.3	3.3.2	3.3.1	3.2.17	3.2.16	3.2.15
335.07 kWh	335.99 kWh	338.2 kWh	337.63 kWh	338.77 kWh	337.76 kWh	329.71 kWh	335.51 kWh	336.45 kWh	340.46 kWh
3.3.8	3.3.9	3.3.10	3.3.11	3.3.12	3.3.13	3.3.14	3.3.15	3.3.16	3.3.17





A hand-drawn architectural floor plan of a building, rendered in white lines on a dark grey background. The plan shows a complex layout with multiple rooms, corridors, and stairwells. The word "PERFORMANCE" is overlaid in the center in a bold, orange, sans-serif font. The drawing style is sketchy and artistic, with some areas filled with light green hatching. The building's footprint is irregular, with a large open area on the right side and a more detailed interior on the left and top. Dashed lines indicate various sections and boundaries within the plan.

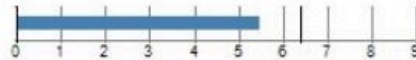
**PERFORMANCE**

# PASSIVEHOUSE REQUIREMENTS

Certificate criteria: PHIUS+ 2015 Standard

## Heating demand

specific: 5.48 kBtu/ft<sup>2</sup>yr  
target: 6.4 kBtu/ft<sup>2</sup>yr  
total: 55,977.07 kBtu/yr



→ 5.48 kBtu/ft<sup>2</sup>yr

## Cooling demand

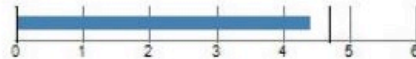
sensible: 0.75 kBtu/ft<sup>2</sup>yr  
latent: 0.03 kBtu/ft<sup>2</sup>yr  
specific: 0.78 kBtu/ft<sup>2</sup>yr  
target: 1.4 kBtu/ft<sup>2</sup>yr  
total: 7,942.54 kBtu/yr



→ 0.78 kBtu/ft<sup>2</sup>yr

## Heating load

specific: 4.42 Btu/hr ft<sup>2</sup>  
target: 4.7 Btu/hr ft<sup>2</sup>  
total: 45,152.73 Btu/hr



→ 4.42 kBtu/ft<sup>2</sup>yr

## Cooling load

specific: 2.28 Btu/hr ft<sup>2</sup>  
target: 3.8 Btu/hr ft<sup>2</sup>  
total: 23,282.09 Btu/hr

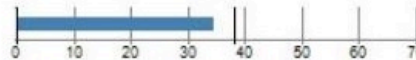


→ 2.28 kBtu/ft<sup>2</sup>yr

## Source energy

PHIUS+ Source Zero: NO

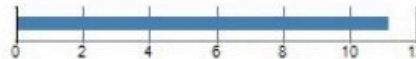
total: 103,494.57 kWh/yr  
specific: 34.57 kBtu/ft<sup>2</sup>yr  
target: 38.04 kBtu/ft<sup>2</sup>yr  
total: 353,103.28 kBtu/yr  
specific: 34.57 kBtu/ft<sup>2</sup>yr



→ 34.57 kBtu/ft<sup>2</sup>yr

## Site energy

total: 114,388.19 kBtu/yr  
specific: 11.2 kBtu/ft<sup>2</sup>yr  
total: 33,527.18 kWh/yr  
specific: 3.28 kWh/ft<sup>2</sup>



→ 11.2 kBtu/ft<sup>2</sup>yr

## Air tightness

ACH50: 0.39 1/hr  
CFM50 per envelope area: 0.03 cfm/ft<sup>2</sup>  
target: 0.58 1/hr  
target CFM50: 0.05 cfm/ft<sup>2</sup>



→ 0.03 cfm/ft<sup>2</sup>





A hand-drawn architectural floor plan of a building, rendered in black lines on a dark grey background. The plan shows a complex layout of rooms, corridors, and stairwells. A large, irregularly shaped room is on the right side. The drawing is surrounded by a greenish-yellow hatched texture. The word "VERIFICATION" is written in a bold, orange, sans-serif font across the center of the plan.

VERIFICATION



# BLOWER DOOR TEST RESULTS

## *First Test Results:*

© average

CFM50=0.040

© Average ACH50=0.47

## *Final Test Results:*

© average

CFM50=0.035

© Average ACH50=0.40

# COST OF CONSTRUCTION

## *Including sitework:*

Construction cost: \$3,332,000

Cost per ft<sup>2</sup>: \$292/sf

## *Building Only:*

Construction cost: \$2,842,000

Cost per ft<sup>2</sup>: \$249/sf

Building Size: 11,400 sf



QUESTIONS?