TRI-COUNTY REGIONAL ENERGY NETWORK
SAN LUIS OBISPO • SANTA BARBARA • VENTURA

The Passive House Network

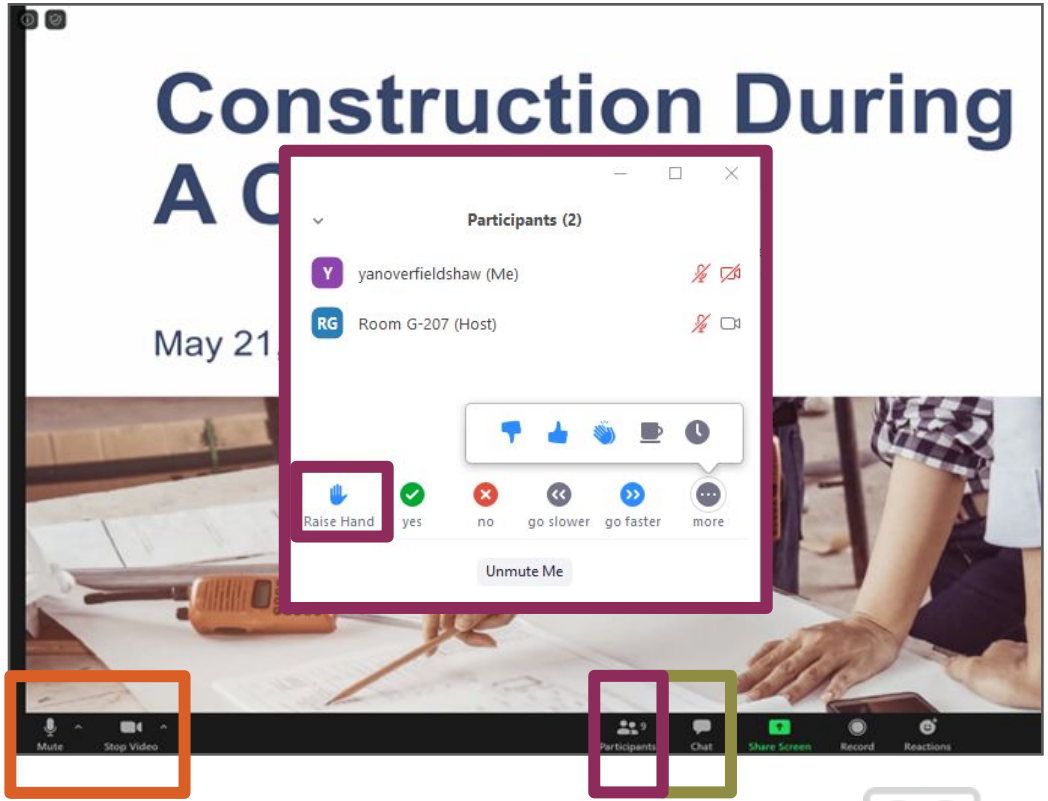
Enclosure in Detail

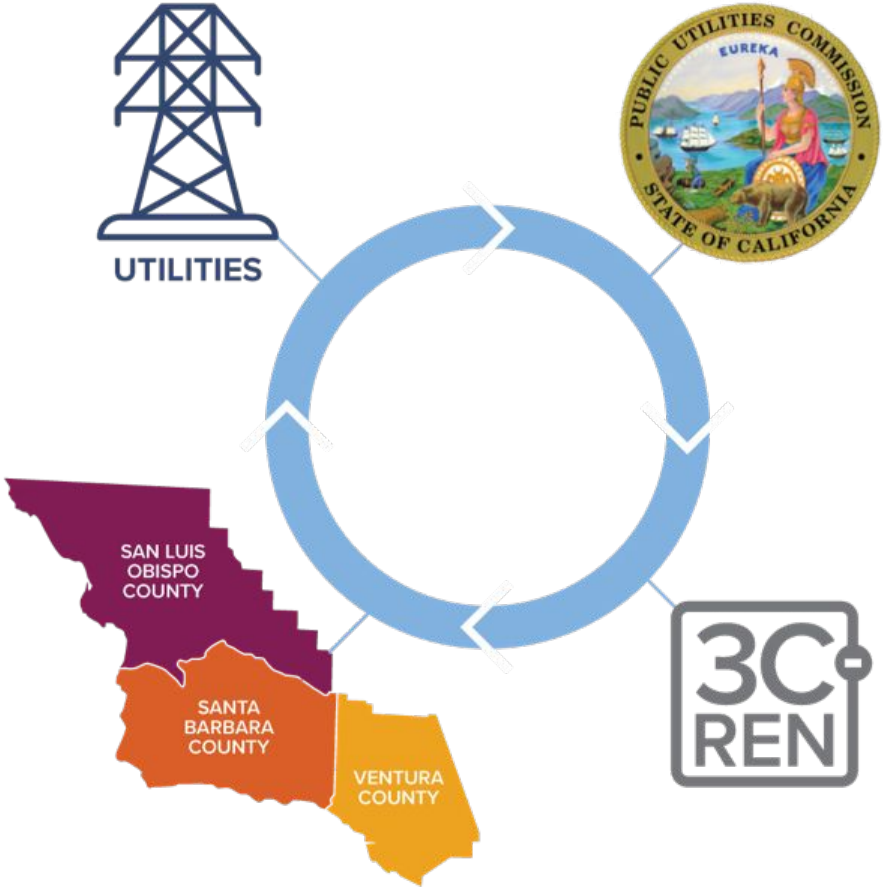
Ken Levenson – The Passive House Network

July 16, 2025

Zoom Orientation

- Add an **introduction** in the chat.
  Be sure **full name** is displayed.
- Did you call in? Please **share** first and last name with us.
- Please **mute** upon joining
- Use the "**Chat**" to share questions or comments
- Under "**Participant**" select "**Raise Hand**" to share a question or comment verbally
- Session may be **recorded** and posted to 3C-REN's on-demand page
- Slides/recording are **shared** after most events
- 3C-REN does **not** allow **AI notetakers**, unless used to accommodate a disability.





Tri-County Regional Energy Network

3C-REN is a collaboration between the tri-counties

Our programs reduce energy use for a more sustainable, equitable and economically vibrant Central Coast

Our free services are funded via the CPUC, bringing ratepayer dollars back to the region

Our Services

Incentives

HOME ENERGY SAVINGS

3c-ren.org/for-residents
3c-ren.org/multifamily

COMMERCIAL ENERGY SAVINGS

3c-ren.org/commercial

Contractors can enroll at
3c-ren.org/contractors

Training

BUILDING PERFORMANCE TRAINING

3c-ren.org/events
3c-ren.org/building

ENERGY CODE CONNECT

3c-ren.org/code

View past trainings at
3c-ren.org/on-demand

Technical Assistance

AGRICULTURE ENERGY SOLUTIONS

3c-ren.org/agriculture

ENERGY ASSURANCE SERVICES

3c-ren.org/assurance

Passive House **Enclosures**

Sendero Verde, Handel Architects

The Network

Global Knowledge. Regional Context. Local Applications





















Passive House Seattle
The Passive House Network

Passive House Rocky Mountains
The Passive House Network

Passive House Minnesota
The Passive House Network

Passive House Pennsylvania
The Passive House Network

Passive House Washington DC
The Passive House Network

New Jersey Passive House
The Passive House Network

Passive House Empire State
The Passive House Network

Passive House Northeast
The Passive House Network

PHCA PASSIVE HOUSE CALIFORNIA

NORTH AMERICAN CERTIFIERS CIRCLE
PASSIVE HOUSE CERTIFIER

International PASSIVE HOUSE Association 1PHA

Passive House Institute

DESIGNER
CERTIFIED PASSIVE HOUSE DESIGNER

CERTIFIED PASSIVE HOUSE TRADESPERSON
TRADESPERSON

Certified Passive House
Passive House Institute

Passive House Enclosures: Design & Construction Optimization

Passive House is an enclosure-first approach that empowers architectural design to drive comfort, resilience, health, and efficiency outcomes. The Passive House enclosure is fundamental to overall building performance optimization. We'll look at the elements of high-performance enclosure design and construction, the order of priorities, the strategies, systems, components, and details required. From cold to hot and humid climates, and across different construction types and building scales, we'll look at how to deliver predictable results.

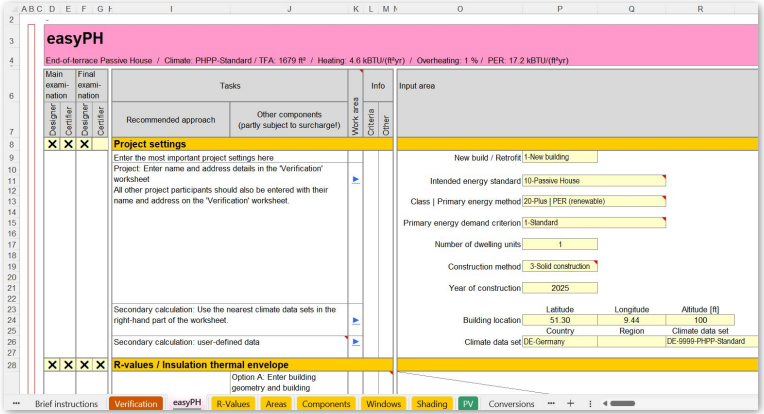
Learning Objectives:

1. Outline the priorities of enclosure performance.
2. Describe major principles in enclosure design and optimization.
3. Outline the systems, components, details, and strategies for successful Passive House enclosures.
4. Describe strategies and steps to ensure the final built enclosure is successful.

Instructor:
Ken Levenson, Executive Director, The Passive House Network.
Ken was a practicing architect for over three decades, completing early Passive House projects in New York City. Committed to accelerating Passive House growth and knowledge sharing, he co-founded 475 High Performance Building Supply, was a founding member of the Phius Passive House Alliance, a co-founder of New York Passive House and of NAPHN, which would become The Passive House Network (PHN). Today, as Executive Director of PHN, Ken continues to focus on driving building industry culture change with Passive House education.

Submission Deadline, September 30th

Thursday, July 24



Fall Cohorts kick off July 1

Incentives are available.

Training is a prerequisite for success.

Pacific Cohort Schedule

Fall 2025 - On-Demand / Live Online CPHD/C Training

October 2nd start

Depending on your learning preferences, **you can tackle this course in three ways:**

1. Focus on the on-demand content and view recordings of live online content. **(Most flexible)**
2. Stick to the cohort schedule of live online sessions. **(Best for clear pacing and making connections and community)**
3. Do a mix! Start before or after the cohort registration deadline, focus on the on-demand format at your pace, and attend the live online sessions as makes sense for you. **(Most popular)**

On-Demand		Live Online Activities		
Week Starts	**Content**	**Activity Date/Time**	**Activity**	**Led by**
9/29/25	Module 1: **Introduction** Module 2: **Insulation**	10/2/25 | 12-1 PM PT	Kick-Off	PHN
10/6/25	Module 3: **Airtightness** Module 4: **Thermal Bridging** Module 5: **Windows**	10/9/25 | 12-1 PM PT	Q&A Session 1	CPHD Practitioner
10/13/25	Webinar 1: **Building Envelope** Module 6: **Ventilation**	10/16/25 | 9-12 PM PT	Webinar 1: Building Envelope	PHN Trainer
10/20/25	Module 7: **Heating & DWH** Module 8: **Cooling** Module 9: **Certification**	10/23/25 | 9-11:30 AM PT	Open Review	Ken Levenson
10/27/25	Module 10: **Economics** Module 11: **QA/QC** Module 12: **Bidding**	10/30/25 | 12-1 PM PT	Q&A Session 2	CPHD Practitioner
11/3/25	Webinar 2: **Building Services & Economics** Review Exam Prep Modules	11/6/25 | 9-12 PM PT	Webinar 2: Building Services & Economics	PHN Trainer
11/10/25	Module 13: **designPH** Module 14: **PHPP** Review Exam Prep Modules	-	-	-
11/17/25	Module 15: **Exam Prep Course & Wrap-up** Review Exam Prep Modules	-	-	-
11/24/25	Review Exam Prep Modules	11/25/25 | 9-11 AM PT	**Exam Review**	PHN Trainer
12/1/25	Review Exam Prep Modules	12/4/25 | 9-10 AM PT	**Tech Setup (Required)**	PHN with PHA
12/8/25	**Exam**	12/11/25 | 9-12 PM PT	**PHI CPHD/C Exam**	PHN with PHA

All live online sessions - excluding the Tech Setup & Exam - will be recorded and made available for all cohort students for reference.

https://passivehousenetwork.org/designer-training/

Agenda

1. Context of Passive House
2. The Work of Enclosures
3. Efficient Design & High Quality
4. Details
5. Execution

Resources

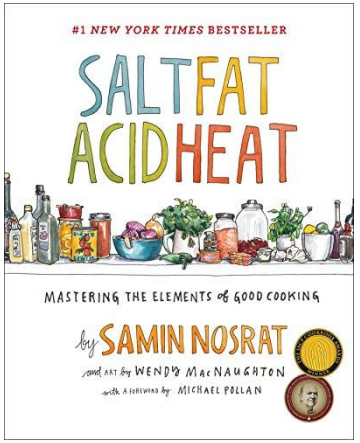
The Waring School, Opal Architecture

1. Context of Passive House
2. The Work of Enclosures
3. Efficient Design & High Quality
4. Details
5. Execution

How we use fundamental elements matters

“I was working as a physicist. I read that the construction industry had experimented with adding insulation to new buildings and that energy consumption had failed to reduce. This offended me – it was counter to the basic laws of physics. I knew that they must be doing something wrong. So I made it my mission to find out what, and to establish what was needed to do it right.”

- Wolfgang Feist, Founder of the Passive House Institute



Passive House masters the elements of high-performance building.

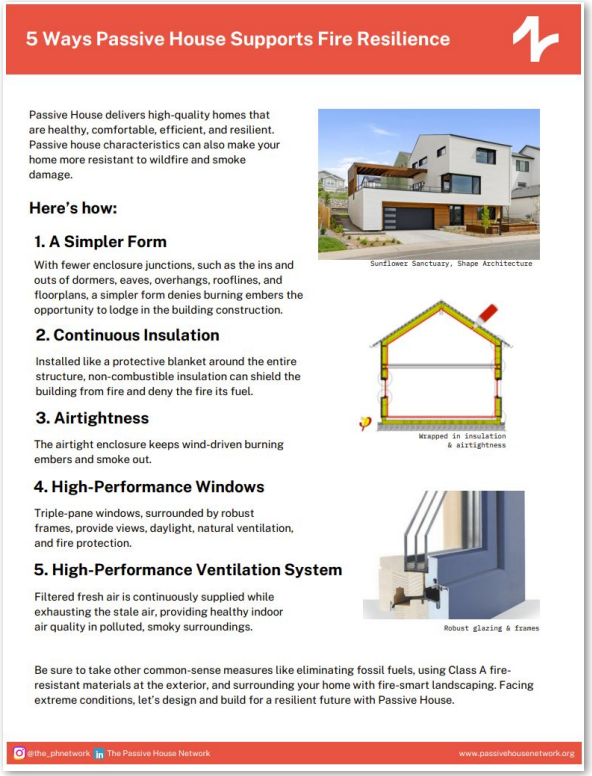
Realization: Passive House efficiency underlies what we value most.

Occupants (home, school, work)

- Comfortable
- Healthy indoor air quality
- Fewer allergies
- More alert
- Quiet
- Resilient & Safe
- Affordable operation & maintenance
- High levels of satisfaction

Owners

- Affordable upfront cost
- Fewer callbacks
- Reduced maintenance
- Perpetual energy savings
- Happy occupants and lower vacancy
- Higher sale price
- Durable high quality asset
- Lower risk investment



5 Ways Passive House Supports Fire Resilience

Passive House delivers high-quality homes that are healthy, comfortable, efficient, and resilient. Passive house characteristics can also make your home more resistant to wildfire and smoke damage.

Here's how:

1. A Simpler Form

With fewer enclosure junctions, such as the ins and outs of dormers, eaves, overhangs, rooflines, and floorplans, a simpler form denies burning embers the opportunity to lodge in the building construction.

Sunflower Sanctuary, Shape Architecture

2. Continuous Insulation

Installed like a protective blanket around the entire structure, non-combustible insulation can shield the building from fire and deny the fire its fuel.

3. Airtightness

The airtight enclosure keeps wind-driven burning embers and smoke out.

Wrapped in insulation & airtightness

4. High-Performance Windows

Triple-pane windows, surrounded by robust frames, provide views, daylight, natural ventilation, and fire protection.

5. High-Performance Ventilation System

Filtered fresh air is continuously supplied while exhausting the stale air, providing healthy indoor air quality in polluted, smoky surroundings.

