BUILDING INHERENT VALUE:

Implementing the Passive House Building Standard

E-ICON ARCHITECTURE

maine passive house MPH

BUILDINGENERGY BOSTON

AIA Provider: Northeast Sustainable Energy Association

Provider Number: G338

Building Inherent Value:

Implementing the Passive House Building Standard

BE18

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March 8, 2018

Learning Objectives

At the end of the this course, participants will be able to:

1. Employ passive house principles and convey how they make good building science sense!
2. Create an airtight envelope and minimizing thermal bridging.
3. Describe the benefits of a heat recovery ventilation systems and how to maximize them.
4. Discuss how building form and program impact detail complexity and cost.

First passive house built in 1991

OVERVIEW:

INSULATION
AIR TIGHTNESS
VENTILATION

METRICS
COST

INSULATION

Multifamily

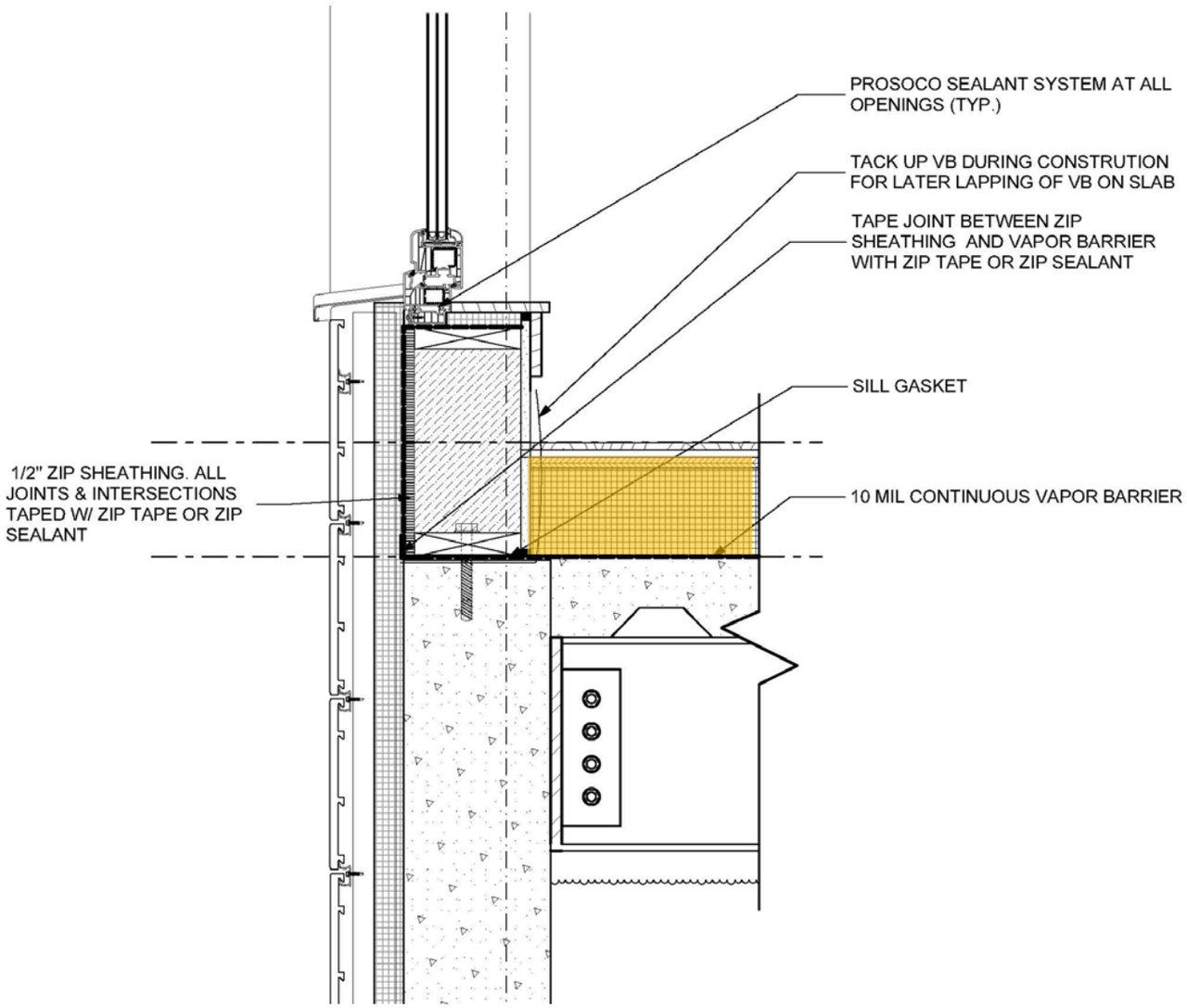
1 PASSIVE HOUSE CERTIFIED PROJECT
1 PASSIVE HOUSE DESIGNED PROJECT

THE DISTILLERY
South Boston, MA
- Mixed Use
- 28 Units
- 37,000 SF (excluding garage)

CONCORD HIGHLAN
Cambridge, MA
- 98 Units,
- 110,000 SF (excluding garage)