Robust glazing & frames

Be sure to take other common-sense measures like eliminating fossil fuels, using Class A fire-resistant materials at the exterior, and surrounding your home with fire-smart landscaping. Facing extreme conditions, let's design and build for a resilient future with Passive House.

@the_phnetwork The Passive House Network www.passivehousenetwork.org

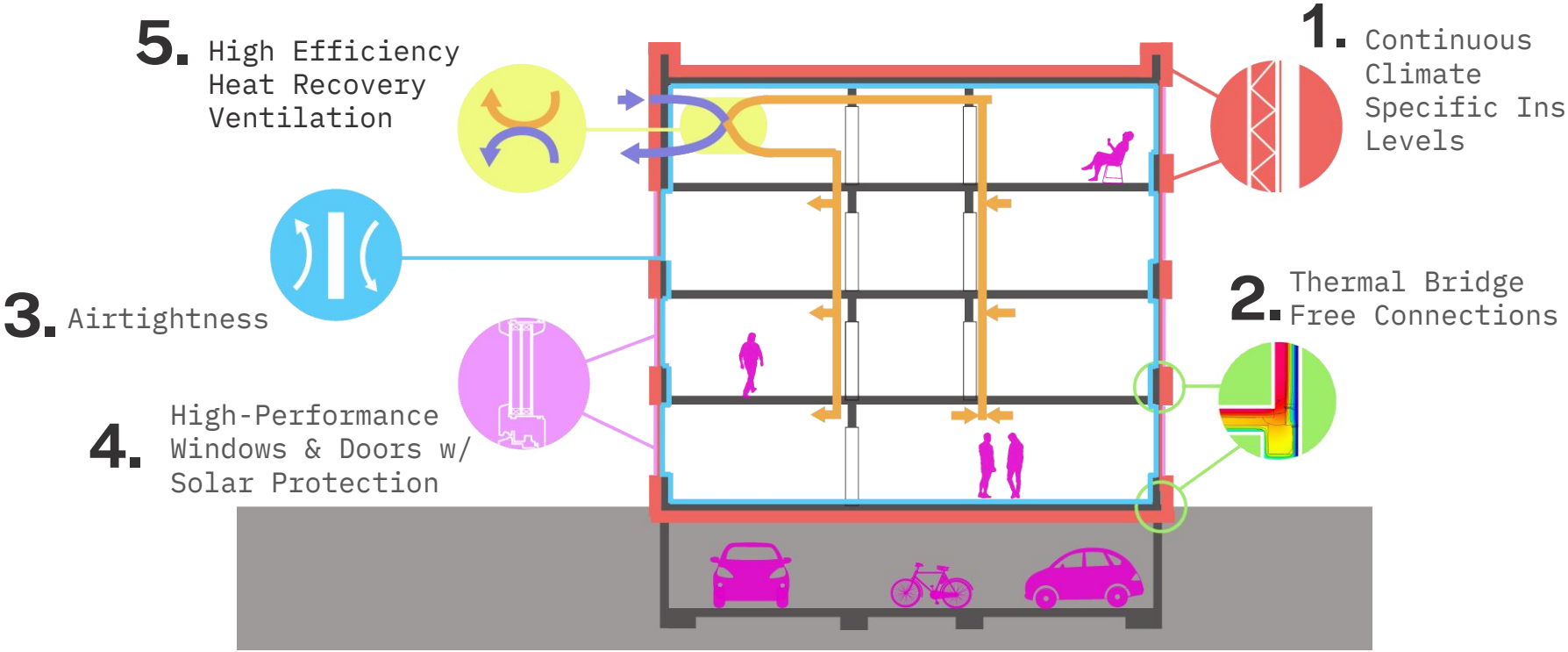
Focus, focus, focus...on the drivers.

Building industry is disconnected from the drivers of building performance.

Passive House connects the dots and transforms industry expectations & capacity

Passive House empowers the builders and designers to deliver high-performance core solutions.

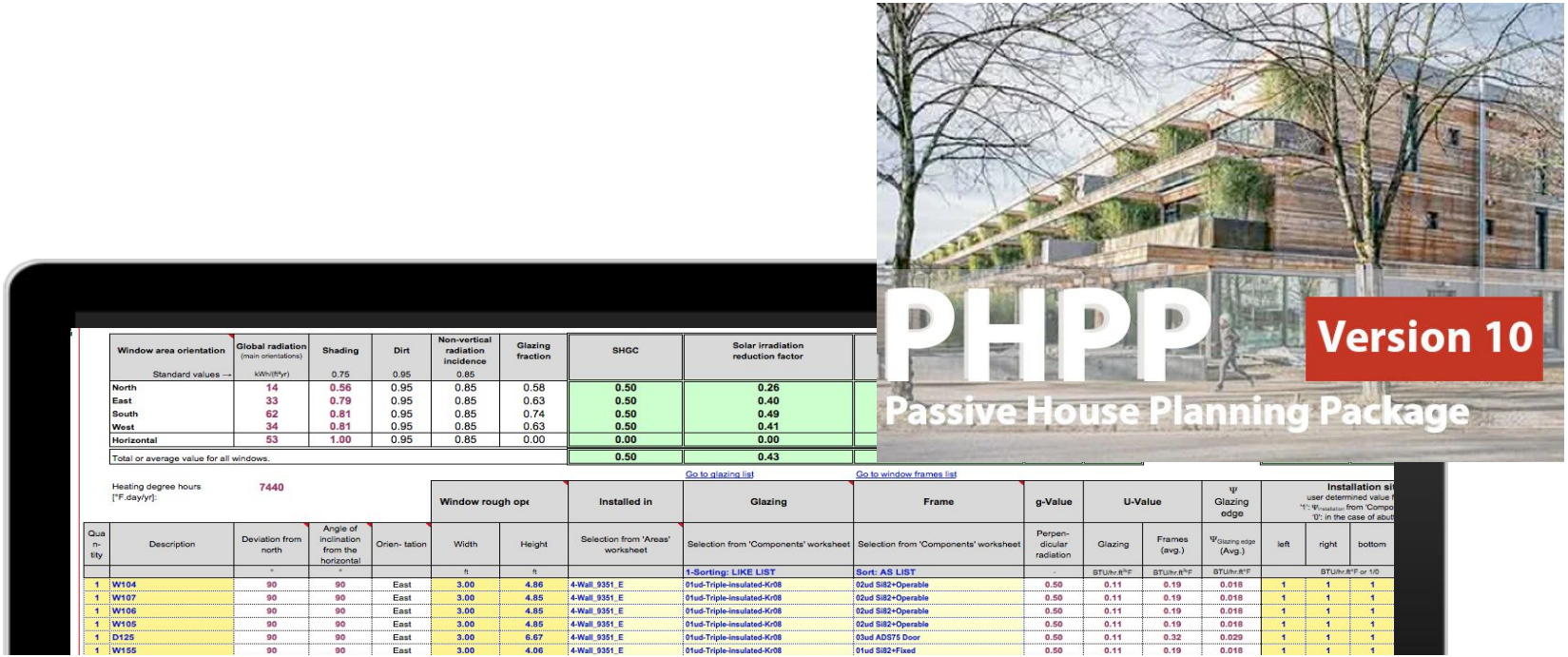
5 Principles



https://passipedia.org/basics/what_is_a_passive_house

Energy Modeling: Calculating Predictable Performance

https://passivehouse.com/04_phpp/04_phpp.htm



It's the catalyst for everything.

Maintain cost & energy budget buffers/contingencies

20%

under budget in schematic

10%

under budget at bid

Sebastian’s approach to budgets

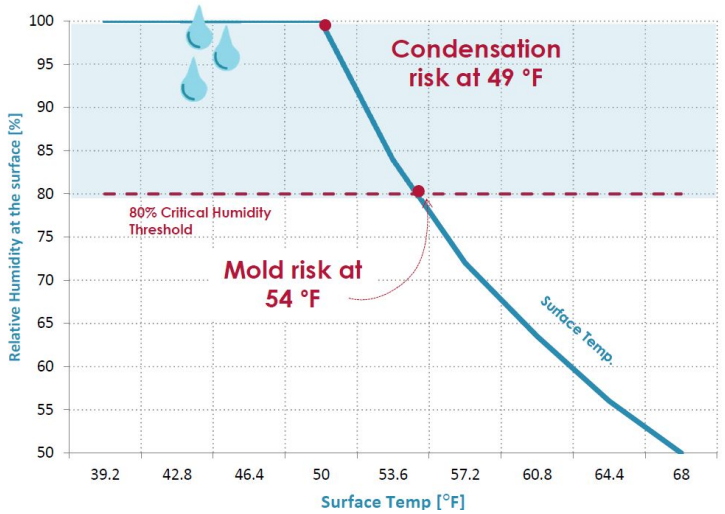
Sebastian Moreno-Vacca of A2M says,

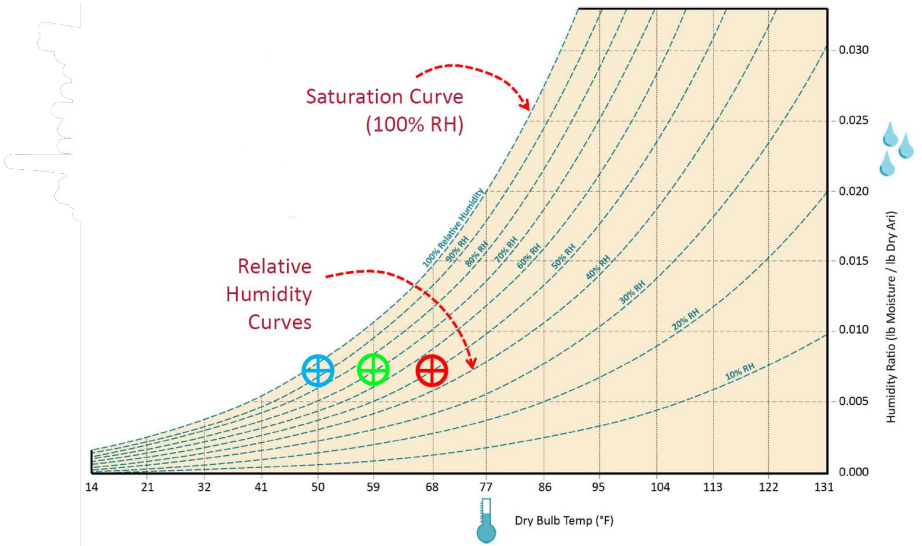
“…cost 10% below conventional. It hurts my fees. *It’s terrible.*”

A2M

Indoor Humidity

40-50% RH in Winter

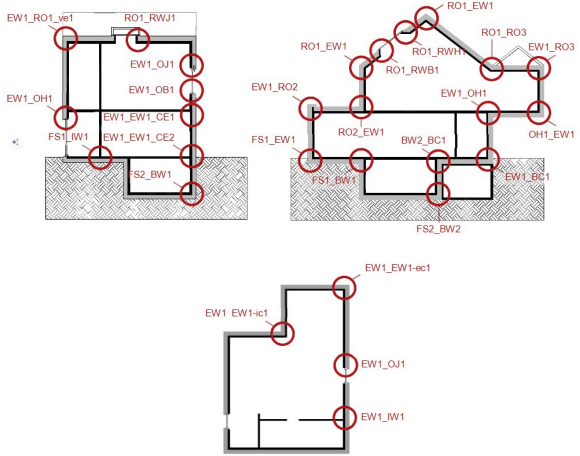




Minimum Thermal & Moisture Protection (weakest links)

Thermal Protection

- Interior Surface Temperatures: not more than 7.6 F below the operative indoor temperature.
- Floors: not below 66.2 F, Checked against 71.6 F in PHPP



Moisture Protection

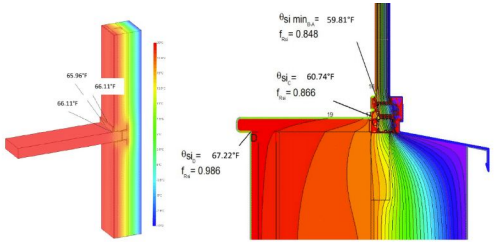
fRsi defines the coldest point which can occur on the interior surface of a construction system. For example, if the temperature factor is 0.7, then 70% of the temperature difference between the inside and outside air is still present at the interior surface. If the temperature factor is achieved, then mould and condensation formation can be safely prevented at normal outdoor temperatures, indoor temperatures and indoor air humidity levels.

$$f_{Rsi} = \frac{\theta_{si} - \theta_a}{\theta_i - \theta_a}$$

θ_{si}: minimum interior surface temperature as per multi-dimensional heat flow calculation [°C]

θ_a: outside temperature as per multi-dimensional heat flow calculation [°C]

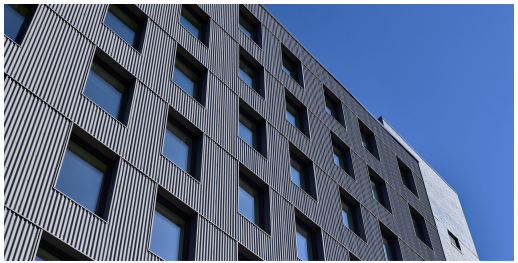
θ_i: inside temperature as per multi-dimensional heat flow calculation [°C]

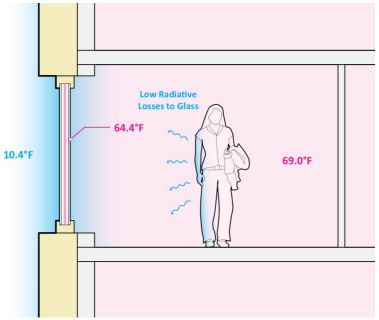


nditions must be modeled as per ISO 10211 & 13788

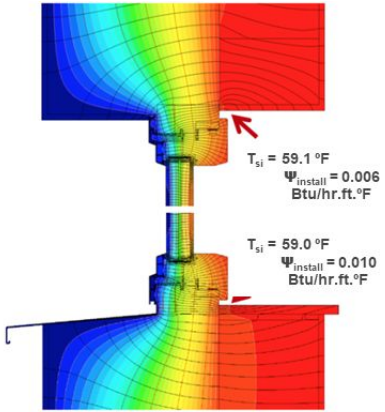
	Min value
Arctic	0.80
Cold	0.75
Cool-temperate	0.70
Warm-temperate	0.65
Warm	0.55
Hot	-
Very hot	-

Window & Door Integration - with Solar Shading





TRIPLE GLAZING = < 5°F ASYMMETRY



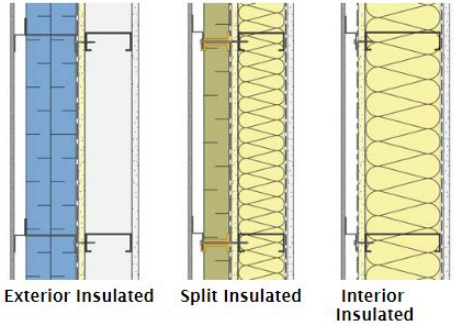
$U_{w\text{-installed}}$ = 0.148 Btu/hr.ft².°F
($R_{w\text{-installed}}$ = 6.76 hr.ft².°F/Btu)

Manufacturer/Supplier	Specialty	Offers PHI Certified Components	HQ Location	Link
Alpen		Yes	Colorado	https://www.thinkalpen.com/
Amberline			Massachussetts	https://amberlinewindows.us/
Bewiso	simulated double-hung		Austria/NY	http://www.bewiso.eu/
Cardinal	glazing, spacers	Yes	Minnesota	https://www.cardinalcorp.com/
Cascadia	fiberglass		British Columbia	https://www.cascadiawindows.com/
Deceuninck		Yes	Ohio	https://deceuninckna.com/
Eco Windows			Connecticut	https://ecowindowsusa.com/
Edge-Tech	spacers		Texas	https://www.quanex.com/product/for-architects/warm-edge-spacers/
ENERsign		Yes	Germany/CO	https://www.enersign.com/en/
EuroLine Windows		Yes	British Columbia	https://euroline-windows.com/
Fakro	skylights		Poland/Illinois	https://shop.fakrousa.com/
Gamma North America		Yes	Ontario	https://gammana.com/
GlassCurtain	curtain wall		Alberta	https://glascurtain.ca/
Hella	exterior shading	Yes	Germany/MN	https://www.tannerbp.com/hella-exterior-blinds
Ikon Windows			New York	https://www.ikonwindows.com/
Inline Fiberglass			Ontario	https://www.inlinefiberglass.com/
Innotech Windows		Yes	British Columbia	https://www.innotech-windows.com/
Internorm		Yes	Germany/NY	https://www.sashandframe.com/
Intus Windwos		Yes	Virginia	https://www.intuswindows.com/
Lamilux	skylights/glass roofs	Yes	Germany/NY	https://475.supply/collections/lamilux
Makrowin		Yes	Slovakia/MA	https://www.eas-usa.com/
Morgan Advanced Materials – Vacupor			UK/MN	https://www.tannerbp.com/
Nord Windows & Doors		Yes	Alaska	https://aknordwindows.com/
NZP Fenestration		Yes	Quebec	https://nzpfenestration.com/en/
Optiwin		Yes	Germany/Wisconsin	https://www.heritagewindow.com/
PH Tech			Quebec	https://phtech.ca/en/
Raico	curtain wall	Yes	Germany/MN	https://www.tannerbp.com/
Rangate		Yes	British Columbia	https://rangate.com/
Rehau		Yes	Switzerland/NY	https://www.rehau.com/us-en/windows
Schueco		Yes	Germany/CT	https://www.schueco.com/ca/company/schueco-usa
Smartwin			Germany/KS	https://advantagewoodwork.com/
Swissspacer	spacers	Yes	Switzerland	https://www.swisspacer.com/en-us/
Tanner			Minnesota	https://www.tannerbp.com/
Technoform	spacers		Germany/OH	https://www.technoform.com/en
Viking		Yes	Estonia/CO	https://www.egresswindowtastic.com/
Westeck		Yes	British Columbia	https://www.westeckwindows.com/
Wythe Windows		Yes	New Jersey	https://www.wythewindows.com/
Yaro			Massachussetts	http://www.yarowindows.com/
Zola	simulated double-hung	Yes	Colorado	https://www.zolawindows.com/

Passive House is enclosure system agnostic

- Wood
- Metal
- Concrete

Build with what your teams know.