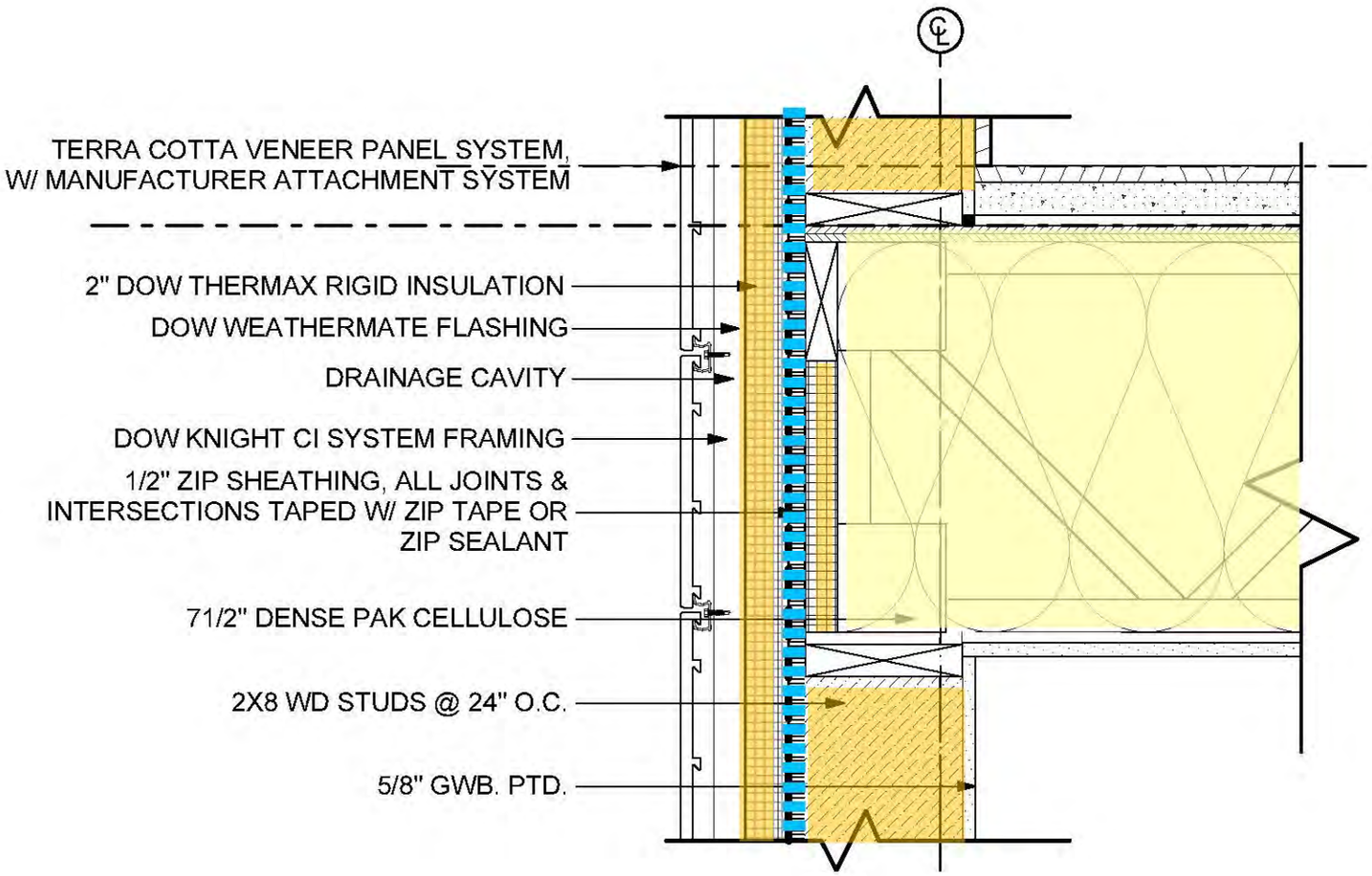
SLAB R:23

- 6” EPS ABOVE DECK



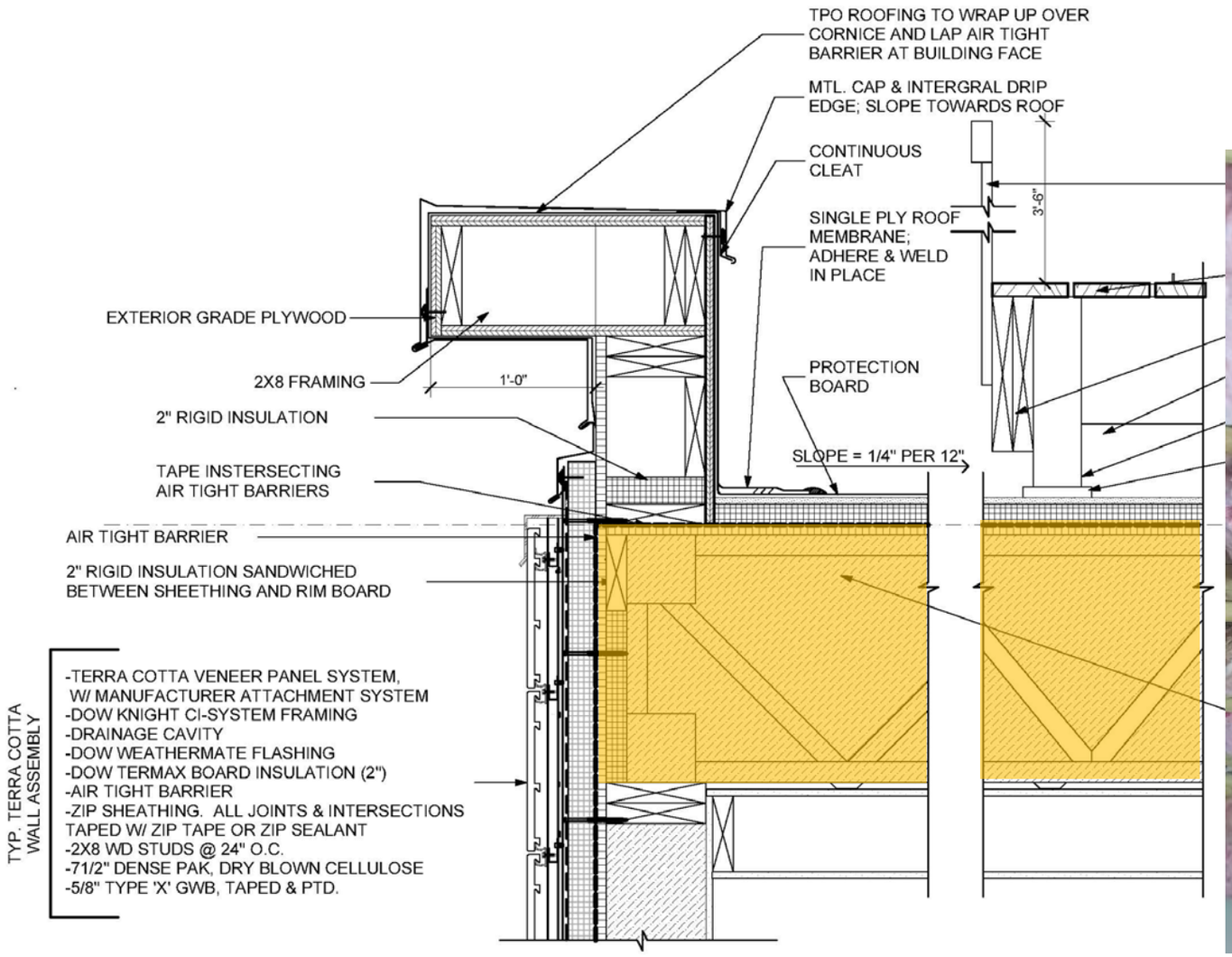
WALLS R:34

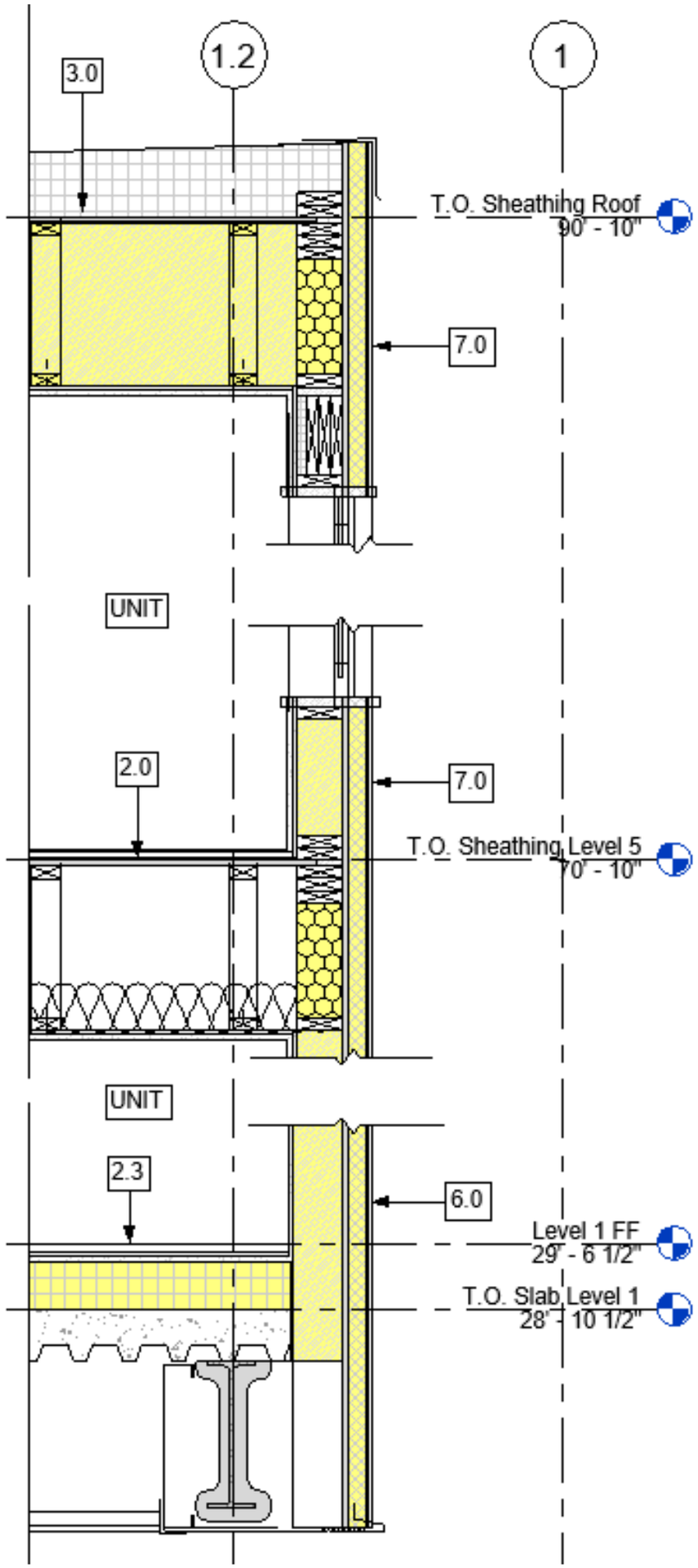
- 3” MINERAL WOOL – CONTINUOUS
- 2X8 CAVITY FILLED WITH CELLULOSE
- CELLULOSE IN FIRST 3’ OF TRUSS BAY



ROOF R:60

- TRUSS CAVITY FILLED WITH CELLULOSE
- 2” MIN CONT INSULATION ABOVE ROOF DECK





CONCORD HIGHLANDS

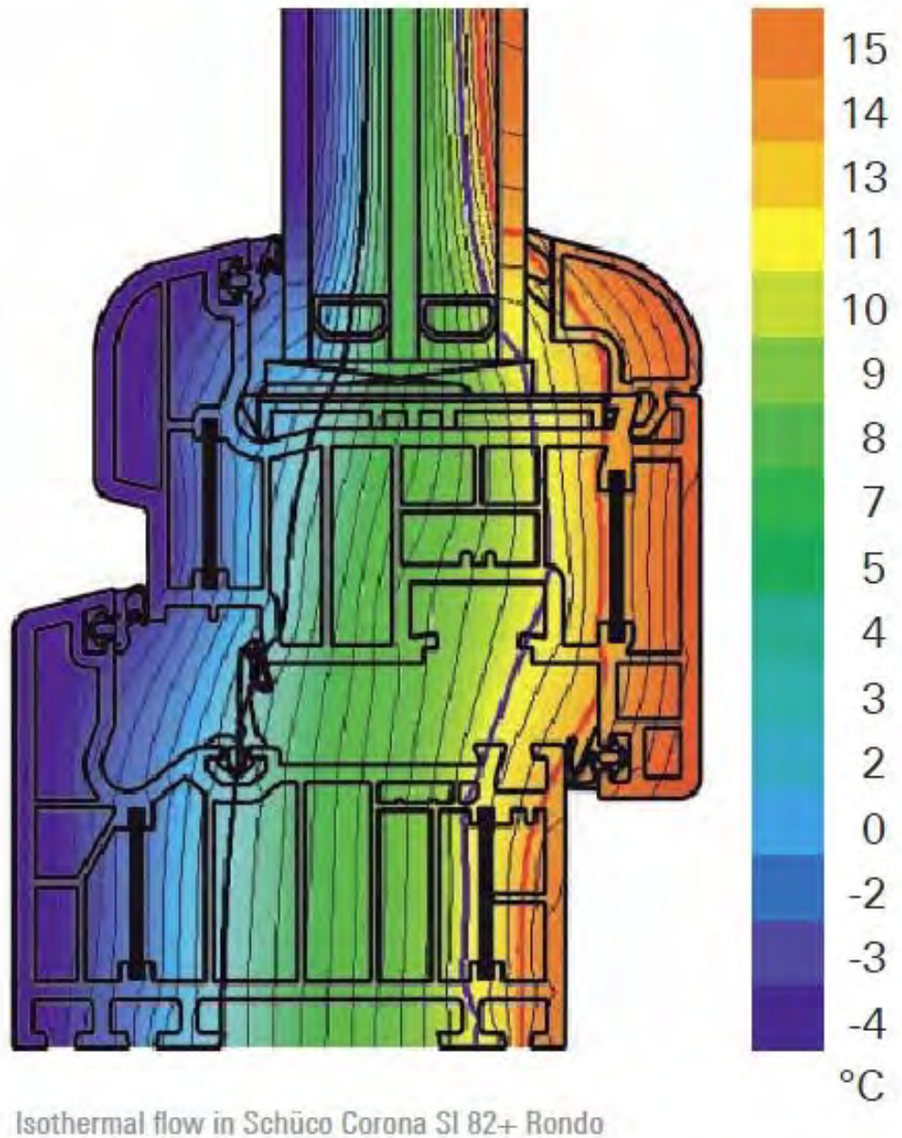
ROOF: (R-75): Truss cavity filled with insulation + 2” continuous minimum

WALL: (R-27): 2” cont. mineral wool + 2X6 stud cavity filled w/ spray fiberglass

SLAB: (R-23): 6” EPS above deck

WINDOWS U - 0.134

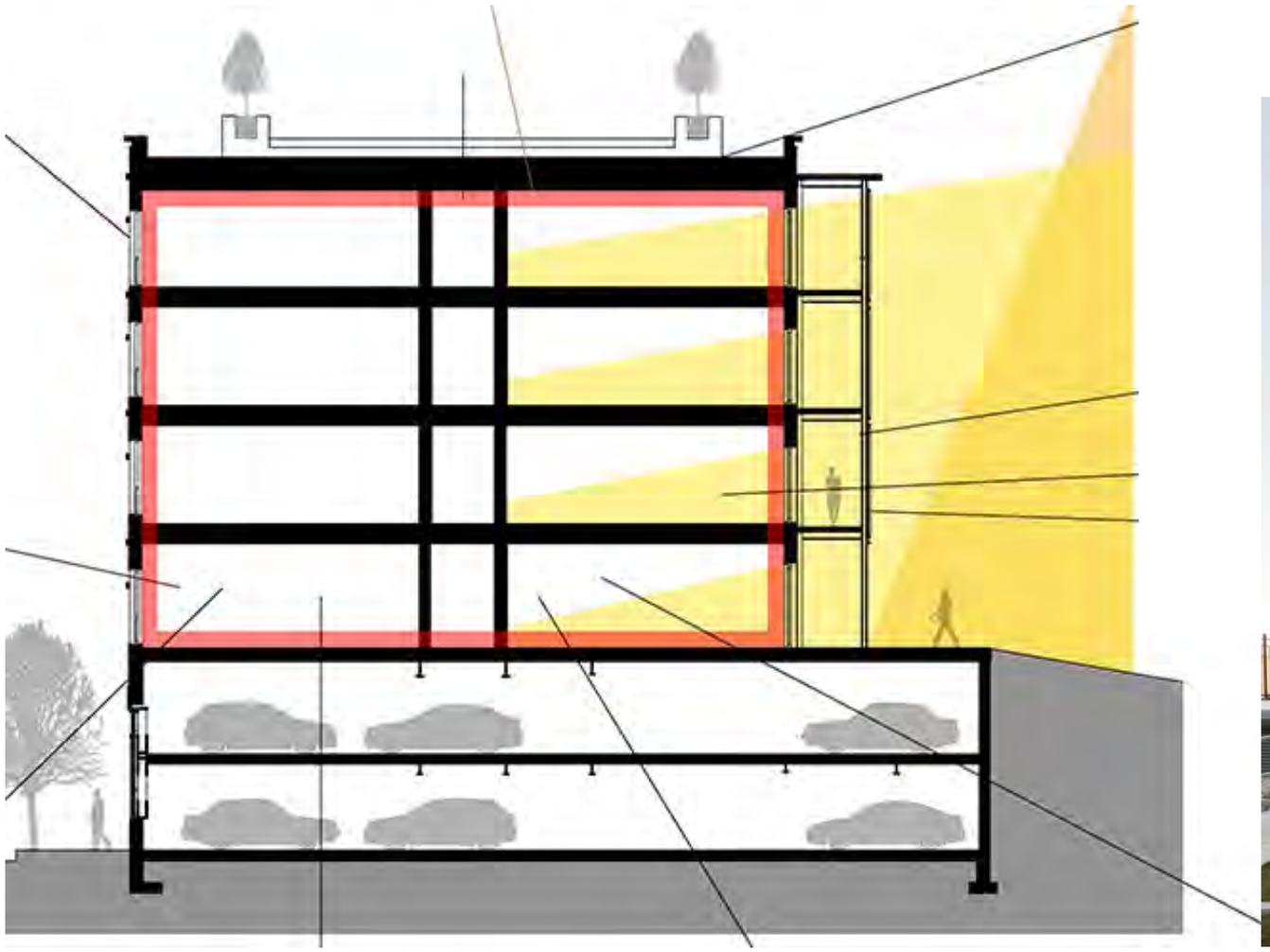
- KLEARWALL uPVC



Isothermal flow in Schüco Corona SI 82+ Rondo

SHADING

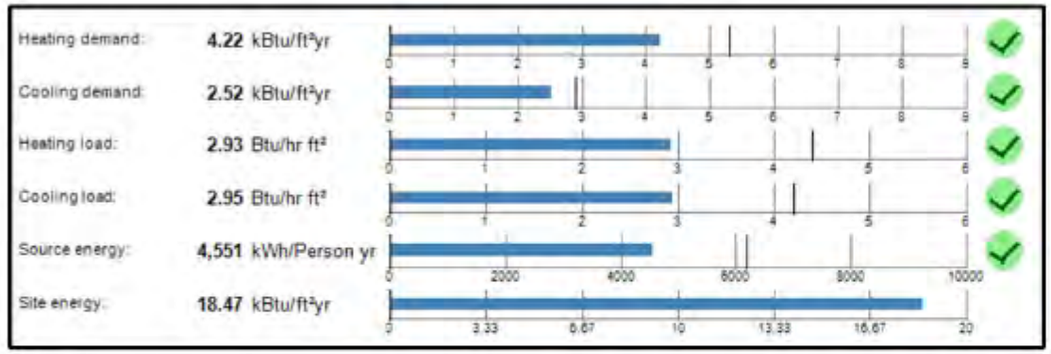
- PERMANENT 5’ DEEP OVERHANG FOR HIGH SUMMER SUN
- MOVEABLE SCREENS ON SOUTH SIDE



ENERGY
COMFORT
DIMINISHING RETURNS

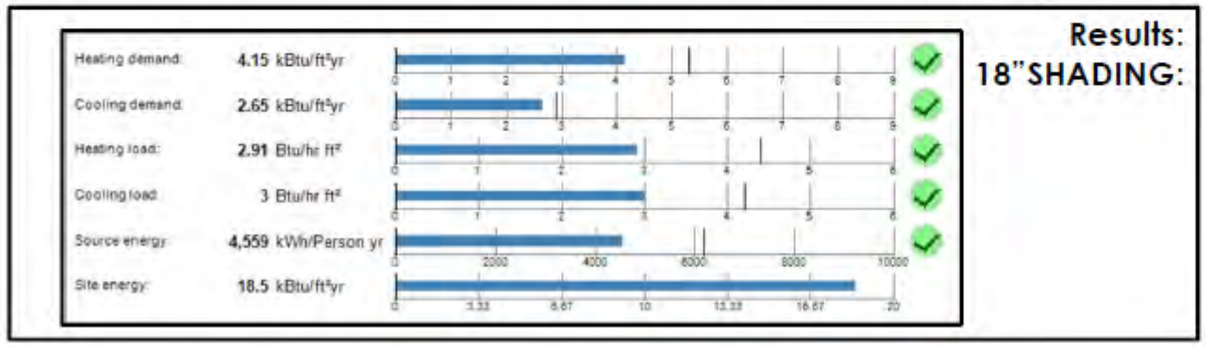
SHADING: SOUTH ONLY (36")

The WUFI results indicated below are based on a design with **36"** shading devices installed on the Southern façade only.



Measured Changes: from 18" Shades

- HD – **Up 0.07 k** kBtu/ft2/yr
- CD – **Down 0.13** kBtu/ft2/yr
- HL – **Up 0.02** Btu/hr/ft2
- CL – **Down 0.05** Btu/hr/ft2
- Source –**Down 8** kwh/p/yr
- Site: **Down 0.03** kBtu/ft2/yr

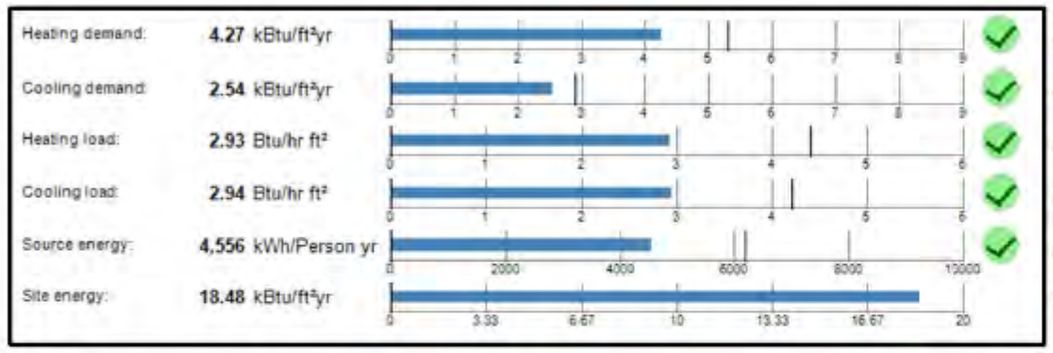


Results: 18"SHADING:

SIGNATURE SUSTAINABILITY

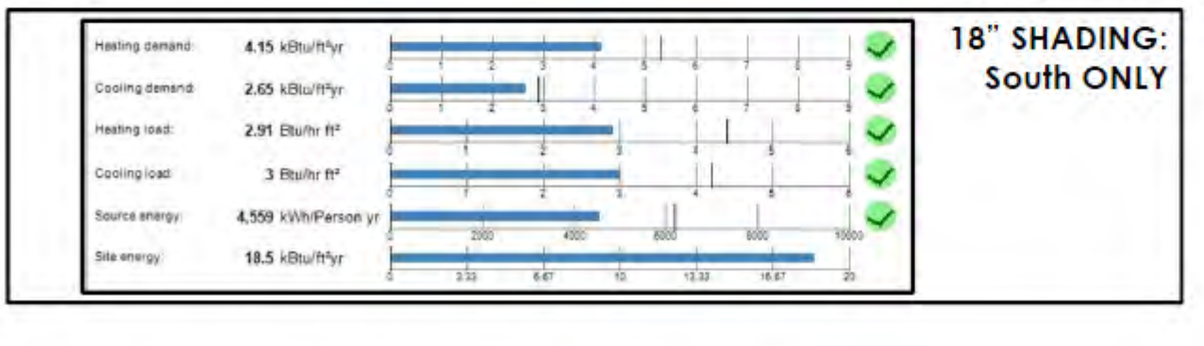
SHADING: SOUTH, EAST & WEST (1'-6")

The WUFI results indicated below are based on a design with **1'- 6"** shading devices installed on the South, East and West façades.



Measured Changes: from 18" South Only

- HD – **Up 0.12 k** kBtu/ft2/yr
- CD – **Down 0.11** kBtu/ft2/yr
- HL – **Up 0.02** Btu/hr/ft2
- CL – **Down 0.06** Btu/hr/ft2
- Source –**Down 3** kwh/p/yr
- Site: **Down 0.02** kBtu/ft2/yr



18" SHADING: South ONLY

SIGNATURE SUSTAINABILITY

Single family

7 PASSIVE HOUSE PROJECTS
3 HIGH PERFORMANCE HOMES

SLAB

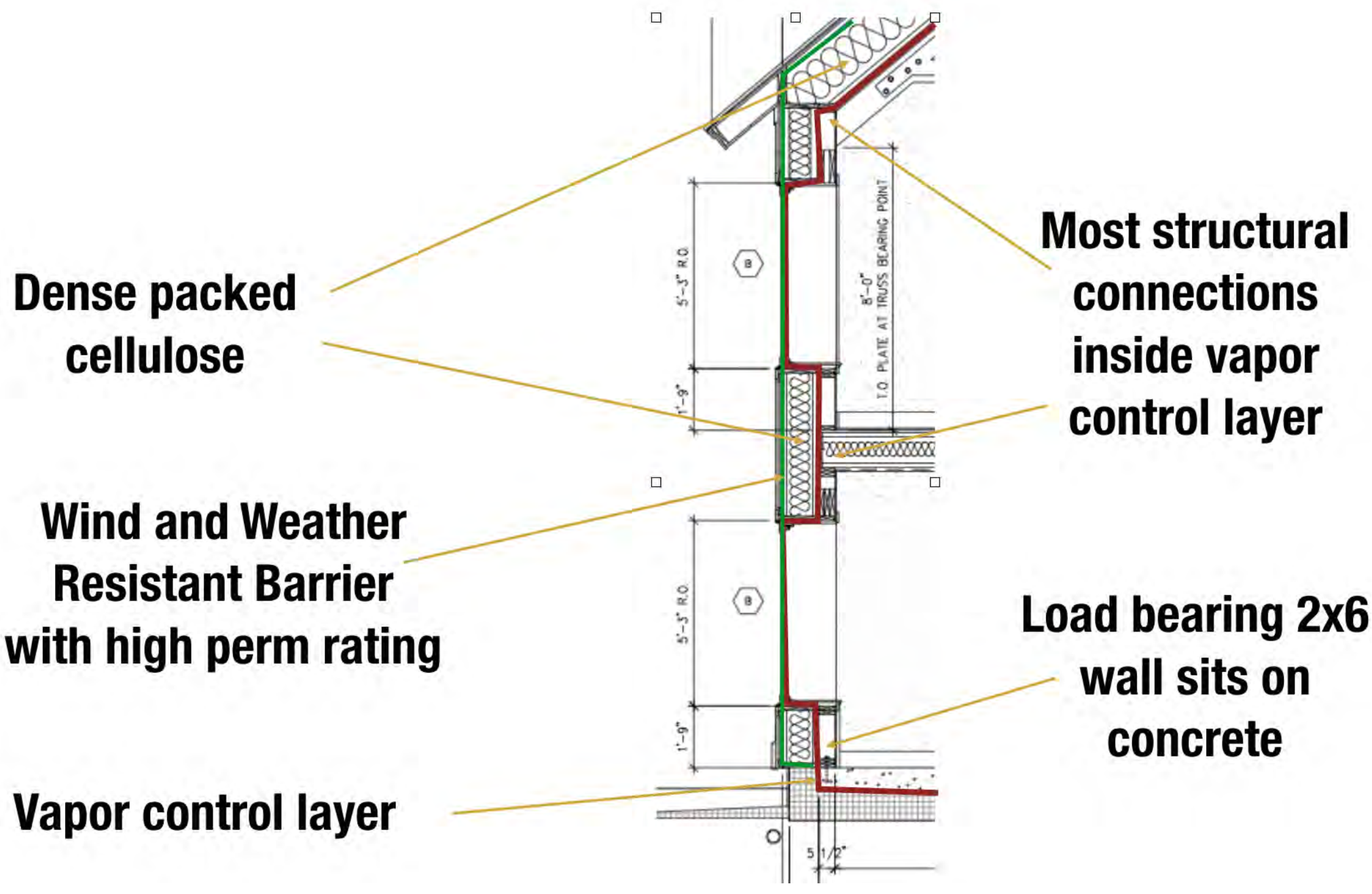
10” EPS foam

15 mill vapor barrier

8” concrete

FOUNDATION

Walls


Dense packed cellulose
Wind and Weather Resistant Barrier with high perm rating
Vapor control layer
Most structural connections inside vapor control layer
Load bearing 2x6 wall sits on concrete
5'-3" R.O.
1'-9"
8'-0"
T.O. PLATE AT TRUSS BEARING POINT
5'-3" R.O.
1'-9"
5 1/2"


MENTO
PLUS

Roofs

Shading

Calculate shade

Design windows for daylight and views.

September

Exterior shading

Windows

Windows

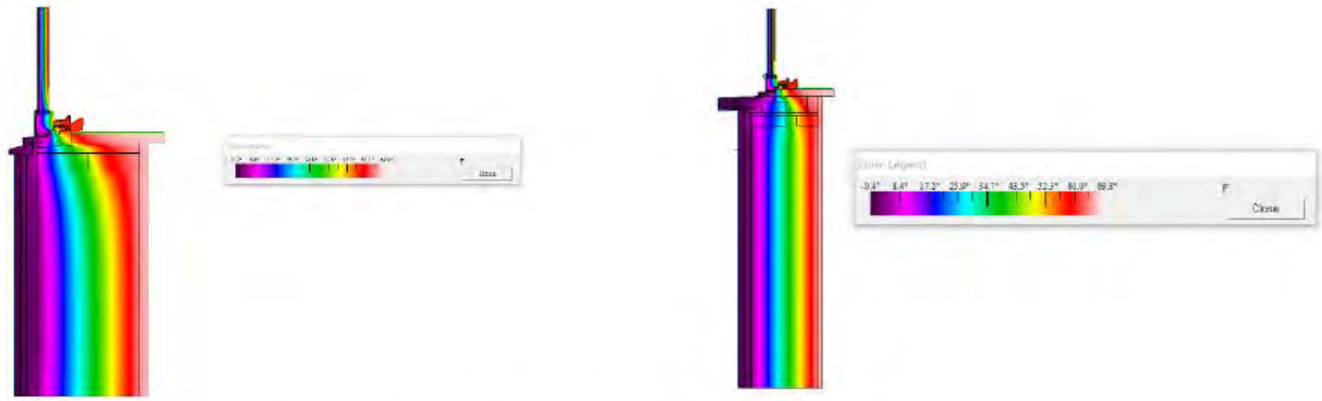


Figure 5: Sill temperature isotherm, (outer on left, centered on right)

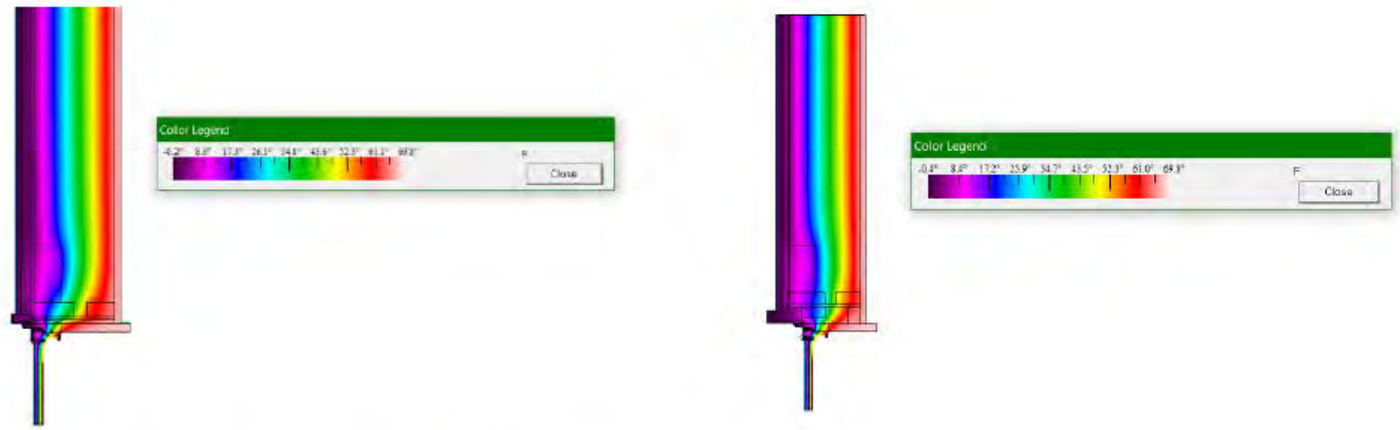


Figure 6: Head temperature isotherms, (outer on left, centered on right)

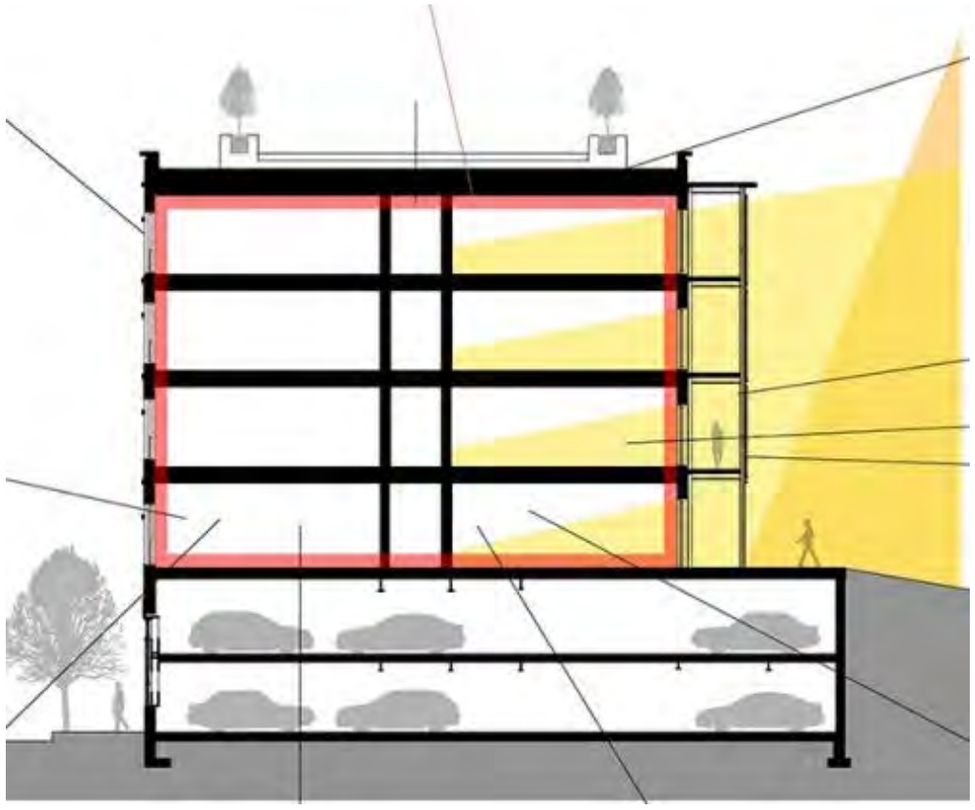
R-VALUE JUXTAPOSTION

SCALE, SURFACE TO VOLUME RATIO, CLIMATE ZONE

MULTI FAMILY			SINGLE FAMILY		
Ground:	R 23	(5” EPS foam)	Ground:	R 45	(10” EPS foam)
Walls:	R 27-34	(7.5” cellulose)	Walls:	R 57	(15” cellulose)
Roof:	R 60 +	(18-20”)	Roof:	R 89-114	(24-36“)