Metal Framed Walls

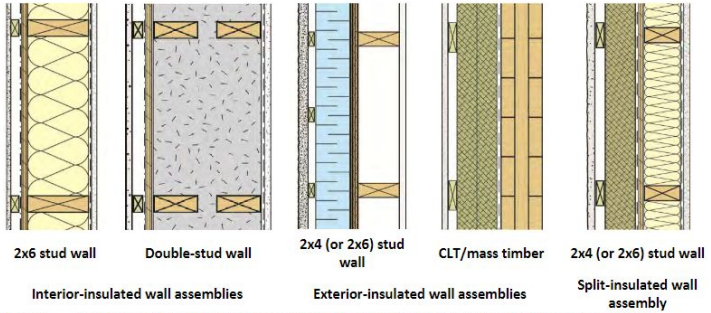


Fig. 3.2.1 Options for placement of insulation within thermally efficient above-grade wood-frame wall assemblies.

Wood Framed Walls

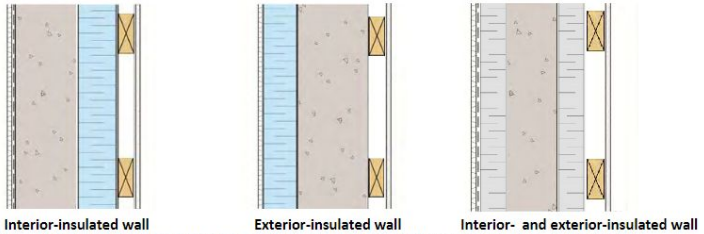


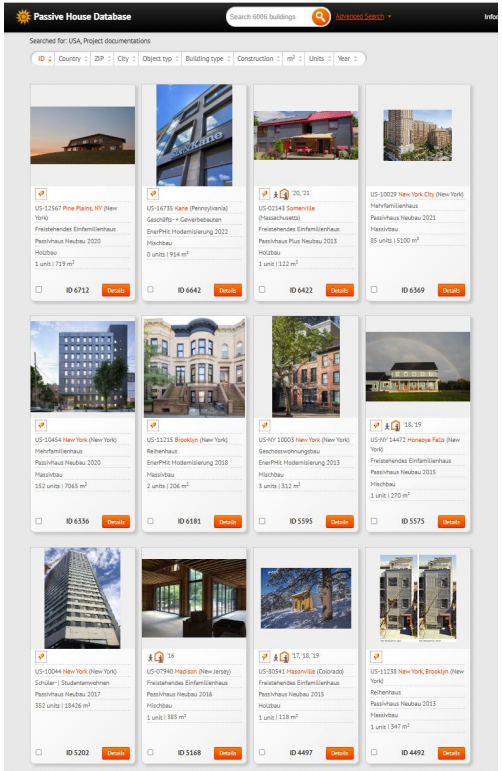
Fig. 3.2.2 Options for placement of insulation within thermally efficient below-grade wood-frame wall assemblies.

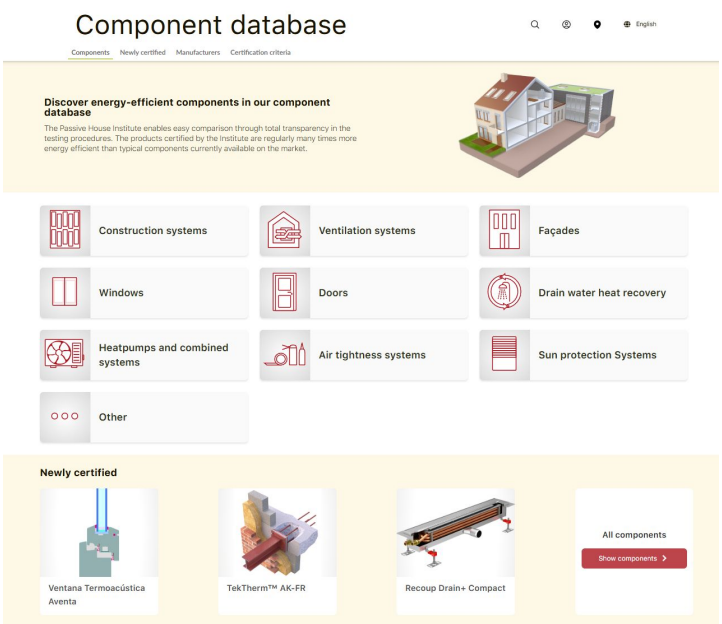
Concrete Walls

Wood, Steel, Concrete

How to make the most effective parka?

Access what's available: Project documentation, Certified Components, Manufacturer Directory





The Passive House Network

Education | Community | Resources | Events | LOGIN | MY ACCOUNT

FACADE SYSTEMS THERMAL BREAKS

Manufacturer/Supplier	Specialty	Offers PHI Certified Components	HQ Location	Link
Cascadia Clip	rainscreen support		British Columbia	https://www.cascadiawindows.com/products/cascadia-clip
Eco Cladding		Yes	Virginia	https://www.ecocladding.com/
Ejot		Yes	Germany/Michigan	https://www.ejot.com/address-USA
Engineered Assemblies			Ontario	https://www.engineeredassemblies.com/
Fero Corp	brick veneer supports	Yes	Alberta	https://ferocorp.com/
SFS Group		Yes	Germany/PA	https://www.sfs.com/ch/en/

STRUCTURAL THERMAL BREAKS

Manufacturer/Supplier	Specialties	Offers PHI Certified Components	HQ Location	Link
Armatherm Thermal Bridging Solutions		Yes	Massachussetts	https://www.armatherm.com/
Schaeck	balcony supports	Yes	Germany/NJ	https://www.schaeck.com/en-us/home
Thermal Breaks Ltd.		Yes	UK	https://thermal-breaks.group/
Thermoblock			Arizona	https://www.thermoblockicf.com/

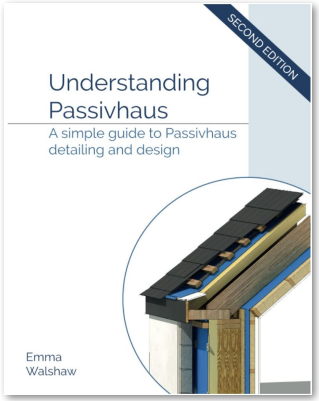
AIRTIGHTNESS & VAPOR CONTROL

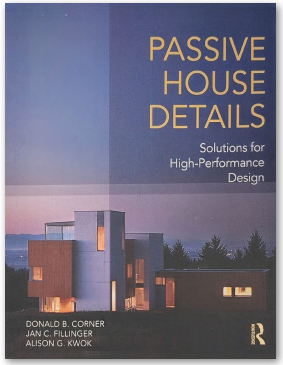
Manufacturer/Supplier	Specialty	Offers PHI Certified Components	HQ Location	Link
Delta - Dorken			Canada	https://www.dorken.com/en/
Hanno		Yes	Germany	https://worldclasssupply.com/
Intelligent Membranes		Yes	UK	https://www.intelligentmembranes.com/
Pertel		Yes	Ireland/NY	https://www.pertel.com/
Pro Clima		Yes	Germany/NY	https://475.supply/collections/pro-clima
Prosoco			Kansas	https://prosoco.com/
Retrotec	blower door		Washington	https://retrotec.com/
Rothoblaas		Yes	Italy	https://www.rothoblaas.com/
Siga		Yes	New York	https://www.siga.swiss/us_en/products
Soprema			Ohio	https://www.soprema.us/
Stego	sub slab		California	https://www.stegoindustries.com/
VaproShield			Washington	https://vaproshield.com/
YEC (Minneapolis Blower Door)	blower door		Minnesota	https://www.energyconservatory.com/

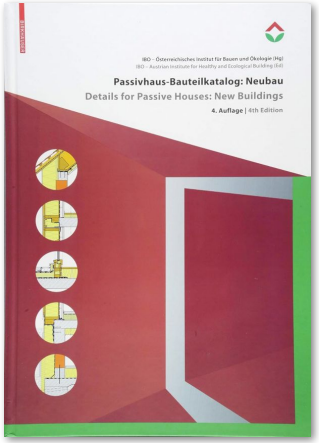
WINDOWS, DOORS & SHADING SYSTEMS

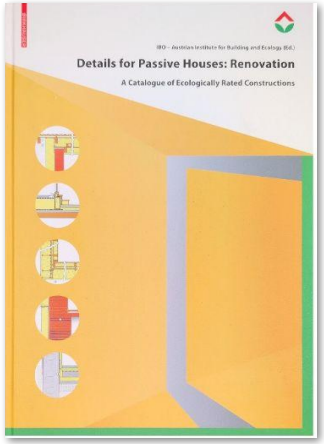
Manufacturer/Supplier	Specialty	Offers PHI Certified Components	HQ Location	Link
Alpen		Yes	Colorado	https://www.thinkalpen.com/
Amberline			Massachussetts	https://amberlinewindows.us/
Bewiso	simulated double-hung		Austria/NY	http://www.bewiso.eu/
Cardinal	glazing, spacers	Yes	Minnesota	https://www.cardinalcorp.com/
Cascadia	fiberglass		British Columbia	https://www.cascadiawindows.com/
Decesuinck		Yes	Ohio	https://decesuinckna.com/
Eco Windows			Connecticut	https://ecowindowsusa.com/
Edge-Tech	spacers		Texas	https://www.quanex.com/product/for-architects/warm-edge-spacers/
ENERsign		Yes	Germany/CO	https://www.enersign.com/en/
EuroLine Windows		Yes	British Columbia	https://euroline-windows.com/
Fakro	skylights		Poland/Illinois	https://shop.fakrousa.com/
Gamma North America		Yes	Ontario	https://gammana.com/
GlassCurtain	curtain wall		Alberta	https://glasscurtain.ca/
Helia	exterior shading	Yes	Germany/MN	https://www.tannertop.com/helia-exterior-blinds
Ikon Windows			New York	https://www.ikonwindows.com/
Inline Fiberglass			Ontario	https://www.inlinefiberglass.com/
Innotech Windows		Yes	British Columbia	https://www.innotech-windows.com/

Books and more









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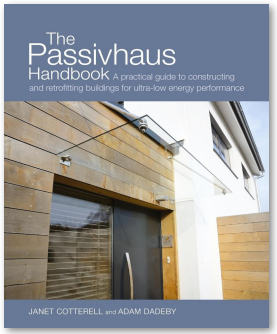
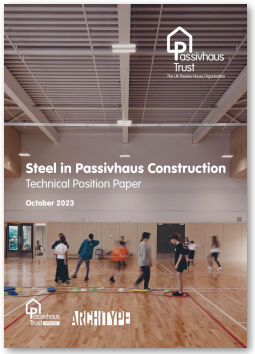
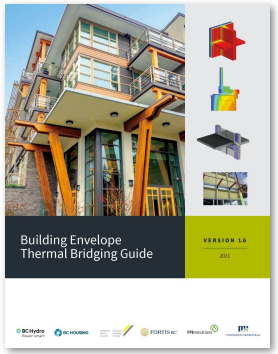
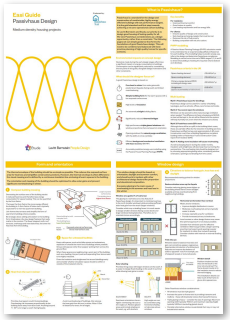
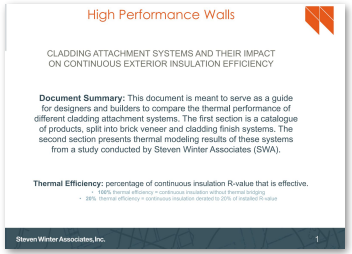


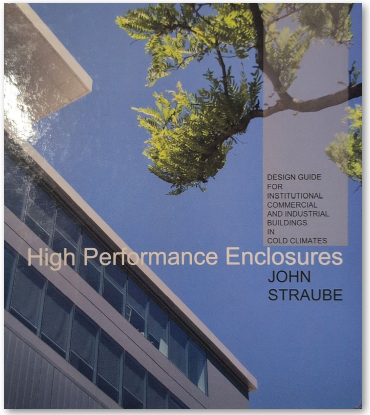


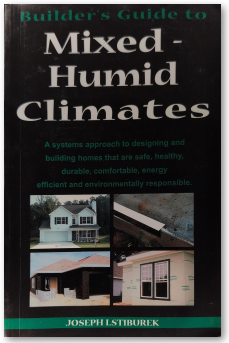






And more...


DESIGN GUIDE FOR INSTITUTIONAL COMMERCIAL AND INDUSTRIAL BUILDINGS IN COLD CLIMATES
High Performance Enclosures
JOHN STRAUBE


Builder's Guide to
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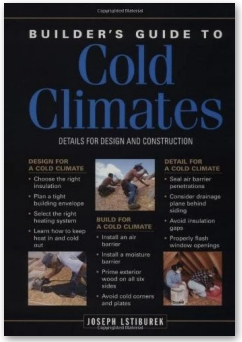
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Cold Climates
DETAILS FOR DESIGN AND CONSTRUCTION
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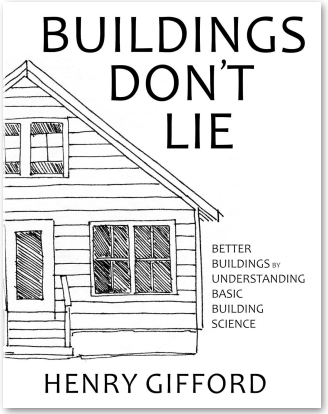
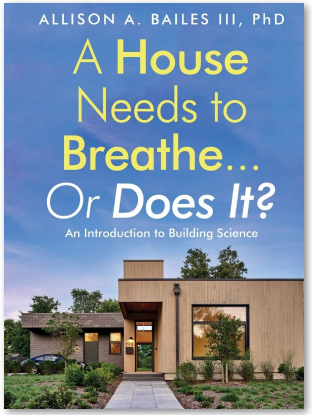
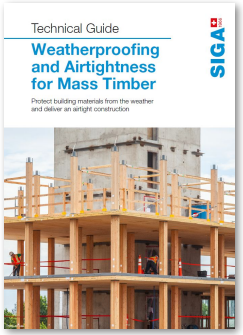

BUILDINGS DON'T LIE
BETTER BUILDINGS BY UNDERSTANDING BASIC BUILDING SCIENCE
HENRY GIFFORD


ALLISON A. BAILES III, PhD
A House Needs to Breathe... Or Does It?
An Introduction to Building Science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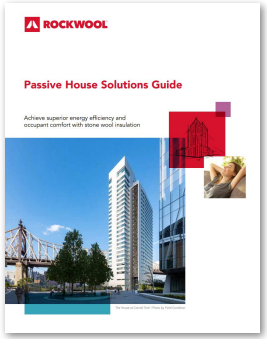
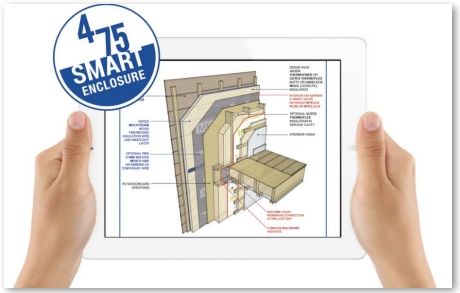
Weatherproofing and Airtightness for Mass Timber
SIGA


ROCKWOOL
Passive House Solutions Guide


475 SMART ENCLOSURE

1. Context of Passive House

2. The Work of Enclosures

3. Efficient Design & High Quality

4. Details

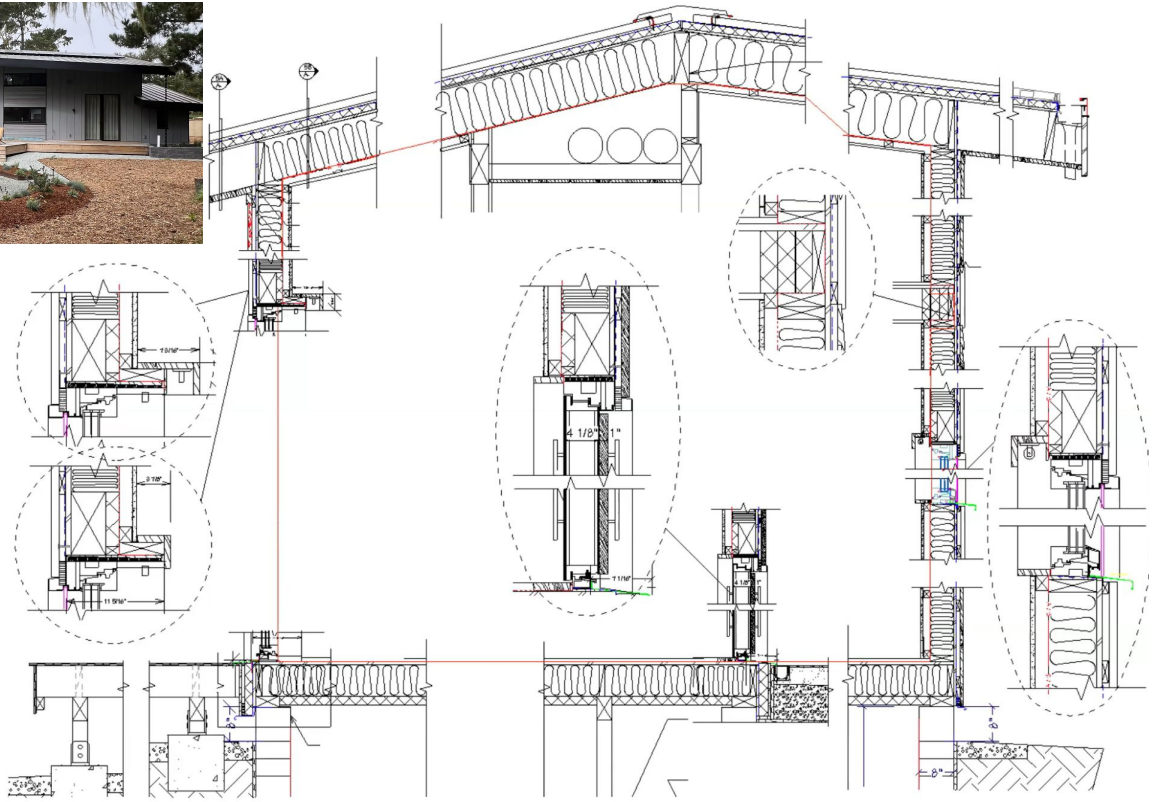
5. Execution

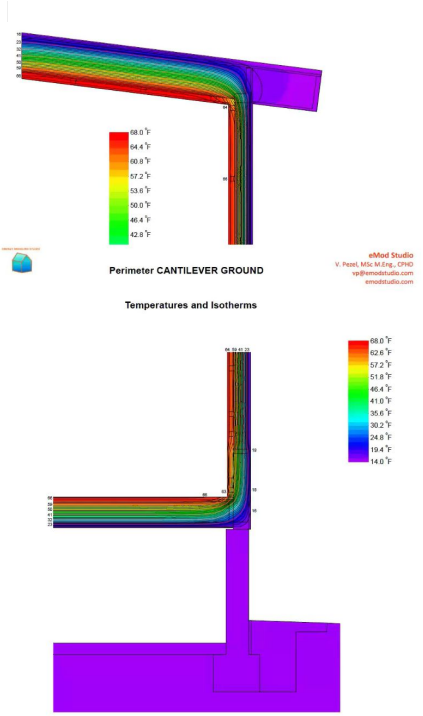
Enclosure’s Purpose

- Keep the weather out
- Stand up
- Be durable
- Provide safety

The Framing is Modest (in much of California)

Credit: PassiveHouse BB, Bronwyn Barry





Biggest threat to success is moisture

- An EPA study* of 100 buildings found:
  - 85% of the buildings were damaged by moisture
  - 45% currently had leaks
- 90% of failures in wall systems are from moisture
- Trapped moisture is the primary cause

*EPA Publication 402-F-13053 – Moisture Control Guidance for Building Design, Construction & Maintenance

Courtesy of RAiNA

Words of Wisdom

"You need to assume that the building will get wet, somehow, at some point in time. **Stuff happens**. So you need a moisture-tolerant design."

- Anton TenWolde
physicist at the U.S. Forest Products Laboratory

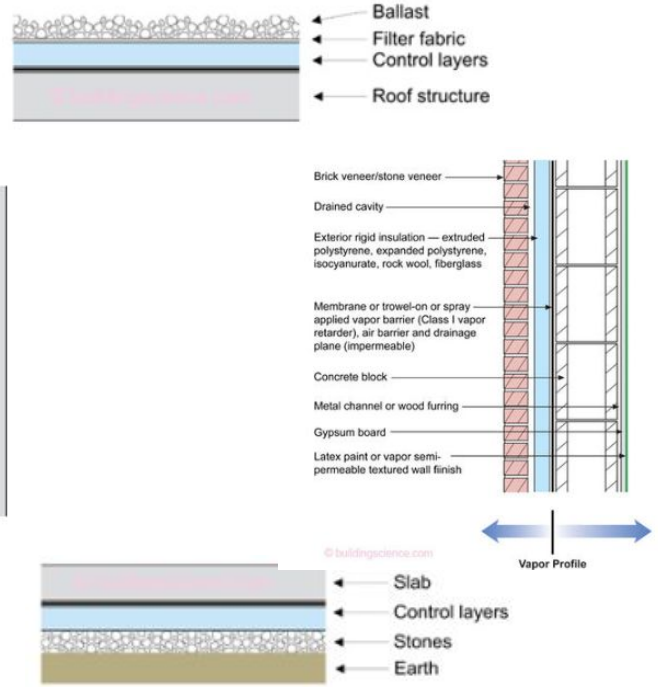
Fundamental Characteristics of Enclosures

Control Layers:

1. Shed Bulk Water
2. Air Control
3. Vapor Control
4. Thermal Control

All are about moisture control.

Slightly different emphasis than Passive House.



"Perfect Wall"

https://buildingscience.com/documents/insights/bsi-001-the-perfect-wall

Shed Bulk Water

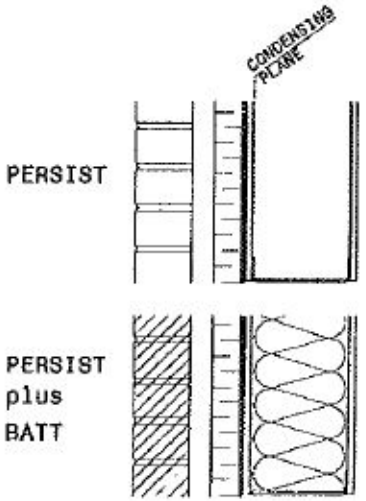
Shed Bulk Water

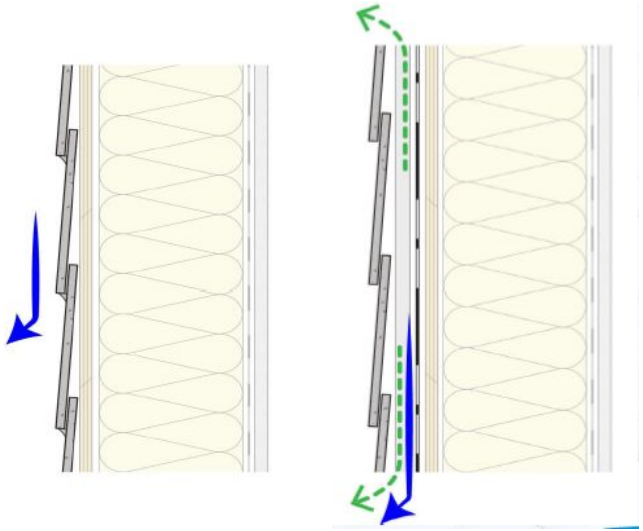
Overhangs
Sills
Drips
Gutters
Downspouts
Grading
Rainscreens

Back Vented Rainscreen for Best Protection

“Pressure Equalized Rain Screen Insulated Structure Technique”

Developed by the National Research Council of Canada in 1960s



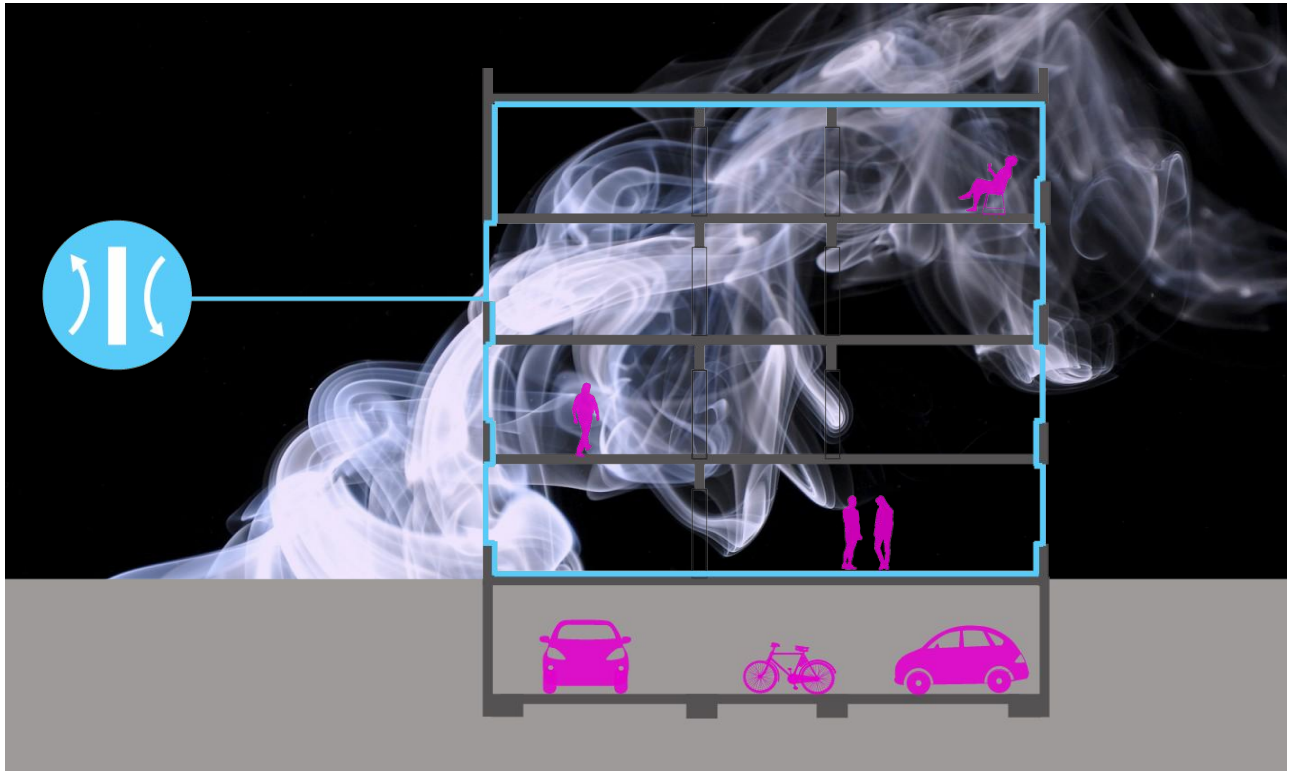


Diagrams Courtesy of Rainscreen Association in North America / RAiNA

Decouple the rain barrier from the wall construction

Air Control

Durability
Air Quality
Comfort
Efficiency



Final Test – as “in use”

ISO 9972 Method 1

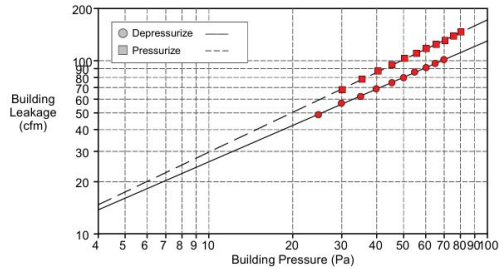
1. Fill plumbing drain p-traps with water or seal opening if no p-trap is present
2. Turn off all supply and/or exhaust fans.
3. Close and latch all access doors.
4. Close and latch all exterior doors and windows.
5. Seal ventilation system intake and exhaust.
6. All interior doors to be open.

Date of Test: 1/11/2013 Test File: 15 Park Place Test
Technician: Nicholas Abreu Signature:
Project Number: 15 Park Place

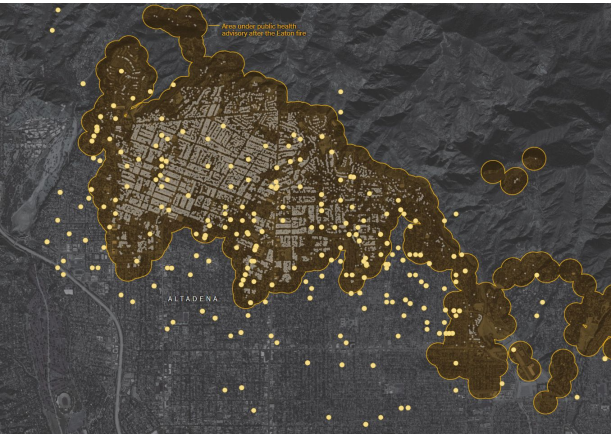
Customer: Placetailor
67 Dudley Street
Roxbury, MA 02119
Phone: 617-639-0633
Fax:

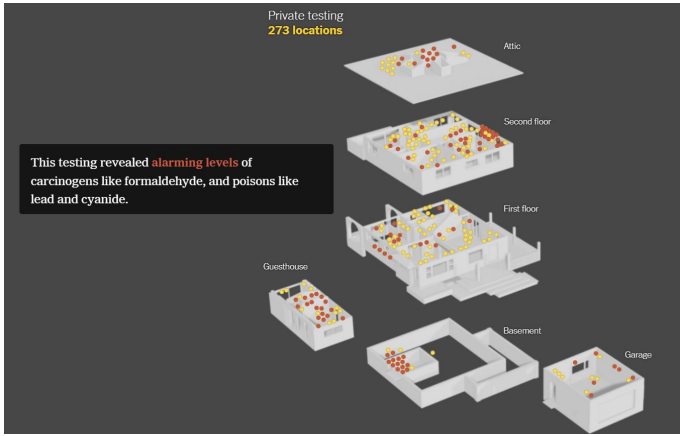
Building Address: 15 Park Place
Somerville, MA 02144

	Depressurization	Pressurization	Average
Test Results at 50 Pascals:			
cfm (Airflow)	80 (+/- 0.6 %)	101 (+/- 0.5 %)	91 (+/- 0.4 %)
ACH50	0.38	0.48	0.43
cfm/ft² (Floor Area)	0.0609	0.0770	0.0689
cfm/ft² (Surface Area)	0.0154	0.0194	0.0174
Leakage Areas:			
Canadian EqLA @ 10 Pa (in²)	7.7 (+/- 2.5 %)	8.7 (+/- 2.6 %)	8.2 (+/- 1.8 %)
in²/ft² Surface Area	0.0015	0.0017	0.0016
LBL ELA @ 4 Pa (in²)	3.9 (+/- 4.0 %)	4.2 (+/- 4.0 %)	4.0 (+/- 2.8 %)
in²/ft² Surface Area	0.0008	0.0008	0.0008
Building Leakage Curve:			
Flow Coefficient (C)	5.2 (+/- 6.2 %)	5.1 (+/- 6.1 %)	5.2 (+/- 4.3 %)
Exponent (n)	0.698 (+/- 0.016)	0.763 (+/- 0.015)	0.730 (+/- 0.011)
Correlation Coefficient	0.99959	0.99965	
Test Standard:	E779-10		
Test Mode:	Depressurization and Pressurization		