AIR BARRIERS

Multifamily

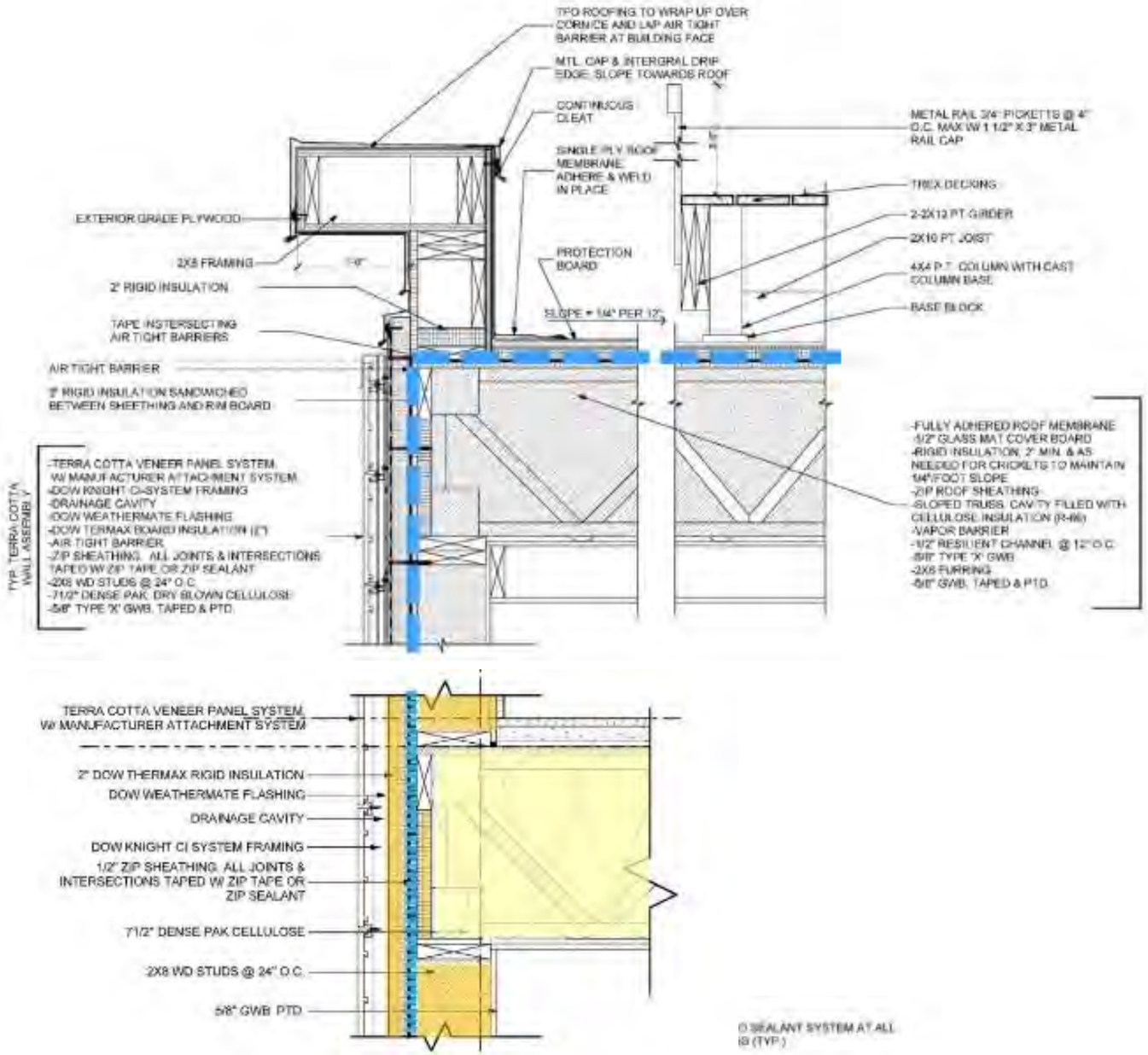


PH ENELOPE

SECTION

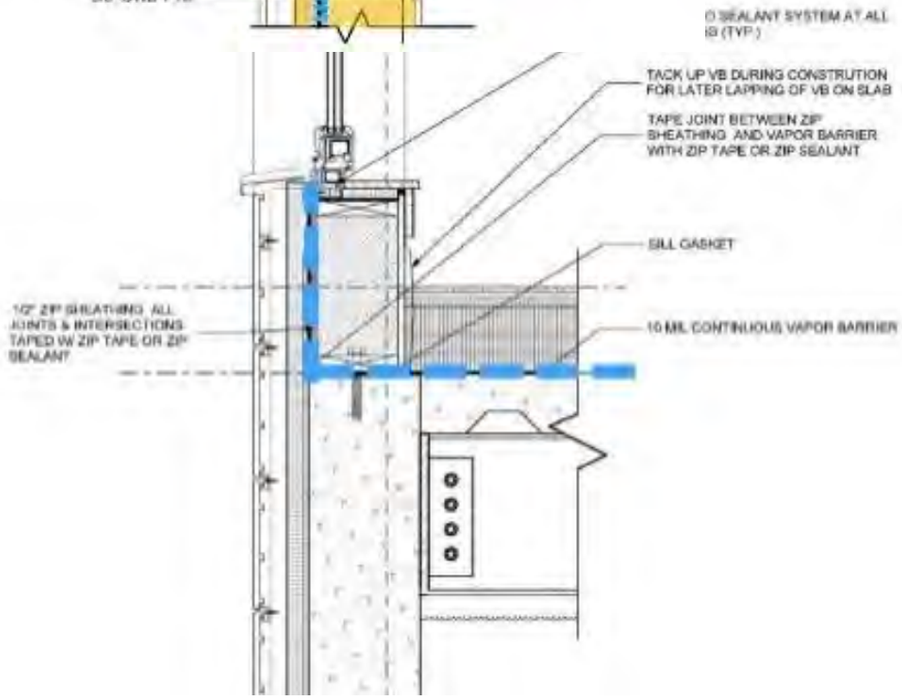
PH ENELOPE

PLAN



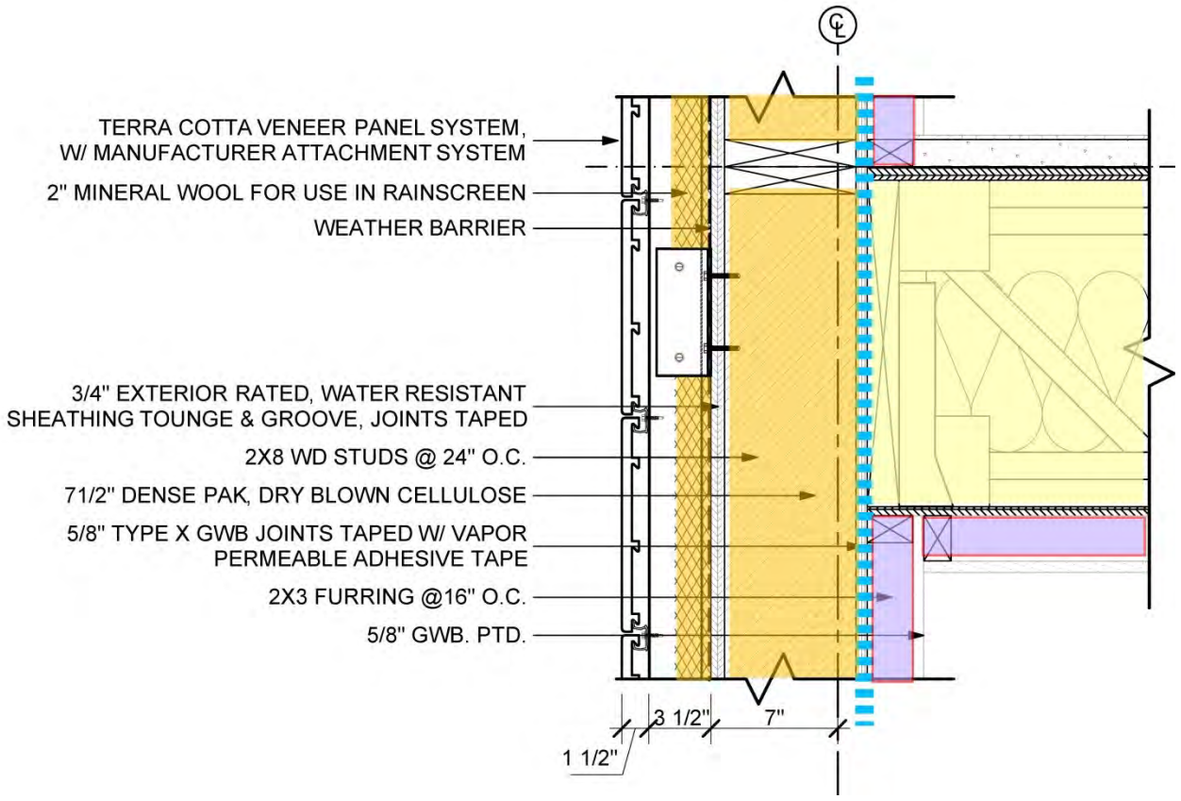
ROOF TO WALL

WALL

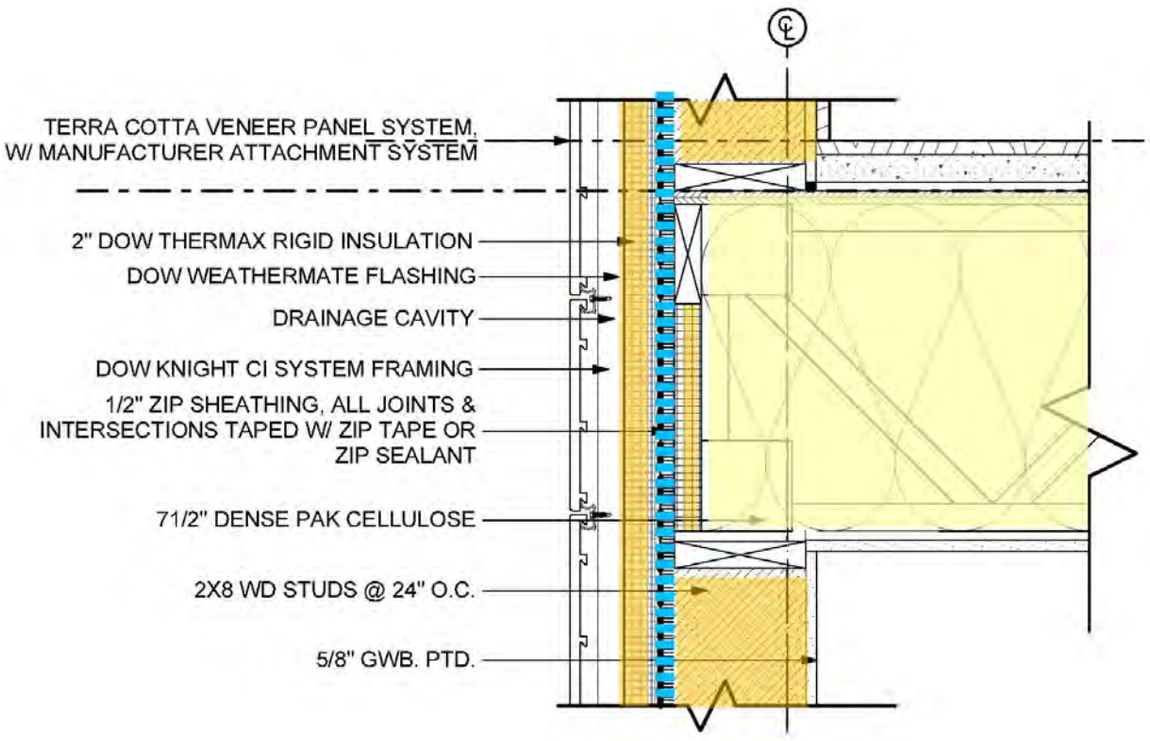


WALL TO SLAB

SECTION EVOLUTION

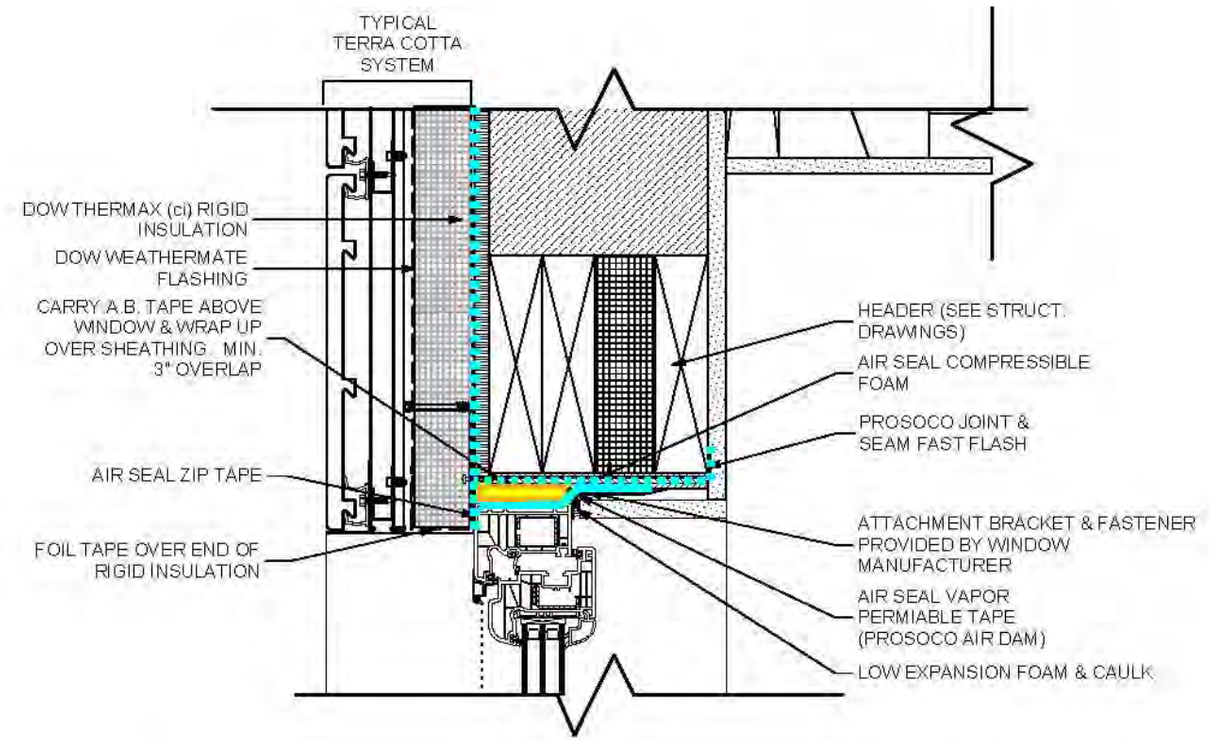


2011



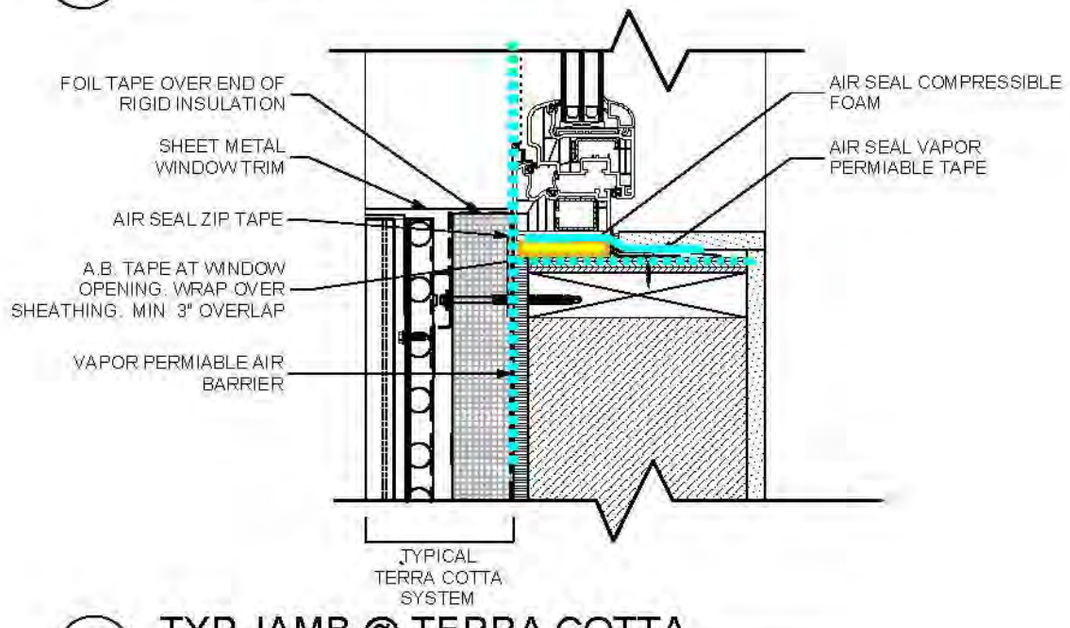
2014

WINDOWS



3 TYP. HEAD @ TERRA COTTA