Wildfire Smoke Infiltration Damage



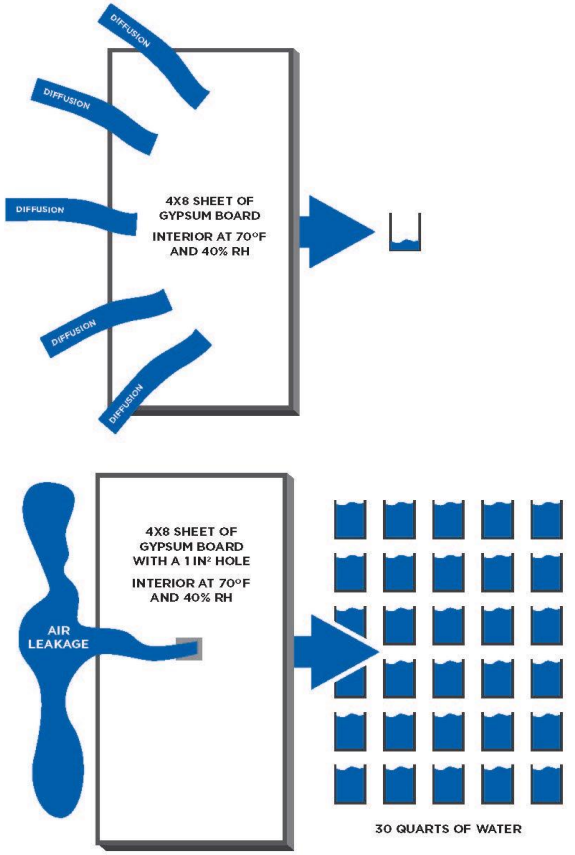


The Morrow family, who suspected the damage was more extensive than the insurance company inspection found, hired their own **certified industrial hygienist for comprehensive testing, revealing "alarming levels of carcinogens like formaldehyde, and poisons like lead and cyanide."**

https://www.nytimes.com/interactive/2025/06/24/realestate/los-angeles-fires-toxic-homes.html

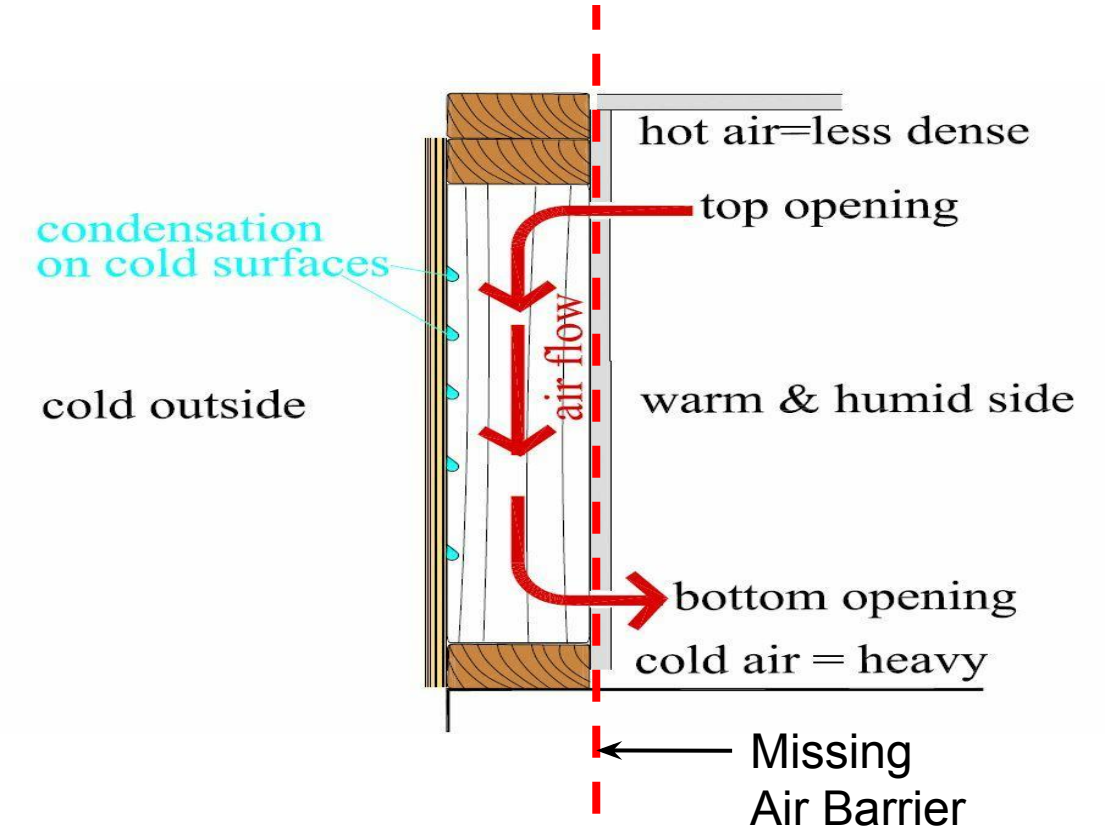
Fundamentally Effective

- Second only to water control.
- Disproportionately effects:
  1. Indoor air quality: control the air to control the quality
  2. Comfort: drafts are uncomfortable
  3. Air transported wetting: a bigger liability than diffusion wetting
  4. Heat loss & energy efficiency



Inboard Airbarrier

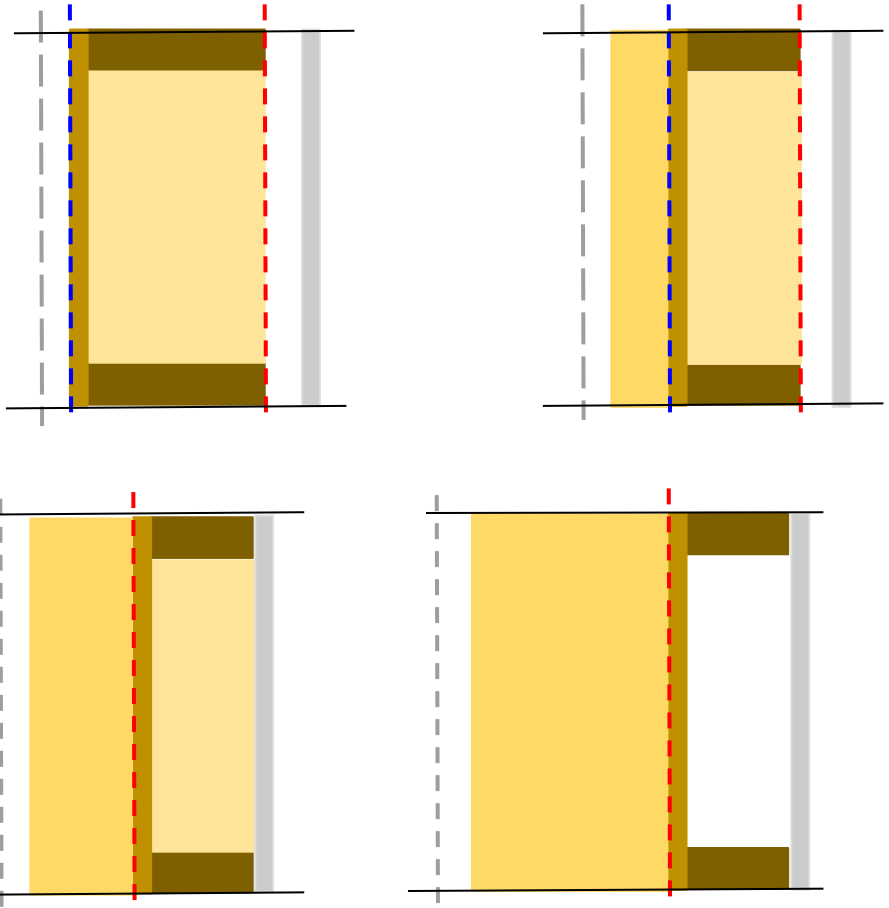
1. Keeps conditioned air within the conditioned space.
2. Better protection against condensation risk.
3. Places the components of this most important control layer in a climate controlled location.
4. Leaks can often be more readily found and easier to repair.
5. The air control layer can/should double as a vapor control layer.



Move the sheathing indoors

Indoor	RH	20	25	30	35	40	50	60
Dewpoint	°C	-3.0	0.0	2.5	4.7	6.6	9.9	12.7
	°F	26.6	32.0	36.6	40.5	44.0	49.9	54.8
$T_{outdoors}$ °C	°F							
10	50	0.00	0.00	0.00	0.00	0.00	0.00	0.24
5	41	0.00	0.00	0.00	0.00	0.10	0.31	0.48
0	32	0.00	0.00	0.12	0.23	0.32	0.47	0.60
-5	23	0.08	0.19	0.29	0.37	0.45	0.57	0.68
-10	14	0.23	0.32	0.40	0.48	0.54	0.64	0.73
-15	5	0.33	0.42	0.49	0.55	0.60	0.69	0.77
-20	-4	0.41	0.49	0.55	0.60	0.65	0.73	0.80
-25	-13	0.48	0.54	0.60	0.65	0.69	0.76	0.82
-30	-22	0.53	0.59	0.64	0.68	0.72	0.78	0.84

Table 1: Ratio of exterior-interior insulation to control air leakage condensation

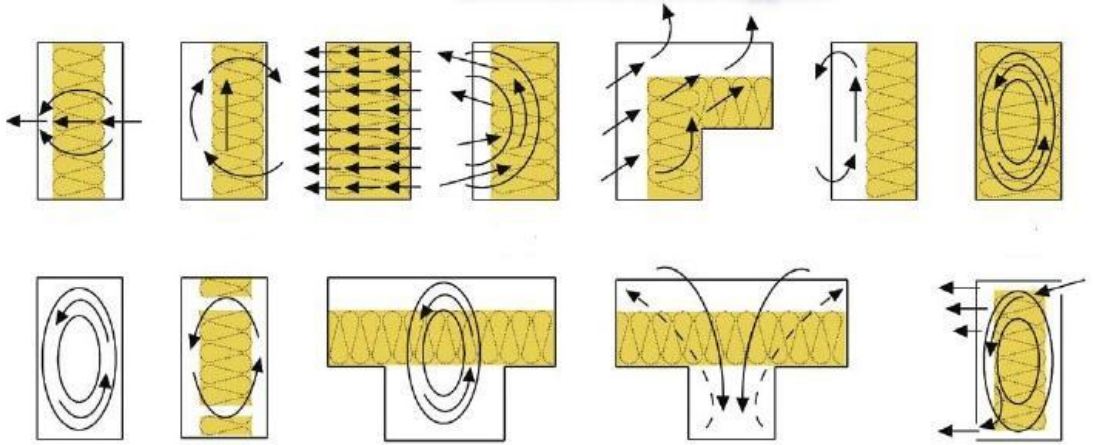


BSD-163: Controlling Cold-Weather Condensation Using Insulation
https://buildingscience.com/documents/digests/bsd-controlling-cold-weather-condensation-using-insulation

Prevent Thermal Bypass

Thermal bypass describes heat loss that gets around intended thermal insulation, including: wind washing, air infiltration, and convective loops.

Thermal Performance of Leaky vs. Airtight enclosures:
Factor of 4.8 or a 79% reduction in performance



Fraunhofer Institute, Stuttgart Germany

Wind Washing

RDH BUILDING SCIENCE LABORATORIES

RDH Building Science Laboratories
167 Lexington Court #6
Waterloo, ON N2J 4R9

Making Buildings Better™

Literature Review and Research Summary on Wind Washing of Air Permeable Insulation

John Straube | Ph.D., P.Eng.
Principal, Senior Building Science Specialist

Jonathan Smegal | M.A.Sc.
Associate, Senior Project Manager

This summary report explains the building science physics of wind washing, including some previous laboratory testing on the air permeance of stone wool insulation. Information about research conducted for ROCKWOOL is used with permission. All contents © RDH Building Science.

Introduction

Modern enclosure design favors the use of exterior continuous insulation (ci) over the supporting structure. This approach has long been favored by building science research because of its excellent thermal performance, condensation resistance, and enhanced durability provided to the materials installed inside of the insulation (Hutcheon 1964). More recently, this design concept has been championed as the "perfect wall" (Lstiburek 2007) shown in Figure 1.

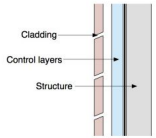


Figure 1: The "perfect wall" concept (Lstiburek 2007)

In a typical well-designed ci assembly, the air and water control (air barrier and water-resistant barrier) is a single membrane placed over the support structure and protected by a layer of continuous exterior insulation (Figure 2). In many enclosure walls, well-vented and even open-jointed cladding is installed over an air gap of ½" to 2" (12 to 50 mm) depth to provide a ventilated space behind the cladding and outside the continuous insulation. The flow of outside air through the gaps into the space behind the cladding – i.e., ventilation – is beneficial for encouraging drying of the back of the cladding and any undrained rainwater or condensation retained on or within the cavity.

Vents through and air gaps (i.e., cavities) behind wall cladding are a common feature of many new wall designs, and have been part of many traditional wall systems. The importance of these air gaps to the performance of walls has been a topic of significant research over the past few decades.

Conclusions

This extensive review of past field and physical laboratory research has reinforced several strong conclusions. Many researchers from different countries working in different decades have developed a solid understanding of the nature and rate of airflow behind ventilated claddings. To a lesser but considera[illegible] extent, the impact of wind washing on the thermal performance of insulation is under[illegible] and the field) shows that the airflows expected meaningful impact on thermal performance if:

- Insulation is low density and high perm[illegible] fibrous insulation of around 1 pound p[illegible] or
- Exterior insulation is not placed in sub[illegible] often also a water barrier) or to a far le[illegible] boards.

The velocities of airflow in the air gap behind v[illegible] 200 feet per minute (1 m/s) in almost all types[illegible] and cladding designs. Less exposed and lower[illegible] than full open joints are likely to see velocities[illegible] fpm (0.1 m/s) range even during windy conditi[illegible]

Although one computer modeling study of ven[illegible] validation reached different conclusions, this c[illegible] validation of the modeling with field measuren[illegible]

There is no risk to wind washing of low-densit[illegible] an air control layer to the exterior of the sheat[illegible]

In all practical designs airflow through the air l[illegible] and more significant factor, which requires an[illegible] construction.

Recommendations for Practice

The literature review leads to several well-supported recommendations for practice for enclosure assemblies that use exterior continuous insulation behind vented or ventilated cladding systems:

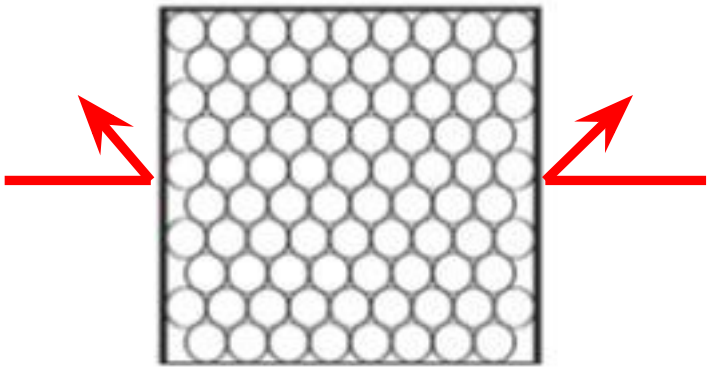
- Place exterior insulation in tight contact with the air barrier to avoid airflow through small gaps behind the insulation[2]. This can be a challenge for stiff board insulations, and hence more pressure, flatter substrates, or more flexible boards may be needed.
- Avoid large gaps (over about 1/8") between boards of insulation (which can lead air to any gaps behind the insulation).
- Avoid very high air permeance products for well-ventilated claddings with large ventilation gaps, that is, specify stone wool products with a density of more than about 64 kg/m^3 (4 pcf) or a dual density product.
- Designers should avoid over-ventilation and excessively large air gaps. The benefits of ventilated gaps diminish rapidly as the gap increases in size above about 1" (25 mm). Large vent areas and large ventilation gaps incur the risk of additional direct rainwater entry, increase problems with animal infestation, and have higher risks of fire spread among other disadvantages.

Food for thought...