SCALE: 3" = 1'-0"



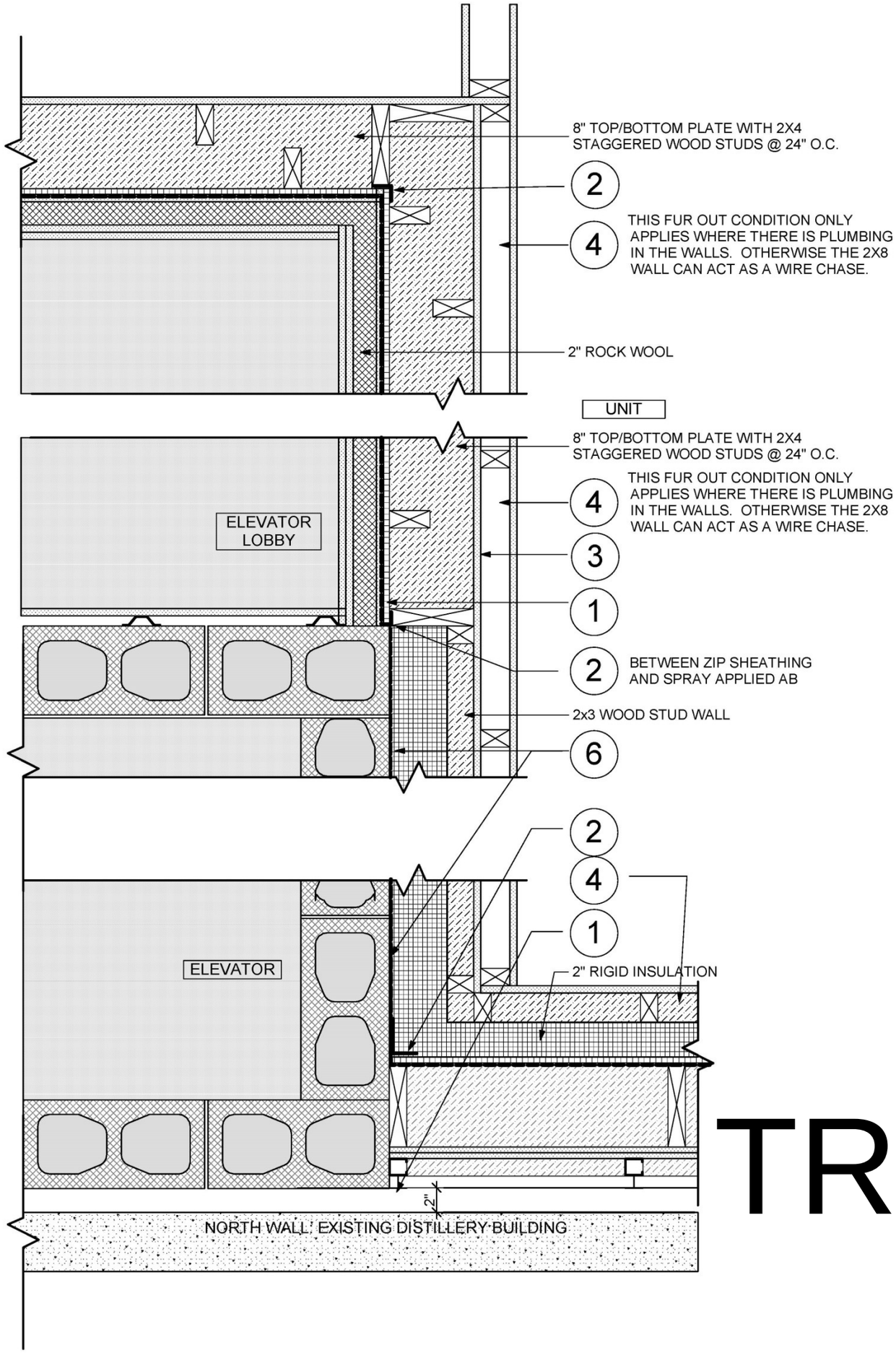
2 TYP JAMB @ TERRA COTTA

SCALE: 3" = 1'-0"

TESTING

.6 ACH$_{50}$	2611 CFM$_{50}$
DUCLOS METHOD RECOMENDATIONS	
Stage #1 Test (envelope no windows & Doors)	652.75 CFM$_{50}$
Stage #2 Test (windows & doors)	1552.75 CFM$_{50}$
Stage #3 Test (MEP penetrations)	2219.35 CFM$_{50}$

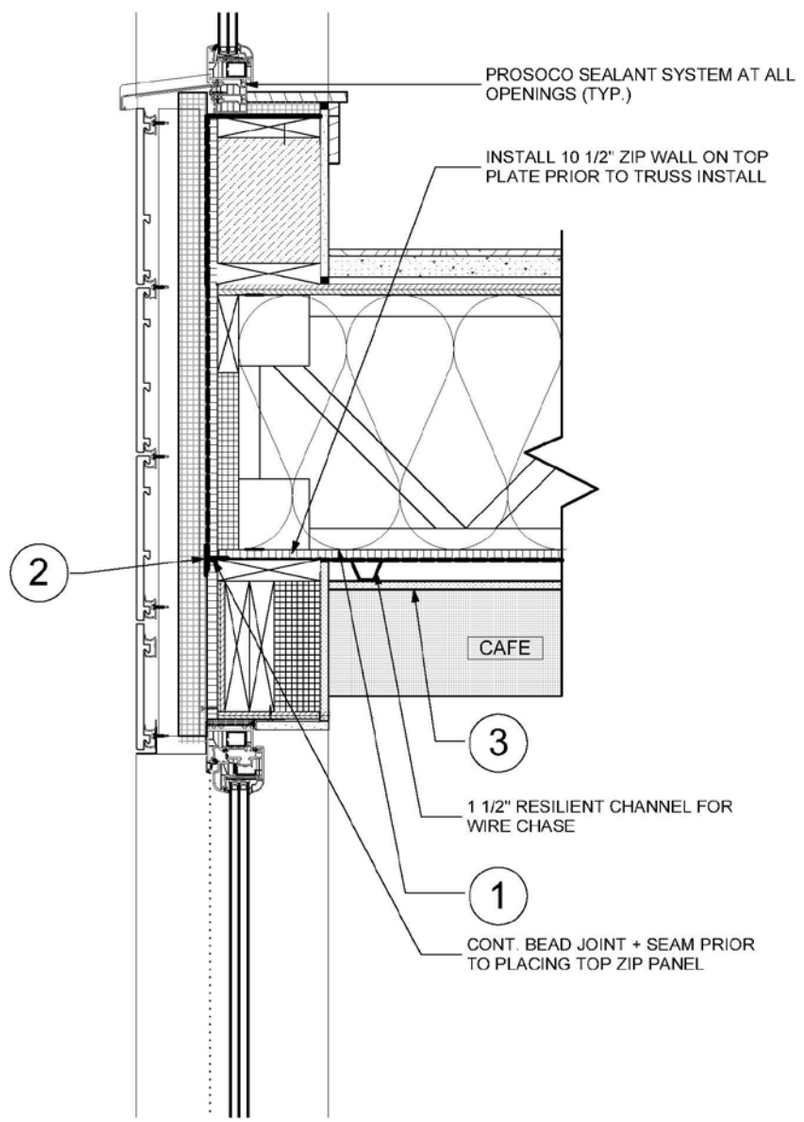
5/16/17: 2563 CFM50 (189.9 in2 leakage area) - .56 ach50

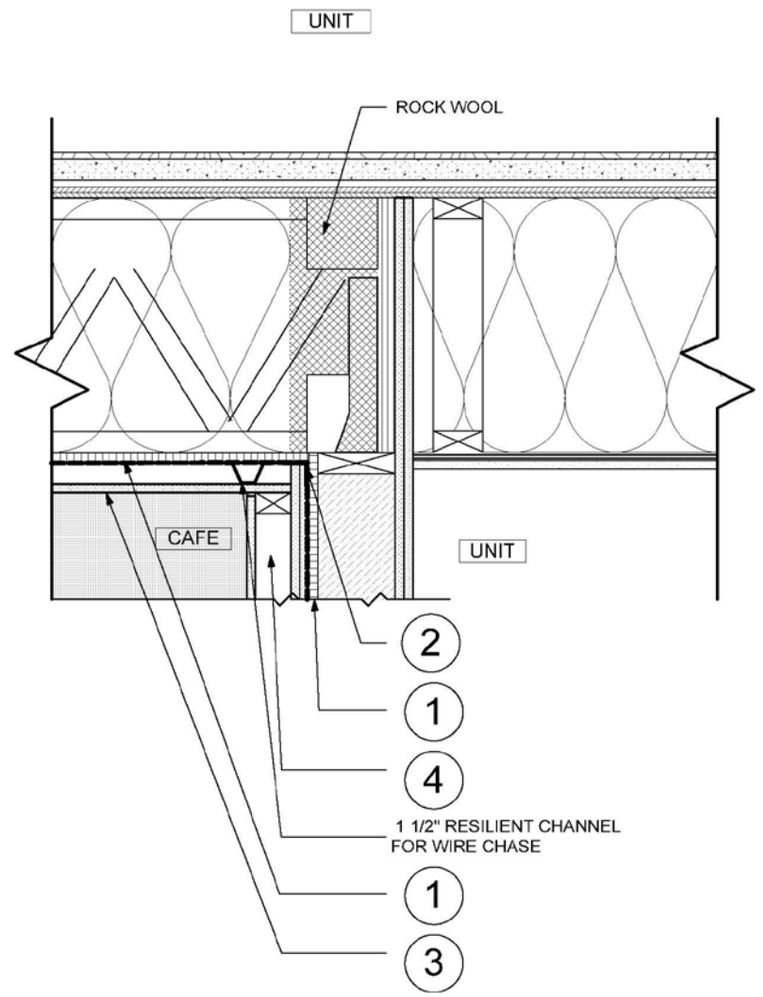


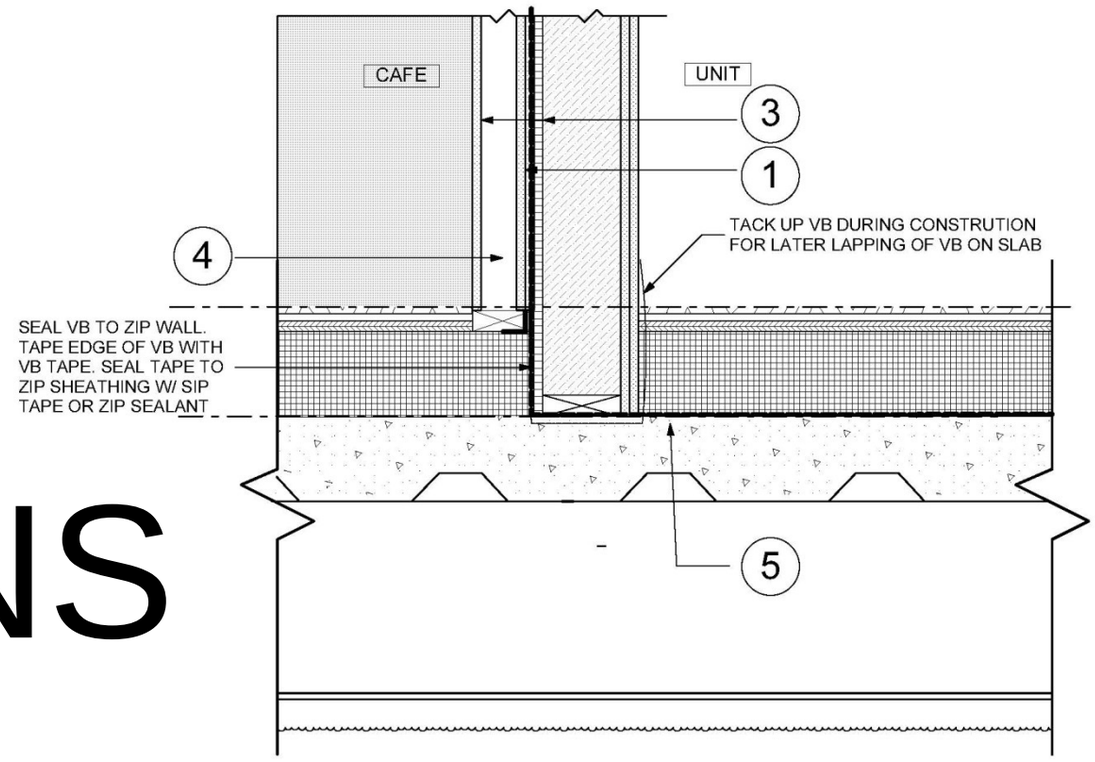
LEGEND

———	DENOTES LOCATION OF CONTINUOUS AIR TIGHT BARRIER
1	1/2" ZIP SHEATHING. ALL JOINTS & INTERSECTIONS TAPED W/ ZIP TAPE OR ZIP SEALANT.
2	TAPE JOINT WITH ZIP TAPE OR ZIP SEALANT
3	5/8" TYPE X GWB., TAPED & PAINTED
4	2X3 FURRING AT 16" O.C.
5	10 MIL CONTINUOUS VAPOR BARRIER
6	LIQUID APPLIED AIR BARRIER

TRANSITIONS







TRANSITIONS


ZIPSystem
FLASHING TAPE
30 YEAR SYSTEM LIMITED WARRANTY
FROM THE CREATORS OF AdvanTech Flooring
KNAACK
KEEP DRY
EAST COAST
KNAACK
STORAGEMASTER® CHEST

Single family

TJI wall

Double stud wall

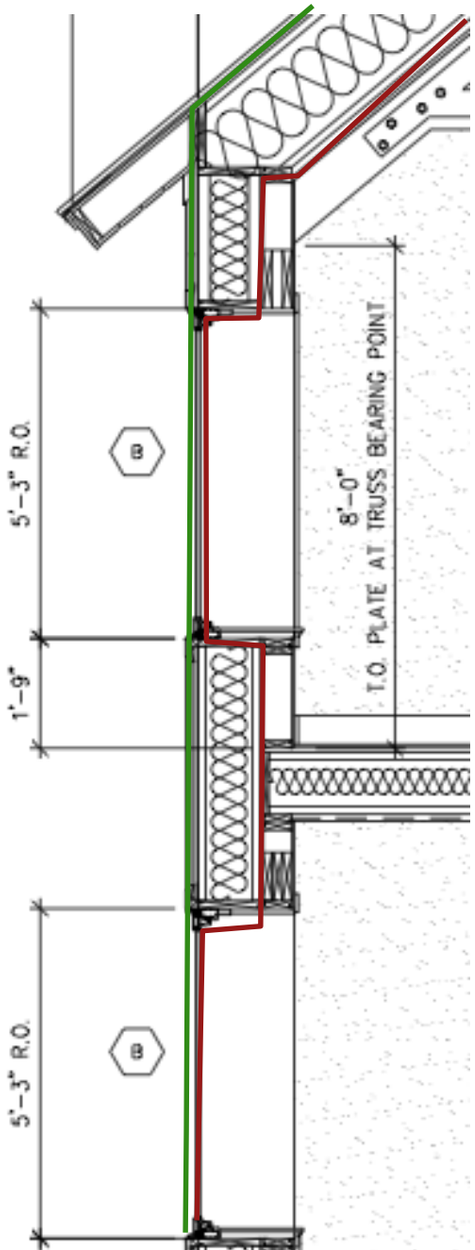
Section (d)evolution

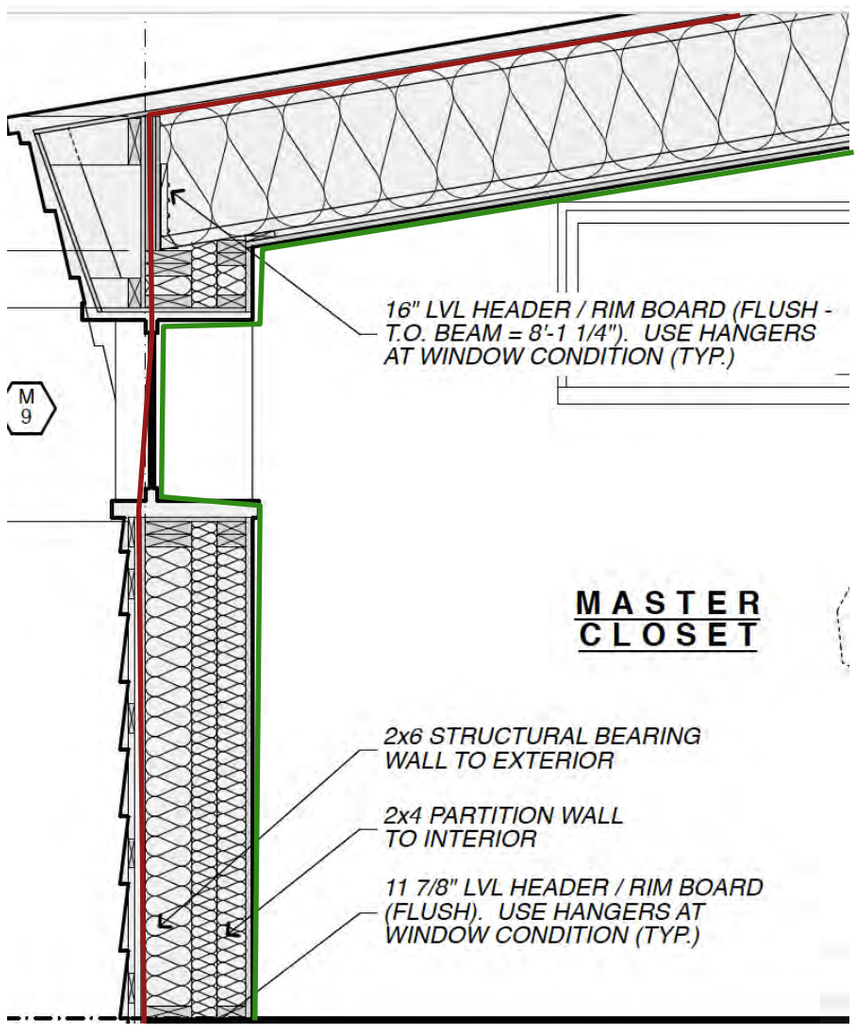
PRIMARY AIR BARRIER 1/2” ZIP

PRIMARY AIR BARRIER 1/2” CDX
WITH VAPOR OPEN WRB

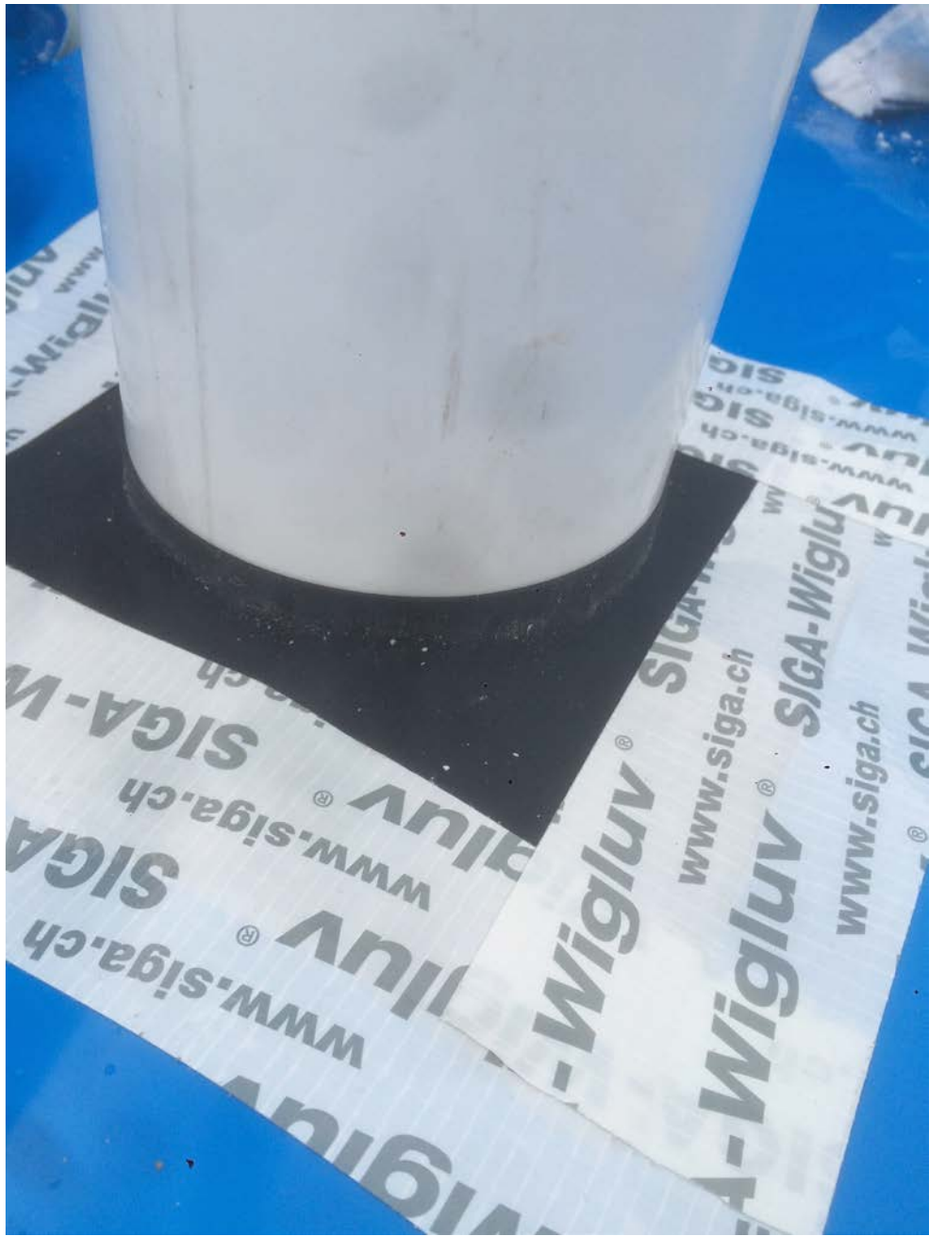
WEATHER AND WIND RESISTANT BARRIER
(CONTINUOUS VAPOR OPEN MEMBRANE)