“Air-sealing both sides of the wall is more important than the fluffing of the insulation in the cavity.”
- Joe Lstiburek

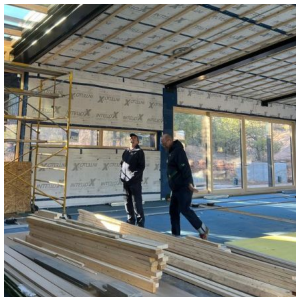
Better yet, Airtight inside and outside

- **Surround the insulation in airtightness.**
- Now the insulation is protected for optimum performance
- *Primary airbarrier should always be the interior air barrier.*



Air Barriers



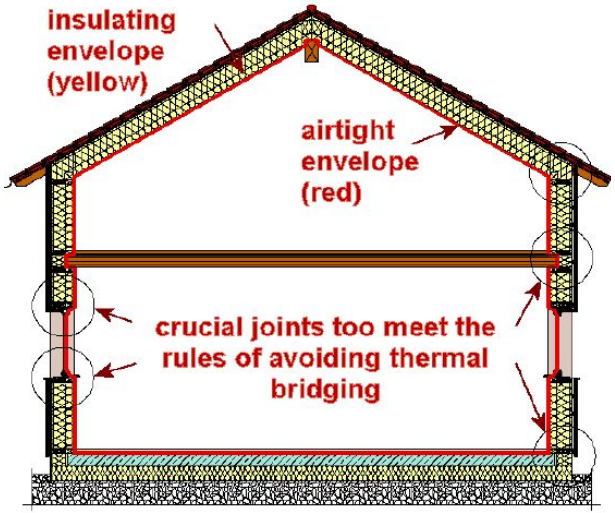




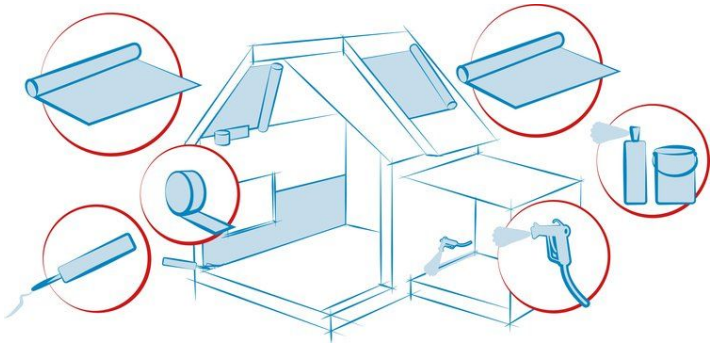

Air Barriers?

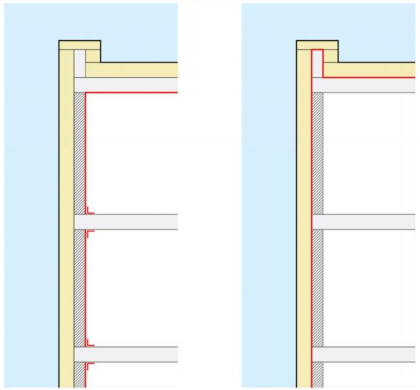
Service Cavities!

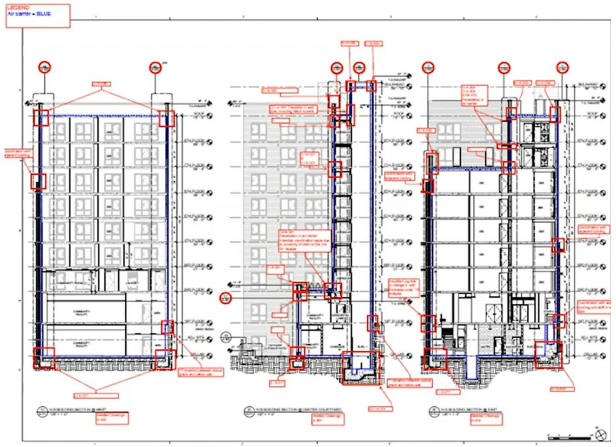
Airtightness is a system



Ref http://passipedia.passiv.de/passipedia_en/







Prioritize the inboard* air barrier

* Inboard of the primary insulation layer. (let's pick the right spot.)

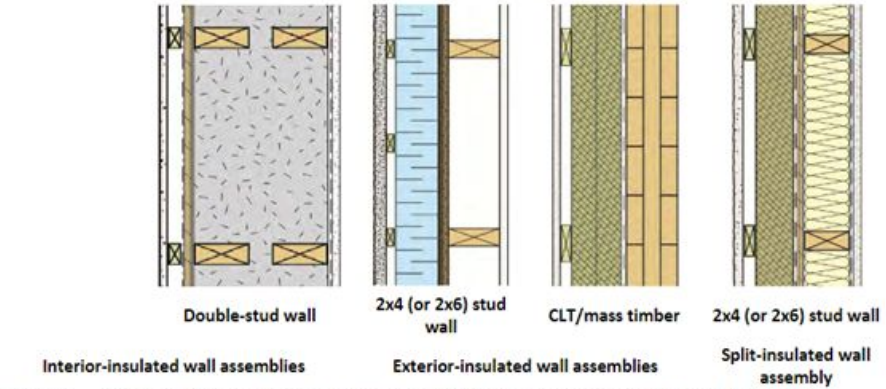


Fig. 3.2.1 Options for placement of insulation within thermally efficient above-grade wood-frame wall assemblies.

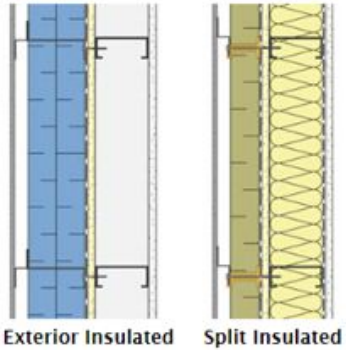
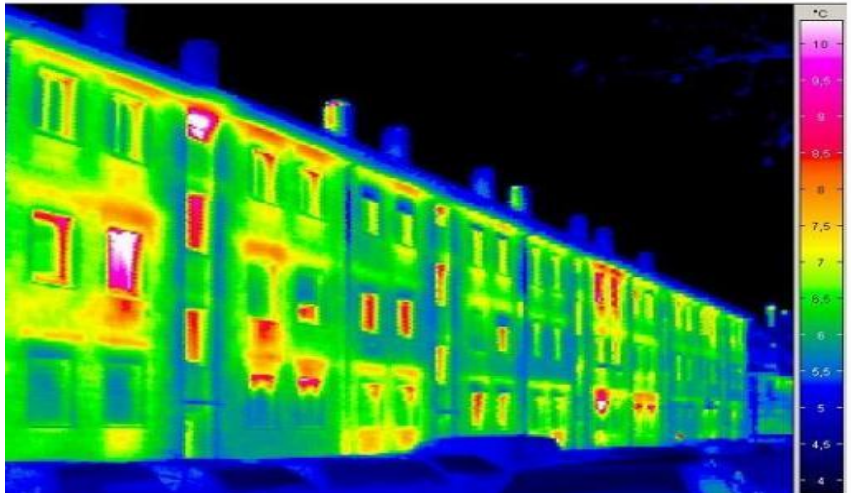
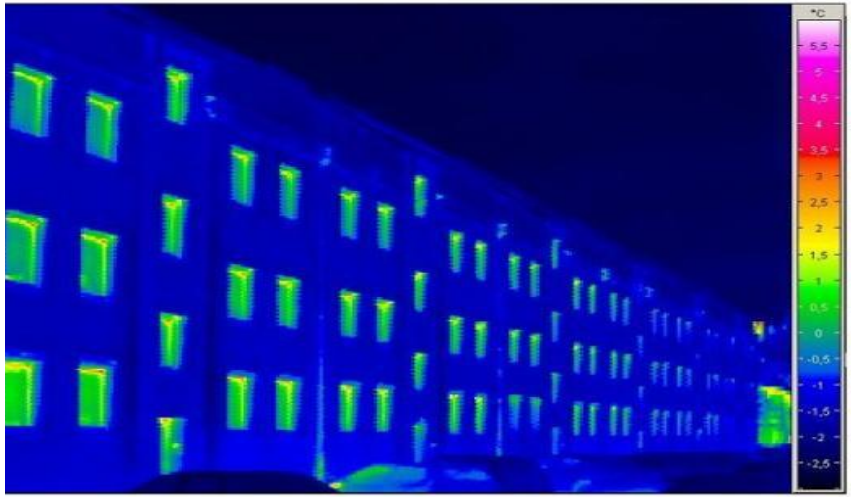


Figure 1: Standard approaches to insulating steel-framed wall assemblies

Vapor Control is foundation of resilience

Vapor is about drying potential.





Credit: PHI

- Poorly insulated walls are often heated dry.
- Well built assemblies dry through vapor diffusion (or they don't dry).
- As insulation levels rise we need greater drying capacity.

Stuff happens. Help the drying.

Drying capacity > Moisture stress = Freedom from damage

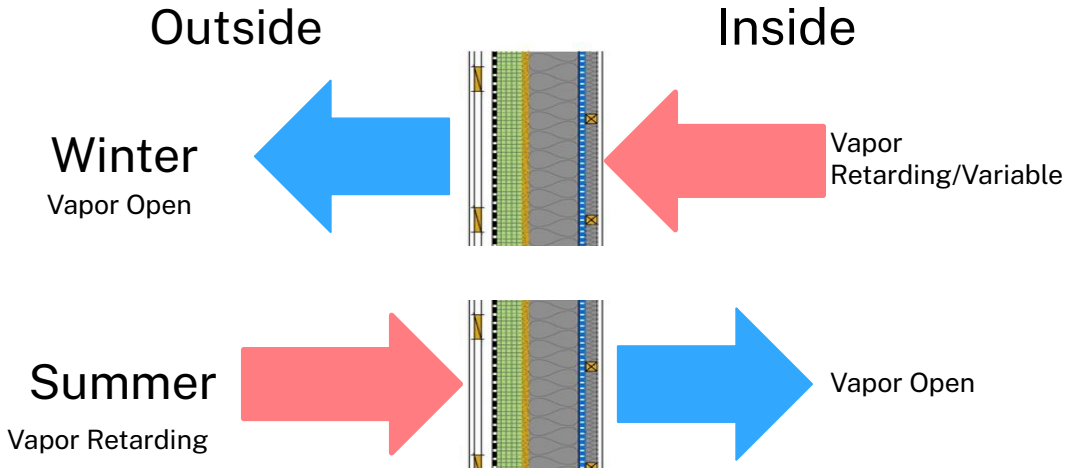
1. Shed bulk water
2. Make airtight
3. Increase drying capacity with vapor control

Permeability of Materials

Class 1 Vapor Retarder (Vapor Impermeable - BARRIER) 0.1 perm or less
Rubber, Plastic, Glass, Metals, Foil-Faced Sheathings
Class 2 Vapor Retarder (Vapor Semi-Impermeable) 0.1 - 1 perm
Oil Paints, Vinyl Wall or Floor Coverings, Polystyrene XPS > 1” thick, Stucco
Class 3 Vapor Retarder (Vapor Semi-Permeable) 1 - 10 perms
Plywood, OSB, EPS or XPS <1” thick, Asphalt Building Paper, Latex Paint
Vapor Permeable (10 perms +)
Unpainted Gypsum Board, Unfaced Fiberglass, Mineral, Cellulose, Wood Fiber Insulations

Primary Vapor Control Layers are often the Air Barriers

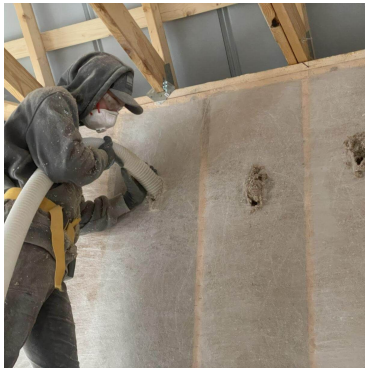
1. Vapor **Open**
2. Vapor **Retarding**
3. Vapor **Variable**








What insulations help the drying?

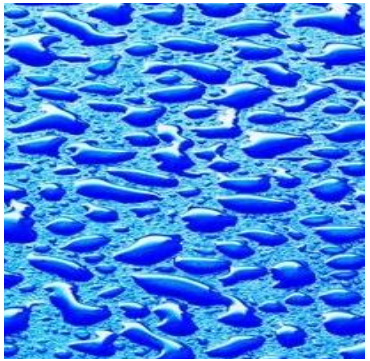


Dense Pack Cellulose - Fibrous

Wood Fiber - Fibrous

Mineral Wool - Fibrous

Fiberglass - Fibrous



Foam - Hygrophobic

1. Fibrous insulations can hold and move excess moisture increasing drying potential.
2. Mineral wool is allows moisture to move through enabling drying.
3. Fiberglass too is vapor open but more easily damaged from wetting.
4. Foams are hydrophobic and more than an inch thick can be inhibiting drying.

Vapor Control? Permeable? Resistive? Barrier? Variable?

Wall Assembly Chart

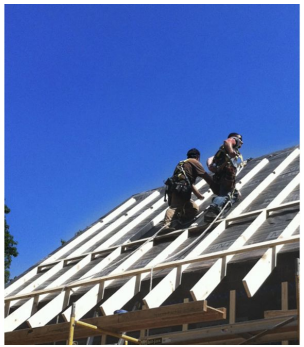
	Cold	Cold/Warm Humid	Hot Humid	Dry
Inboard Control	Retarding/Variable	Variable	Open	Open
Insulation	Fibrous	Fibrous	Fibrous	Fibrous
Outboard Control	Open	Open	Retarding	Open

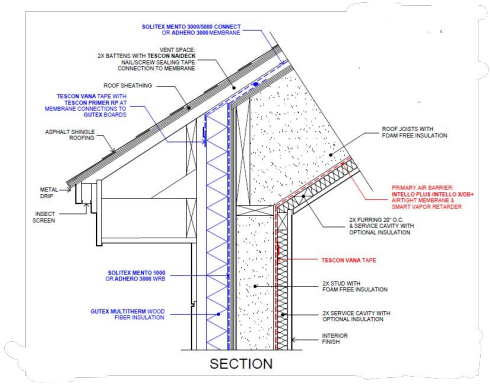
Notes:

- Foam insulation is possible in all cases as well and can also provide vapor retarding.
- Reservoir rainscreens like brick with solar exposure consider retarding outboard.

Roof

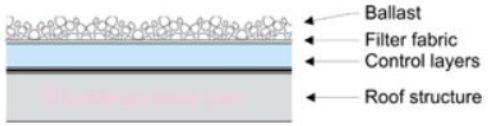
Pitched - Ventilated “Cold Roof”

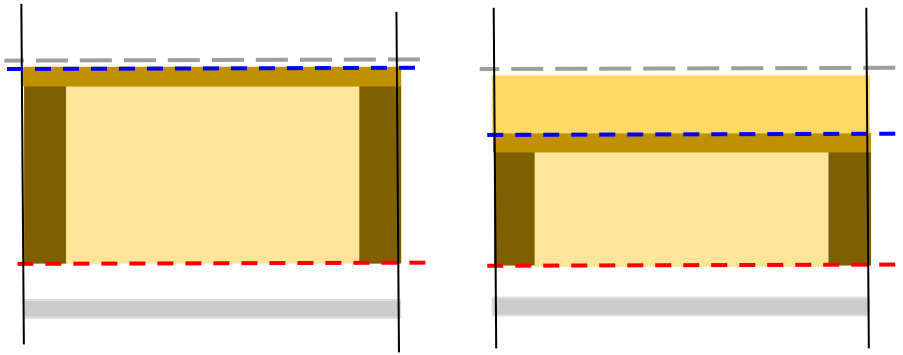




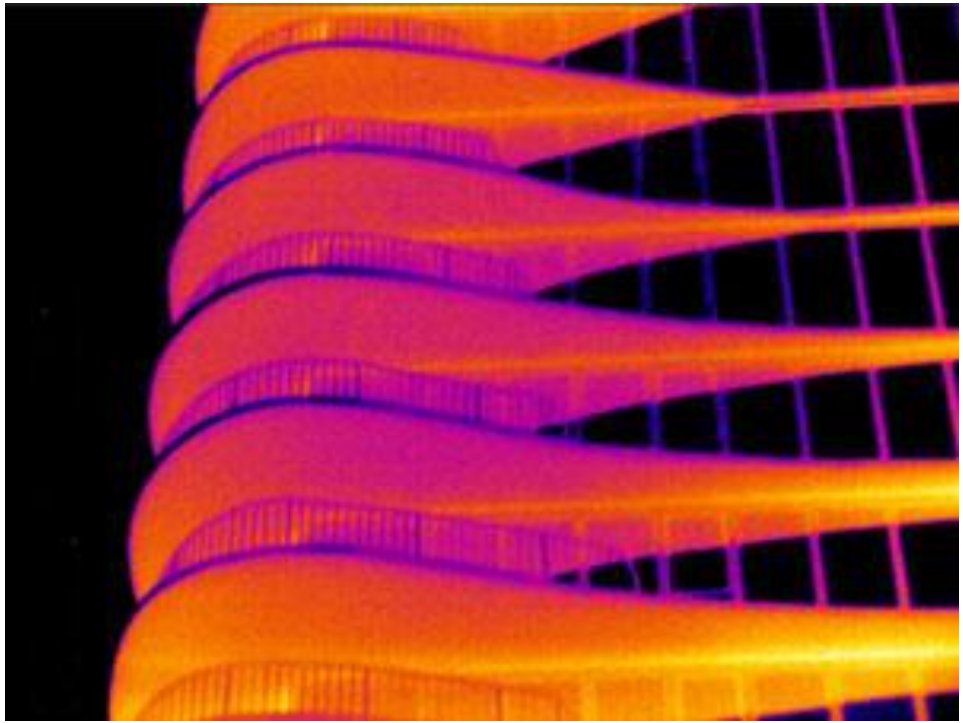
SECTION

Flat - “Perfect Roof”