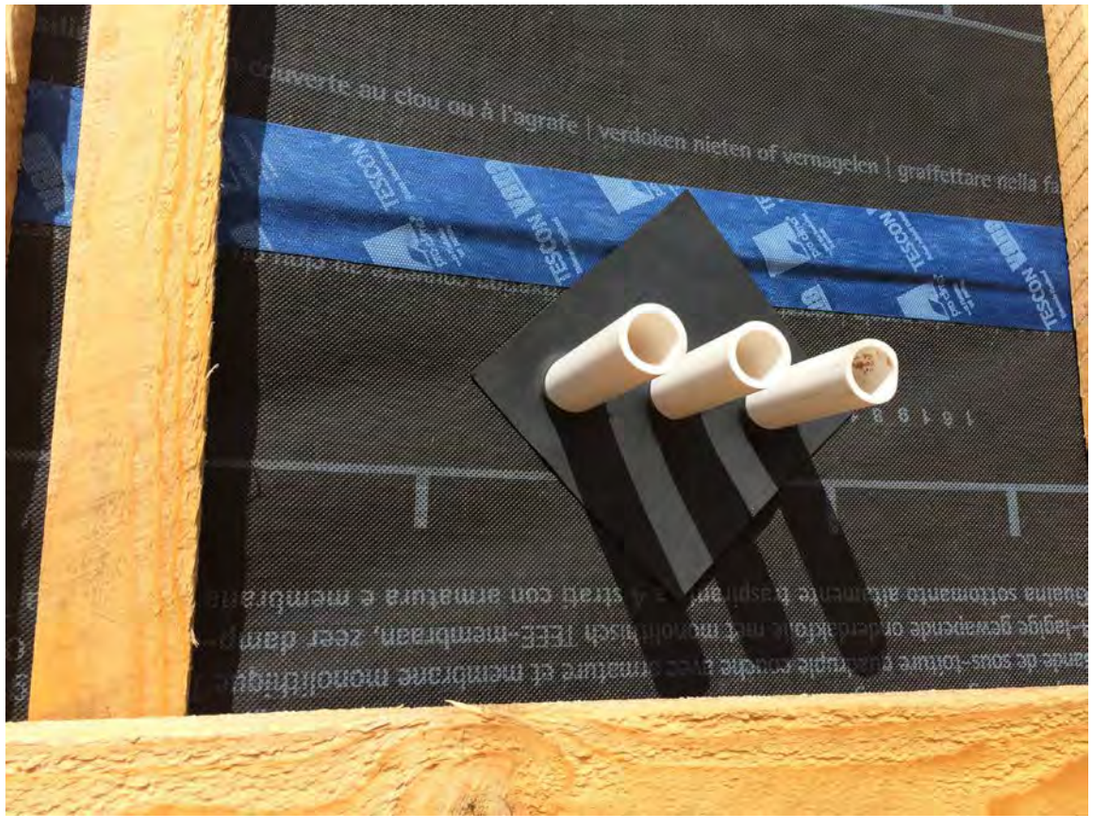
SMART VAPOR RETARDER
MOSTLY CONTINUOUS





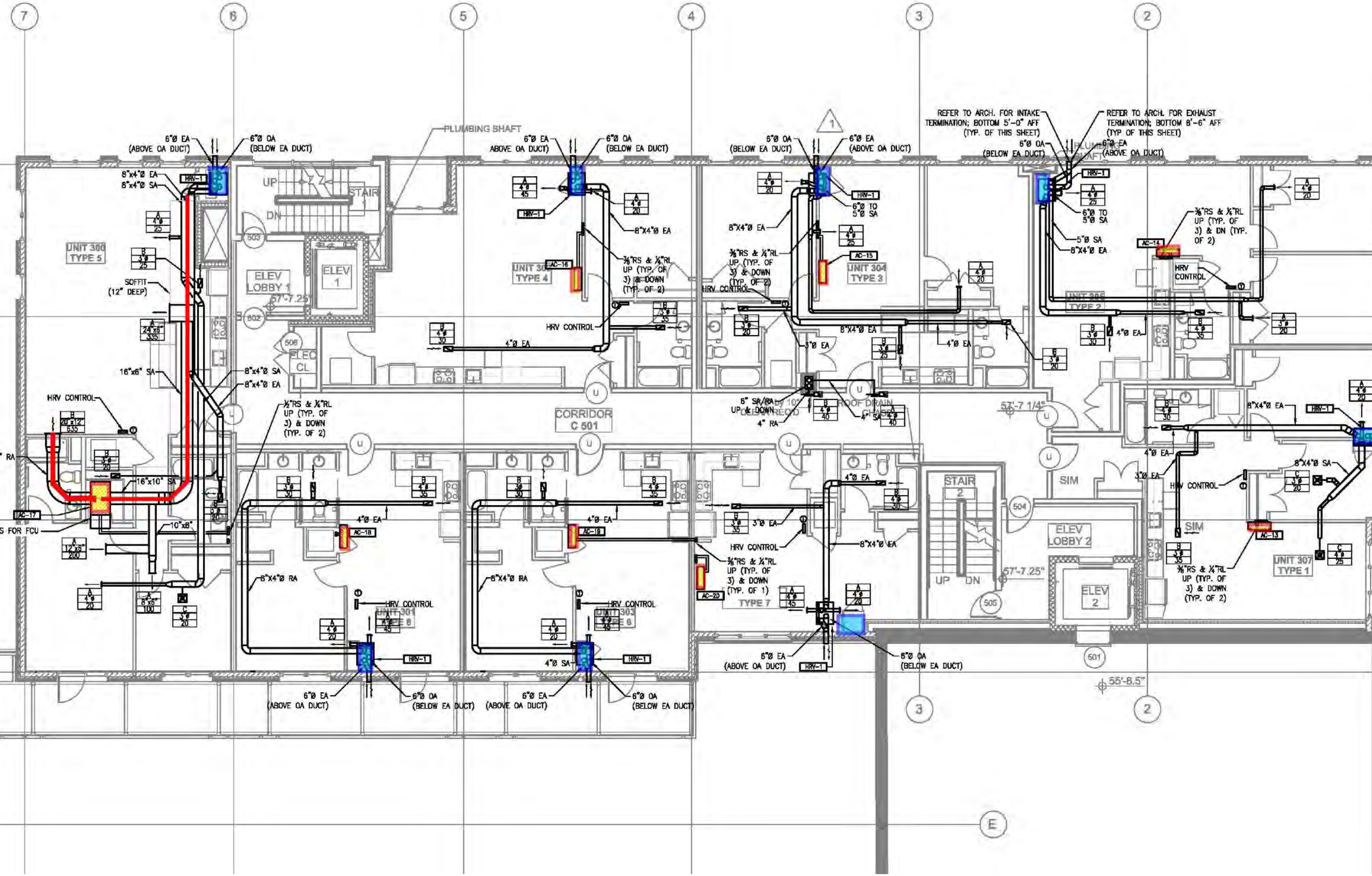
Penetrations





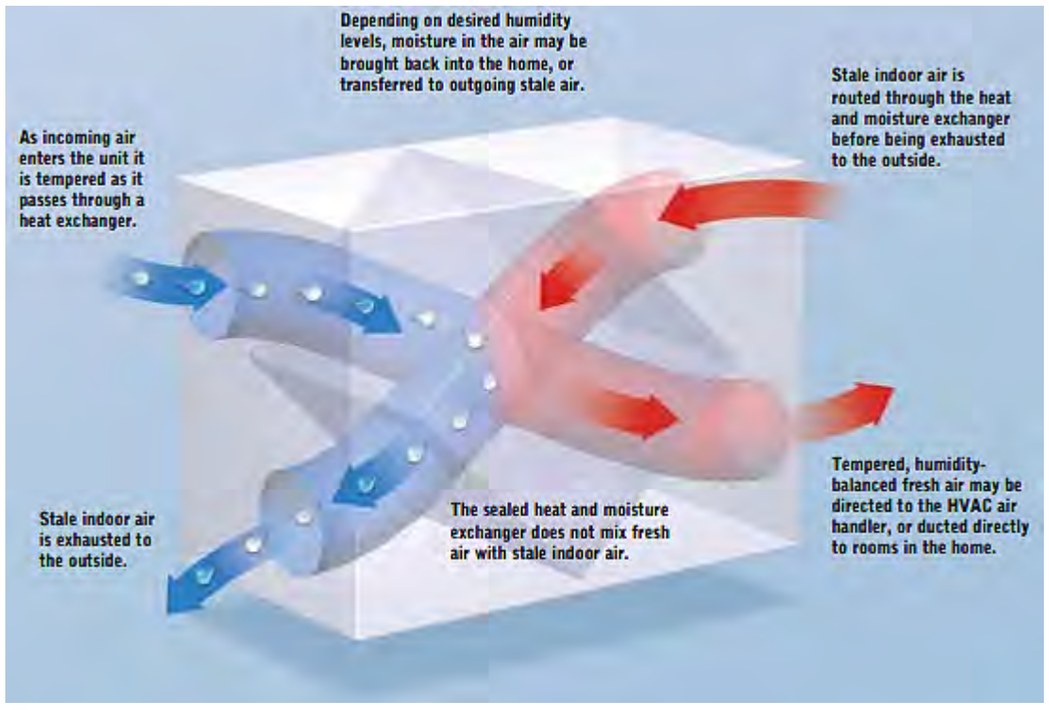
VENTILATION

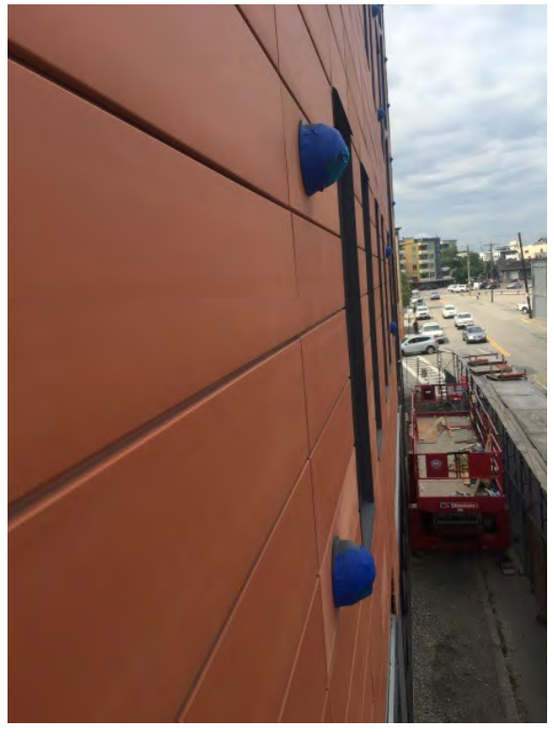
Multifamily


7
6
5
4
3
2
1
E
PLUMBING SHAFT
6"Ø EA (ABOVE OA DUCT)
6"Ø OA (BELOW EA DUCT)
HRV-1
8"x4"Ø EA
8"x4"Ø SA
UNIT 300 TYPE 5
SOFFIT (12" DEEP)
UP
DN
STAIR 1
ELEV LOBBY 1
ELEV 1
57'-7.25"
503
502
506
ELEC CL
16"x6" SA
HRV CONTROL
½"RS & ¼"RL UP (TYP. OF 3) & DOWN (TYP. OF 2)
CORRIDOR C 501
16"x10" SA
10"x8"
AC-17
S FOR FCU
6"X4"Ø RA
4"Ø EA
AC-18
UNIT 301 TYPE 6
UNIT 303 TYPE 6
4"Ø SA
AC-16
UNIT 302 TYPE 4
8"X4"Ø EA
⅜"RS & ¼"RL UP (TYP. OF 3) & DOWN (TYP. OF 2)
3"Ø EA
AC-15
UNIT 304 TYPE 3
6" SA/RA
UP & DOWN
4" RA
ROOF DRAIN CHASE
4" SA
AC-20
TYPE 7
⅜"RS & ¼"RL UP (TYP. OF 3) & DOWN (TYP. OF 1)
REFER TO ARCH. FOR INTAKE TERMINATION; BOTTOM 5'-0" AFF (TYP. OF THIS SHEET)
REFER TO ARCH. FOR EXHAUST TERMINATION; BOTTOM 8'-6" AFF (TYP OF THIS SHEET)
6"Ø TO 5"Ø SA
5"Ø SA
AC-14
UNIT 306 TYPE 2
57'-7 1/4"
STAIR 2
SIM
504
ELEV LOBBY 2
505
ELEV 2
501
UNIT 307 TYPE 1
AC-13
55'-8.5"

ENERGY RECOVERY VENTILATOR

- ZEHNDER: COMFOAIR 250





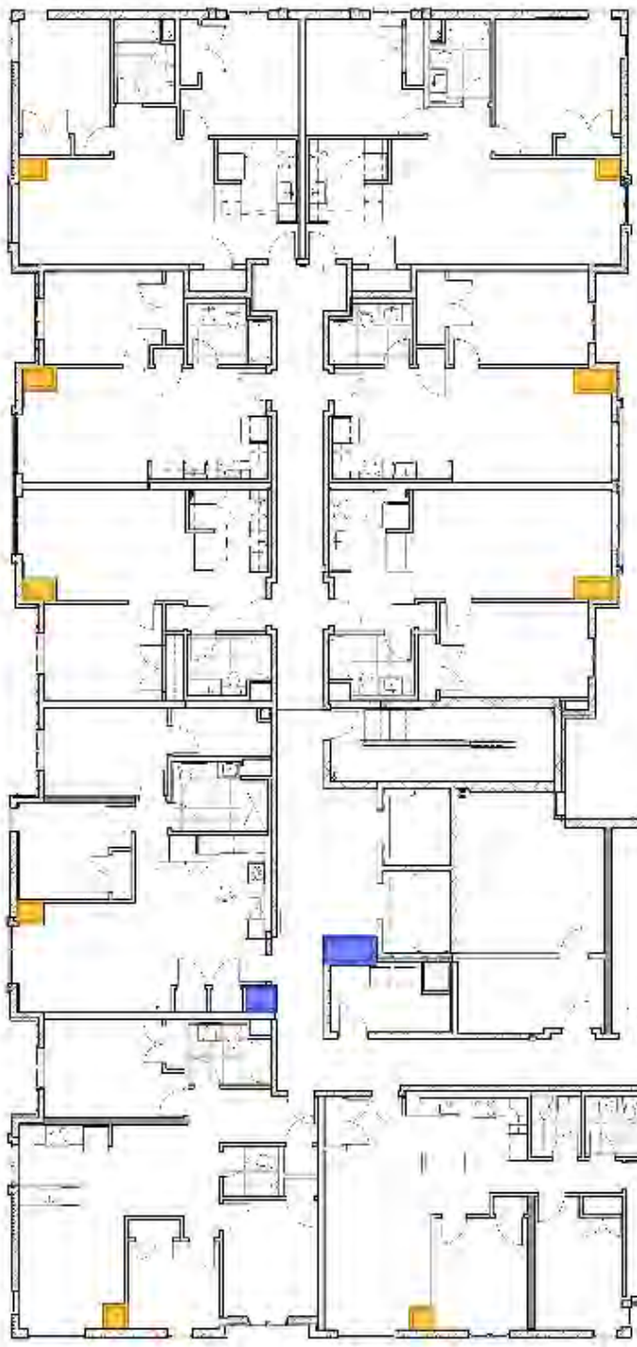
HEATING & COOLING

- INDIVIDUAL MITSUBISHI HEAT PUMPS

CONCORD HIGHLANDS

Central ERVs

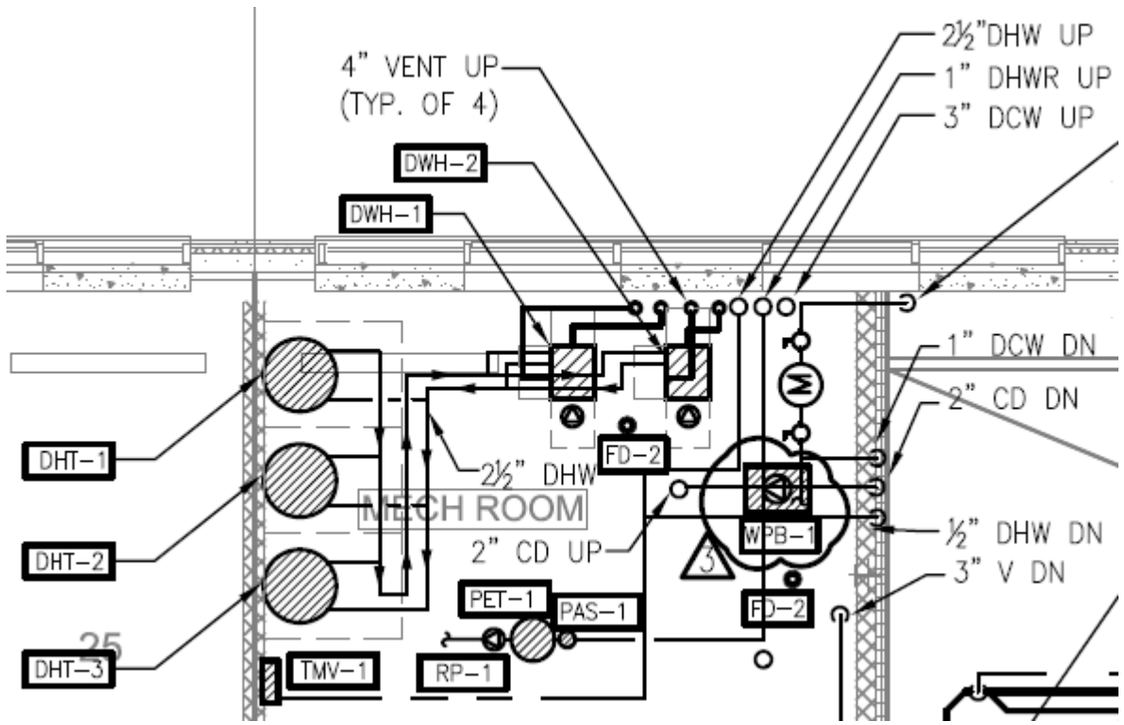
VRF System



HOT WATER

CENTRAL SYSTEM: Lochinvar condensing water heater, gas fired

- Now about 30% of the total energy budget – next Frontier



Single family

-Flexible duct work

-ERV. No drain.

-commission systems

HEAT PUMPS & WOODSTOVES

HOT WATER

Heat Pump Water Heater

Electric water heater
(Vaughn 3”polyurethane foam)

Solar Thermal Systems

METRICS

DISTILLERY

Electric Bills - 455 East First St., Unit 300

	$	Kwh
7/15/2017	$56.07	254
8/16/2017	$90.53	418
9/12/2017	$65.69	298
10/15/2017	$67.68	308
11/14/2017	$56.36	257
12/15/2017	$63.23	297
1/13/2017	$88.87	431
2/16/2018	$195.58	916
3/17/2018	$104.49	437

Annual Electric Bill = Appr. $1050

Building Type/Use:	Multi-family		
Treated Floor Area A_{TFA}:	27480	ft²	
Space Heat Demand incl. Distribution	2.3	kBTU/(ft2yr)	
Useful Cooling Demand:	2.7	kBTU/(ft2yr)	

	Final Energy	Primary Energy	Emissions CO_2-Equivalent
CHOOSE UNITS:	kBTU/(ft2yr) ▼	kBTU/(ft2yr)	lb/(ft²yr)

Electricity Demand (without Heat Pump)				PE Value	CO_2-Emissions Factor (CO_2-Equivalent)
Covered Fraction of Space Heat Demand		*(Project)*	0%	kBTU/kBTU	lb/kBTU
Covered Fraction of DHW Demand		*(Project)*	0%	2.7	0.44
Direct Electric Heating	$Q_{H,de}$		0.0	0.0	0.00
DHW Production, Direct Electric (without Wash&Dish)	$Q_{DHW,de}$	*(DHW+Distribution, SolarDHW)*	0.0	0.0	0.00
Electric Postheating DHW Wash&Dish		*(Electricity, SolarDHW)*	0.0	0.0	0.00
Electricity Demand Household Appliances	Q_{EHH}	*(Electricity worksheet)*	3.6	9.6	1.56
Electricity Demand - Auxiliary Electricity			1.2	3.3	0.54
Total Electricity Demand (without Heat Pump)			**4.8**	**12.9**	**2.10**
			kBTU/(ft2yr)	kBTU/(ft2yr)	lb/(ft²yr)

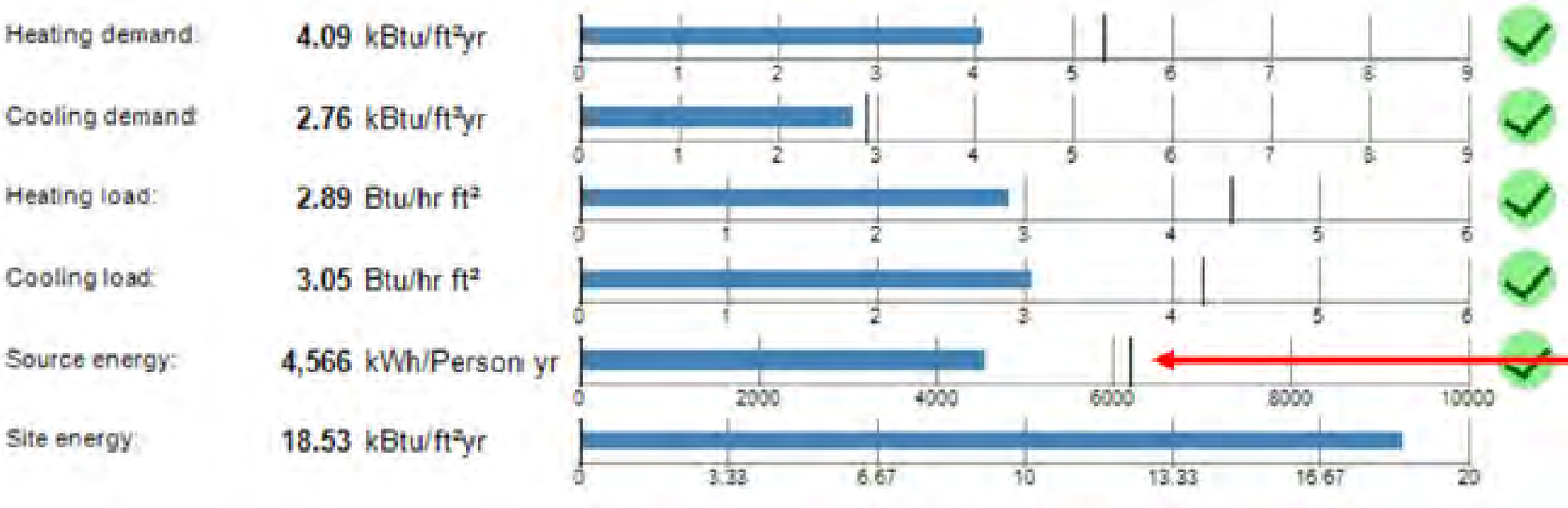
Heat Pump				PE Value	CO_2-Emission Factor (CO_2-Equivalent)
Covered Fraction of Space Heat Demand		*(Project)*	100%	kBTU/kBTU	lb/kBTU
Covered Fraction of DHW Demand		*(Project)*	0%	2.7	0.44
					lb/kBTU
Energy Carrier - Supplementary Heating			Electricity	2.7	
Annual Coefficient of Performance - Heat Pump		*Separate Calculation*	2.17		
Total System Performance Ratio of Heat Generator		*Separate Calculation*	0.46		
Electricity Demand Heat Pump (without DHW Wash&Dish)	Q_{HP}		1.1	2.8	0.46
Non-Electric Demand, DHW Wash&Dish		*(Electricity worksheet)*	0.0	0.0	0.00
Total Electricity Demand Heat Pump			**1.1**	**2.8**	**0.46**
			kBTU/(ft2yr)	kBTU/(ft2yr)	lb/(ft²yr)

DISTILLERY

$&KWH/hr		HEATING&COOLING		ALL ELECTRIC		Adjusted heat/cool		
Unit #	s.f.	$/s.f./yr	kwh/s.f./yr	$/s.f/yr	kwh/s.f/yr	$/yr (*.9)		
207	973	$0.28	1.31	$0.75	3.56	$241.11 e		
300	1488	$0.21	0.98	$0.72	3.43	$274.87 s	0.167107	South
310	733	$0.10	0.50	$0.52	2.49	$68.72 s	0.29694	North
302	1029	$0.35	1.68	$0.80	3.81	$327.21 n	0.23006	East
303	732	$0.19	0.92	$0.72	3.41	$126.96 s		
303	1058	$0.23	1.11	$0.74	3.53	$222.79 n		
305	596	$0.14	0.67	$0.78	3.73	$75.70 s		
306	1075	$0.21	1.01	$0.78	3.72	$204.81 e		
307	975	$0.23	1.08	$0.93	4.45	$199.44 e		
400	1487	$0.31	1.49	$0.83	3.95	$419.28 s		
401	733	$0.31	1.47	$1.25	5.96	$204.27 s		
402	980	$0.33	1.58	$0.88	4.19	$292.58 n		
403	733	$0.15	0.73	$0.78	3.72	$101.46 s		
404	1038	$0.35	1.69	$0.87	4.15	$330.70 n		
405	598	$0.02	0.09	$0.66	3.14	$9.93 s		
406	1076	$0.23	1.08	$0.72	3.45	$219.03 e		
407	978	$0.21	1.00	$0.84	3.98	$184.68 e		

Orientation and Set Points matter

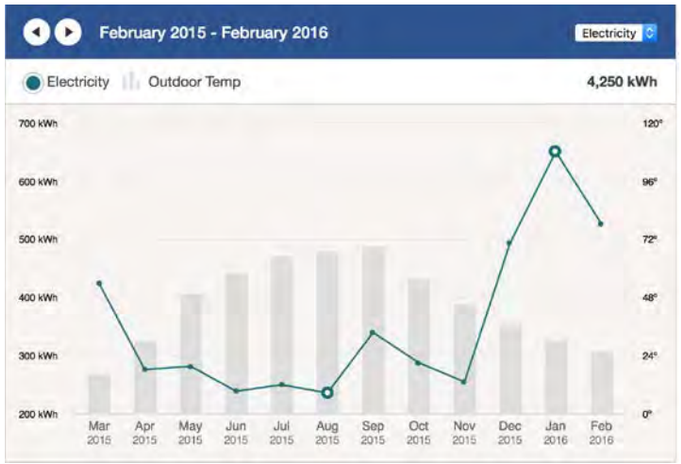
CONCORD HIGHLANDS

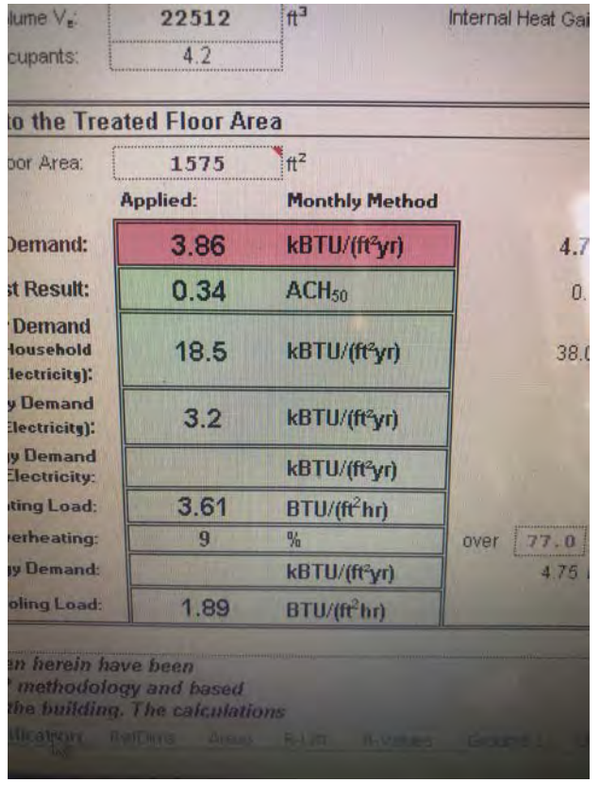


Green "checks" show building meets PHIUS+ requirements.

Darkened vertical lines indicate thresholds for PHIUS compliance.

Hidden Lake passive house

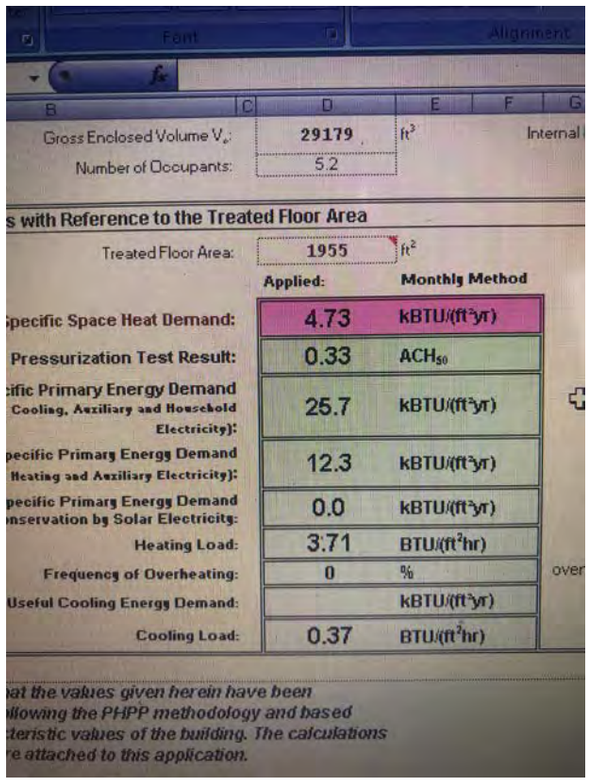




Calculated energy usage: 3,822 kWh/yr (12% off PHPP)

Newry passive house

Energy Usage 2017:
6658kWh
1/8 cord hardwood (880kWh)
Total 7538 kWh (16% off PHPP)



More $ - Envelope
Less $ - Mechanical Systems/ductwork
Always Saving- Low Operational Costs for life

cost

SheepskinBog Addition

Original proposal:
2x6 wall w/ 2x2 (7” wall)
Andersen 400 windows
No heat
$108,000 - $193/SF (INCL SITEWORK)

Updated proposal:
12” double stud wall
Triple pane windows
electric heaters
Airtight details
$115,000 ($206 SF)
(6.5% increase)