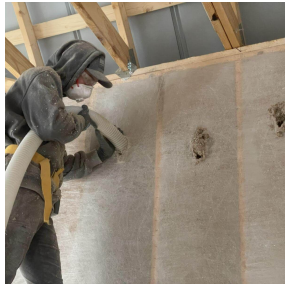


Thermal Control



Insulations

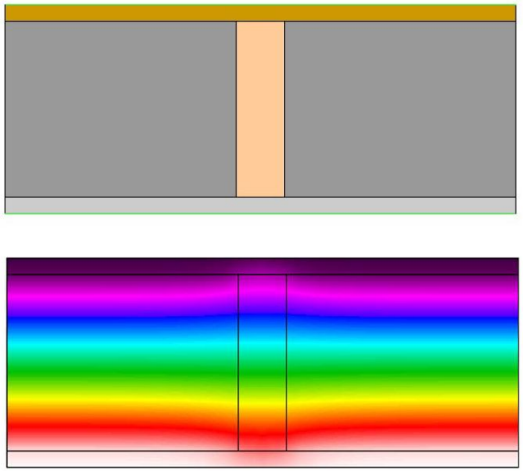
Material Group	Description	R per inch	Conductivity BTU/hr.ft.F	Conductivity W/mK	Density kg.m3
Insulation - Cellulose	Loose fill	3.20	0.026	0.045	
	Blown-in dense-pack (3.5lbs density)	3.70	0.023	0.039	
	Wet spray applied low density	3.20	0.026	0.034	
	Wet spray applied high density	3.70	0.023	0.039	
Insulation - EPS	Type 1	3.80	0.022	0.038	
	Type 2	4.01	0.021	0.036	
	Type 3	4.24	0.020	0.034	
	Type 4	4.97	0.017	0.029	
	Type I	3.61	0.023	0.040	
	Type VIII	3.80	0.022	0.038	
	Type II	4.01	0.021	0.036	
	Type IX	4	0.020	0.034	
	Type XIV	4.24	0.020	0.034	
	Type XI	3.07	0.027	0.047	
	Type XV	4.24	0.020	0.034	
	PHPP	3.61	0.023	0.040	
	EPS-Foam	4.65	0.018	0.031	
Insulation - Cellular Glass	Boards	3.4 - 3.8	0.025 - 0.022	0.042 - 0.038	
	Gravel	1.70	0.049	0.085	
Insulation - Cotton	Batts	3.70	0.023	0.040	
Insulation - Fiberglass	Loose	2.70	0.031	0.053	
	Ba	3.60	0.023	0.040	
	Blow	4.00	0.021	0.036	
Insulation - Mineral Wo	Batts, a ose fill	4.00	0.021	0.036	
	ds	4.00	0.021	0.036	
Insulation - Polyet e (PE)	Fo	3.70	0.023	0.039	
Insulation - Perlite	Ex ded	2.40 - 2.88	0.034 - 0.029	0.06 - 0.04	
Insulation - Polyurehan l)	C Cell Spray Foam	3.70	0.023	0.039	
	osed Cell Spray Foam	5.1 - 6.8	0.016 - 0.012	0.028 - 0.021	
Insulation - Sheeps Wool	Batts	3.60	0.023	0.040	
	Blow in	4.30	0.019	0.034	
Insulation - Straw	perpendicular heat flow with fibers	2.77	0.030	0.052	
	parallel heat flow with fibers	1.80	0.046	0.080	
Insulation - Wood Fiber	loose fill	3.40	0.021	0.042	
	dense pack	3.80	0.022	0.038	
	batt	4.00	0.021	0.036	
	board	3.40 -3.70	0.021 - 0.023	0.042 - 0.039	
Insulation - XPS	Type IV, V, VI, VII, X	5.00	0.017	0.029	
	Type XII	4.60	0.018	0.031	
	XPS-Foam-PHPP	3.61	0.023	0.040	
	XPS-Foam	4.12	0.020	0.031	



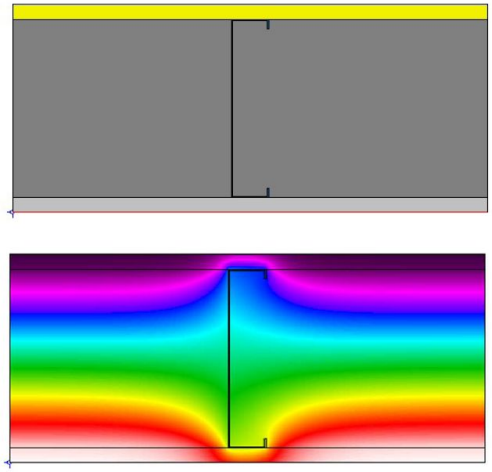


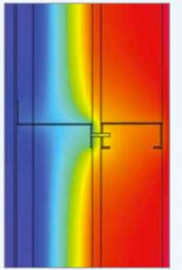

Insulation value in framing

Wood stud wall, insulated cavity:
Nominal R-value (through cavity): 22.3
Actual R-value (incl. framing): 19.0



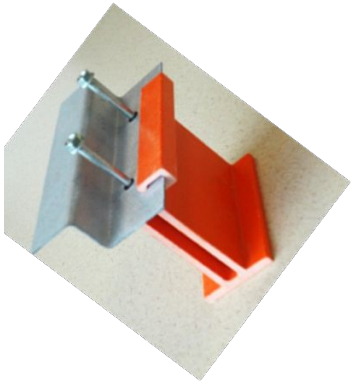
Steel stud wall, insulated cavity:
Nominal R-value (through cavity): 22.3
Actual R-value (incl. framing): 11.6





Typical Z-girt system

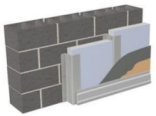
Cascadia Clip® system



Steven Winter Associates Study

For Cladding Finish Systems: Girts

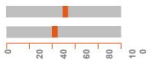
Galvanized Girts



Description

Typical z-girts are usually galvanized steel. Most projects use these to support their cladding systems.

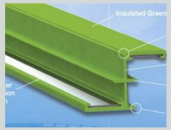
Thermal efficiency per SWA: **43%-53%**



53% for Steel backup
43% for CMU backup

Standard Product

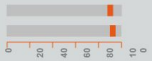
Fiberglass Girts



Description

Fiberglass girts are installed and used the same way as typical metal z-girt. The fiberglass material reduces thermal bridging.

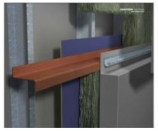
Thermal efficiency per SWA: **91%-95%**



91% for Steel backup
95% for CMU backup

Example Products:
Green Girt- Simple Z

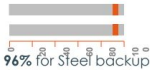
Thermoset Resin Girts



Description

These girts have a low thermal conductivity. Made of fire resistant resin material. Can be spaced 16" or 24" o.c. and is very strong.

Thermal efficiency per SWA: **96%**



96% for Steel backup
96% for CMU backup

Example Products:
Armatherm Z Girt

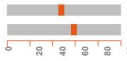
For Cladding Finish Systems: Clips

Galvanized Metal Clips

Description

These clips are usually galvanized steel and are used to support rainscreen and panel cladding systems.

Thermal efficiency per SWA: **46-59%**



46% for Steel backup
59% for CMU backup

Standard Product

Stainless Steel Clips

Description

Replacing galvanized steel clips with stainless steel ones can greatly reduce the thermal conductivity.

Thermal efficiency per SWA: **63-74%**

63% for Steel backup
74% for CMU backup

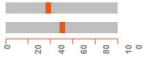
Example Products:
A-Clip. MFSSCHAN

Aluminum Clips

Description

Aluminum clips are light weight and strong. They are a more elastic and non corrosive alternative to traditional metal clips.

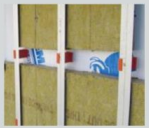
Thermal efficiency per SWA: **38-52%**



38% for Steel backup
52% for CMU backup

Example Products:
Alpha Brackets

Fiberglass Clips



Description

Fiberglass clips have a much lower thermal transmittance coefficient than any metal equivalent.

Thermal efficiency per SWA: **64-79%**

64% for Steel backup
79% for CMU backup

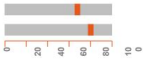
Example Products:
Cascada Clip

Thermal Stop Clips

Description

This clip has a plastic thermal stop at the base and head to help mitigate thermal bridging.

Thermal efficiency per SWA: **67-80%**



67% for Steel backup
80% for CMU backup

Example Products:
Pos-I-Tie Thermal Clip, Nvelope NV1 Thermal Clip

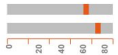
For Brick Veneer Systems: Ties

Galvanized Steel Brick Ties

Description

Typical brick ties are galvanized steel. Most brick veneer projects use this type of product.

Thermal efficiency per SWA: **75-84%**



75% for Steel backup
84% for CMU backup

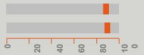
Standard Product

Stainless Steel Brick Ties

Description

Stainless steel ties are less conductive than galvanized steel ties.

Thermal efficiency per SWA: **87-93%**



87% for Steel backup
93% for CMU backup

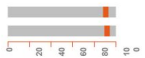
Example Products:
2 Seal Tie Thermal, Original Pos-I-Tie

Thermal Break Brick Ties

Description

This stainless steel brick tie has a plastic coating, which reduces thermal bridging.

Thermal efficiency per SWA: **88-94%**



88% for Steel backup
94% for CMU backup

Example Products:
2 Seal Tie Thermal Wing Nut Anchor

Basalt Fiber Wall Ties

Description

Basalt fiber is a material made from fine fibers of basalt. They tend to be stronger and lighter than stainless steel wall ties and much less thermally conductive.

Example Products:
Teplo Ties, Galen Wall Ties

Connectors

Description

These are used in place of brick ties. The combination of horizontal and vertical elements increases strength despite its small size.

These can be applied prior to liquid applied air barrier installation, so air tightness is improved.

Example Products:
Block Shear Connector

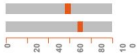
For Brick Veneer Systems: Angles

Typical Shelf Angle

Description

Typically, shelf-angles are made of galvanized steel.

Thermal efficiency per SWA: **58-69%**



58% for Steel backup
69% for CMU backup

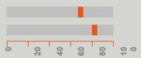
Standard Product

Stand-off Shelf Angle

Description

This stand off shelf angle allows insulation to be installed behind it. The bracket can be used with readily available shelf angles.

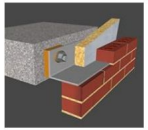
Thermal efficiency per SWA: **73-81%**



73% for Steel backup
81% for CMU backup

Example Products:
FAST (Fero Angle Support Technology),

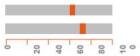
Shelf Angle with Thermal Break



Description

The thermal break plate is installed between the shelf angle and bracket to reduce the thermal bridge at those points.

Thermal efficiency per SWA: **63-74%**

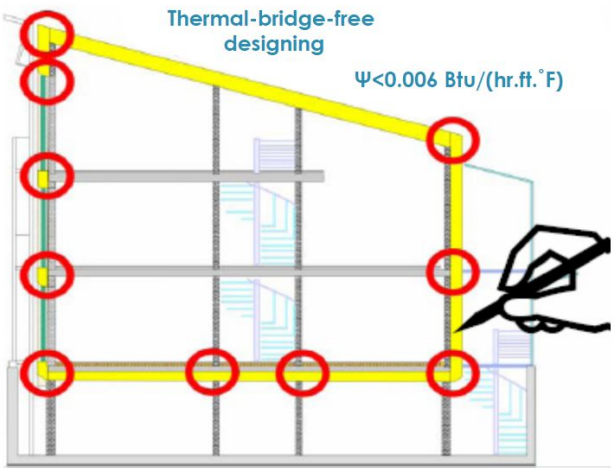


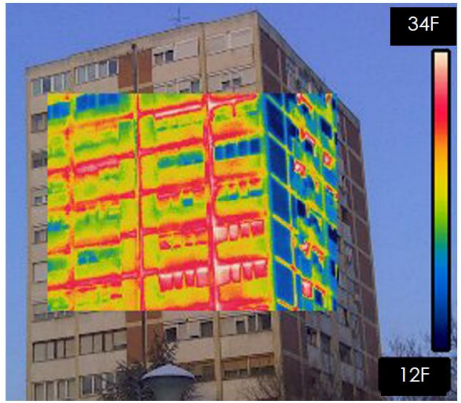
63% for Steel backup
74% for CMU backup

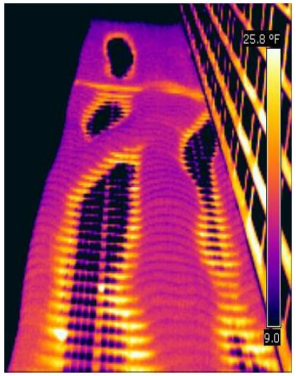
Example Products:
Armatherm Shelf Angle

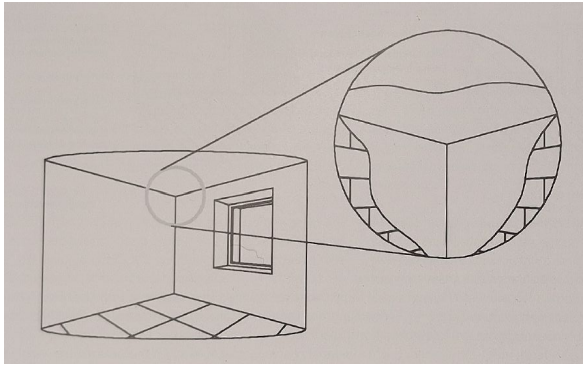
Thermal Bridges All Around

- Can account for 20-30% of heat loss.
- Conservative placeholder values in SD.
- Figure out details in DD and build a catalog.
- Leave a buffer in CDs

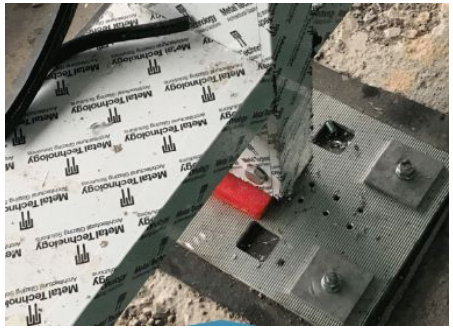


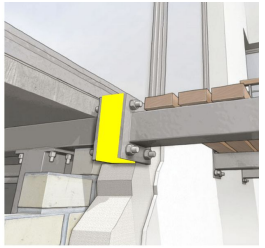


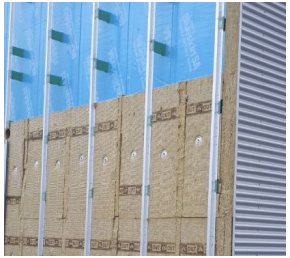




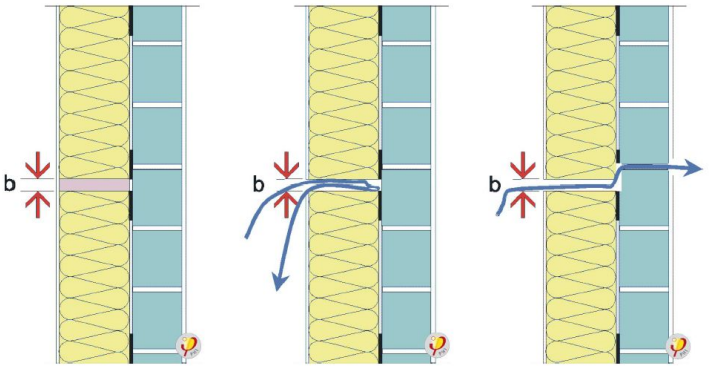
Thermal Bridge Free Continuous Insulation...







No Gaps in Insulation



Gap filled with adhesive

Gap in insulation

Gap at rear of insulation

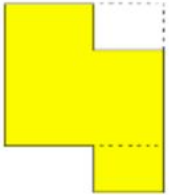
Remember

Prevent the wetting,
and help the drying.

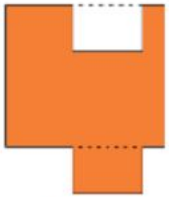
1. Context of Passive House
2. The Work of Enclosures
3. Efficient Design & High Quality
4. Details
5. Execution

Minimize Surface Area

Four corners

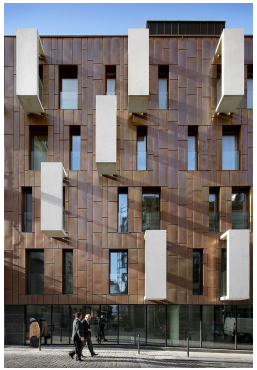


Eight corners
10% more surface area
One inch more insulation

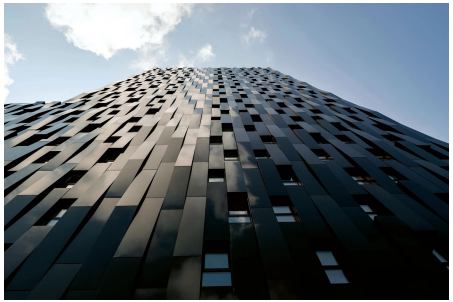


Twelve corners
20% more surface area
Two inches more insulation

Articulate the Skin, Not the Thermal Enclosure

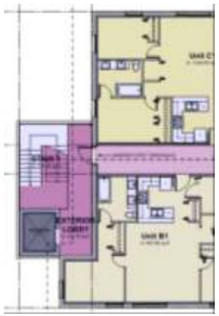





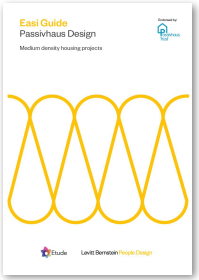



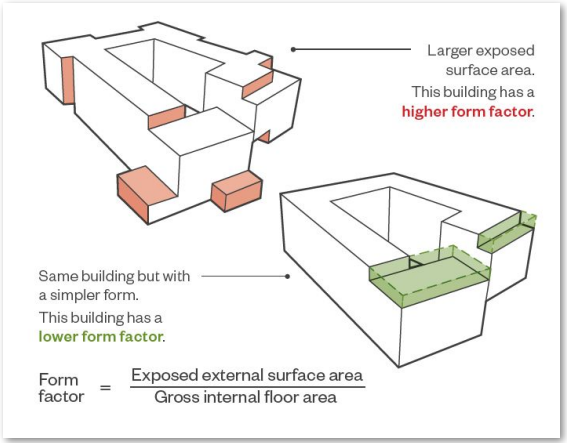
Know what’s inside and what’s outside

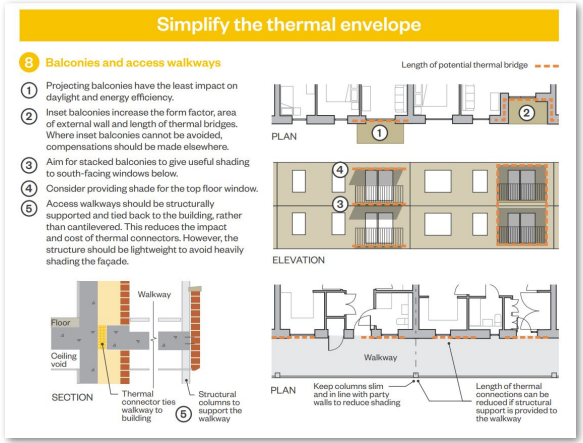
- What can be outside the thermal enclosure (and perhaps should be)?
  - Parking
  - Bicycle storage
  - Vestibules
  - Circulation Elements:
    - Stairs
    - Elevators
    - Hallways (perhaps not)
  - Storage Lockers
  - Trash Collection
  - Commercial Areas of mixed-use building. (see PHI criteria for options)



Efficient Form

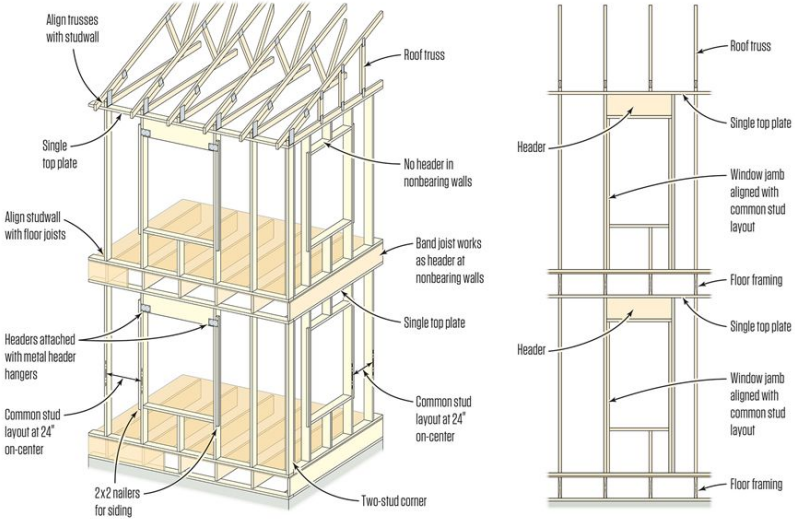


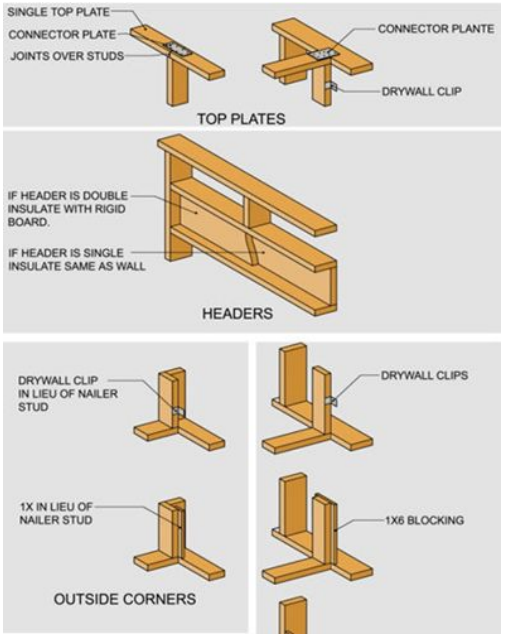




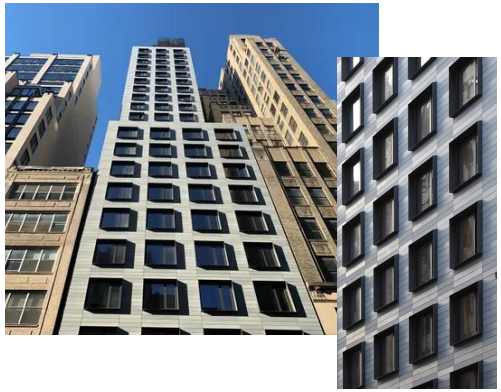
https://www.levittbernstein.co.uk/site/assets/files/3553/passivhaus-easi-guide_screen_portrait.pdf

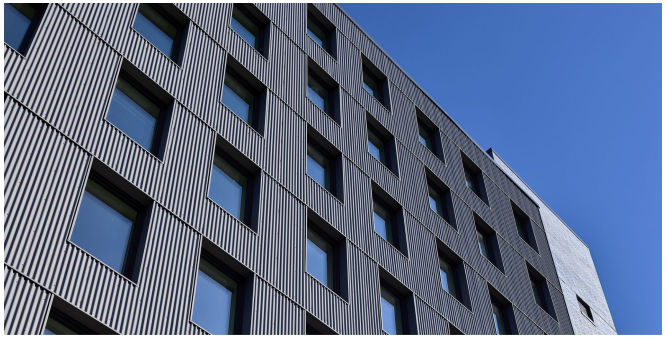
Advanced Framing: Use less framing.





Provide architectural shading & visualize from the start





Kill Bad Balconies

- A balcony is not likely to be used if:
  - It’s less than six feet deep.
  - On a busy, loud and polluted street.
- And if it’s not likely to be used kill it.
- However if it is six feet deep, and only a pleasant street then provide thermal bridge free design that minimizes enclosure complications.

Sensible Glazing: Windows with Purpose

Windows bring light, views, and ventilation. Overglazing brings high heat loss, overheating, storm damage and greater costs.

Only place a window where it has a specific purpose, and where it's the best solution for that purpose. (daylight, view, ventilation)

Take the point of view of the resident and visualizing each proposed window ask: What is the purpose of this piece of glass and is this arrangement the most effective way to serve that purpose?

Large Panes: Less Heat Loss, Less Cost

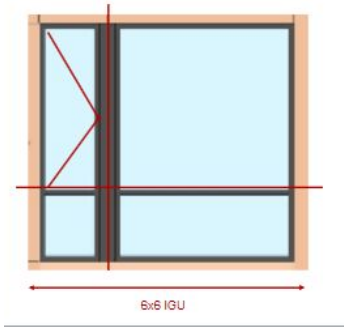
Windows bring light, views, and ventilation.

Overglazing brings high heat loss, overheating, storm damage and greater costs.

Only place a window where it has a specific purpose, and where it's the best solution for that purpose. (daylight, view, ventilation)

Ask: What is the purpose of this piece of glass and is this arrangement the most effective way to serve that purpose?

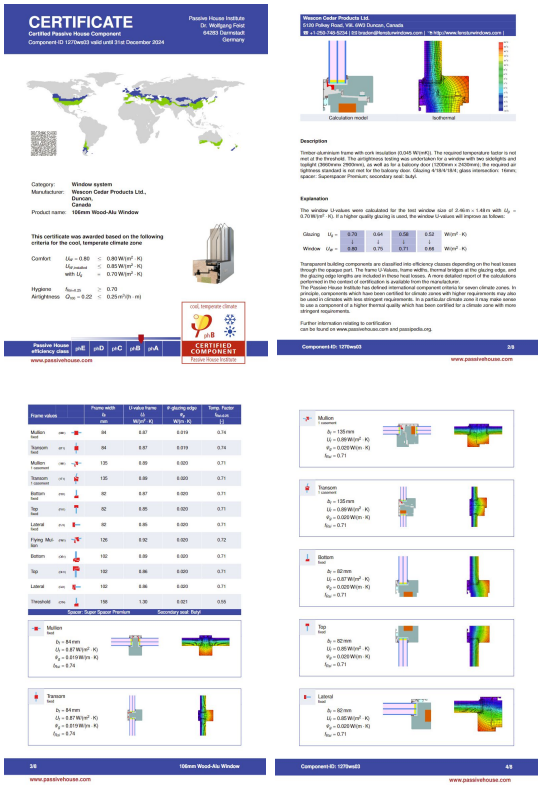
Don't Do This.



- The window unit was relatively expensive.
- Most of the bottom panes were covered by a sofa.
- Nearly an inch of additional insulation was required to offset the thermal bridging.

Many manufacturers to choose from

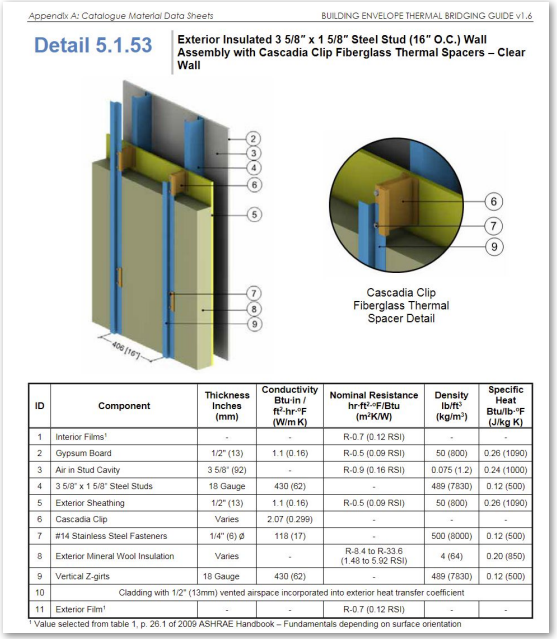
Manufacturer/Supplier	Speciality	Offers PHI Certified Components	HQ Location	Link
Alpen		Yes	Colorado	https://www.thinkalpen.com/
Amberline			Massachussetts	https://amberlinewindows.us/
Bewiso	simulated double-hung		Austria/NY	http://www.bewiso.eu/
Cardinal	glazing, spacers	Yes	Minnesota	https://www.cardinalcorp.com/
Cascadia	fiberglass		British Columbia	https://www.cascadiawindows.com/
Deceuninck		Yes	Ohio	https://deceuninckna.com/
Eco Windows			Connecticut	https://ecowindowsusa.com/
Edge-Tech	spacers		Texas	https://www.quanex.com/product/for-architects/warm-edge-spacers/
ENERsign		Yes	Germany/CO	https://www.enersign.com/en/
EuroLine Windows		Yes	British Columbia	https://euroline-windows.com/
Fakro	skylights		Poland/Illinois	https://shop.fakrousa.com/
Gamma North America		Yes	Ontario	https://gammana.com/
GlassCurtain	curtain wall		Alberta	https://glascurtain.ca/
Hella	exterior shading	Yes	Germany/MN	https://www.tannerbp.com/hella-exterior-blinds
Ikon Windows			New York	https://www.ikonwindows.com/
Inline Fiberglass			Ontario	https://www.inlinefiberglass.com/
Innotech Windows		Yes	British Columbia	https://www.innotech-windows.com/
Internorm		Yes	Germany/NY	https://www.sashandframe.com/
Intus Windwos		Yes	Virginia	https://www.intuswindows.com/
Lamilux	skylights/glass roofs	Yes	Germany/NY	https://475.supply/collections/lamilux
Makrowin		Yes	Slovakia/MA	https://www.eas-usa.com/
Morgan Advanced Materials – Vacupor			UK/MN	https://www.tannerbp.com/
Nord Windows & Doors		Yes	Alaska	https://aknordwindows.com/
NZP Fenestration		Yes	Quebec	https://nzpfenestration.com/en/
Optiwin		Yes	Germany/Wisconsin	https://www.heritagewindow.com/
PH Tech			Quebec	https://phtech.ca/en/
Raico	curtain wall	Yes	Germany/MN	https://www.tannerbp.com/
Rangate		Yes	British Columbia	https://rangate.com/
Rehau		Yes	Switzerland/NY	https://www.rehau.com/us-en/windows
Schueco		Yes	Germany/CT	https://www.schueco.com/ca/company/schueco-usa
Smartwin			Germany/KS	https://advantagewoodwork.com/
Swissspacer	spacers	Yes	Switzerland	https://www.swisspacer.com/en-us/
Tanner			Minnesota	https://www.tannerbp.com/
Technoform	spacers		Germany/OH	https://www.technoform.com/en
Viking		Yes	Estonia/CO	https://www.egresswindowtastic.com/
Westeck		Yes	British Columbia	https://www.westeckwindows.com/
Wythe Windows		Yes	New Jersey	https://www.wythewindows.com/
Yaro			Massachussetts	http://www.yarowindows.com/
Zola	simulated double-hung	Yes	Colorado	https://www.zolawindows.com/



Repeat What Works

- Any multifamily project that is not leveraging repetition is not serious about affordability.
- Repeat **details**.
- Repeat **components**, like windows.
- Repeat **wall panels**.
- Repeat **building modules**.
- Repeat **buildings**.

Make *your* catalog of Passive House details.



Appendix A: Catalogue Material Data Sheets — BUILDING ENVELOPE THERMAL BRIDGING GUIDE v1.6

Detail 5.1.53 — **Exterior Insulated 3 5/8" x 1 5/8" Steel Stud (16" O.C.) Wall Assembly with Cascadia Clip Fiberglass Thermal Spacers – Clear Wall**

ID	Component	Thickness Inches (mm)	Conductivity Btu·in / ft²·hr·°F (W/m K)	Nominal Resistance hr·ft²·°F/Btu (m²K/W)	Density lb/ft³ (kg/m³)	Specific Heat Btu/lb·°F (J/kg K)
1	Interior Films[1]	-	-	R-0.7 (0.12 RSI)	-	-
2	Gypsum Board	1/2" (13)	1.1 (0.16)	R-0.5 (0.09 RSI)	50 (800)	0.26 (1090)
3	Air in Stud Cavity	3 5/8" (92)	-	R-0.9 (0.16 RSI)	0.075 (1.2)	0.24 (1000)
4	3 5/8" x 1 5/8" Steel Studs	18 Gauge	430 (62)	-	489 (7830)	0.12 (500)
5	Exterior Sheathing	1/2" (13)	1.1 (0.16)	R-0.5 (0.09 RSI)	50 (800)	0.26 (1090)
6	Cascadia Clip	Varies	2.07 (0.299)	-	-	-
7	#14 Stainless Steel Fasteners	1/4" (6) ø	118 (17)	-	500 (8000)	0.12 (500)
8	Exterior Mineral Wool Insulation	Varies	-	R-8.4 to R-33.6 (1.48 to 5.92 RSI)	4 (64)	0.20 (850)
9	Vertical Z-girts	18 Gauge	430 (62)	-	489 (7830)	0.12 (500)
10	Cladding with 1/2" (13mm) vented airspace incorporated into exterior heat transfer coefficient					
11	Exterior Film[1]	-	-	R-0.7 (0.12 RSI)	-	-

[1] Value selected from table 1, p. 26.1 of 2009 ASHRAE Handbook – Fundamentals depending on surface orientation

https://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/power-smart/builders-developers/building-envelope-thermal-bridging-guide-v1-6.pdf

1. Context of Passive House
2. The Work of Enclosures
3. Efficient Design & High Quality
4. Details
5. Execution

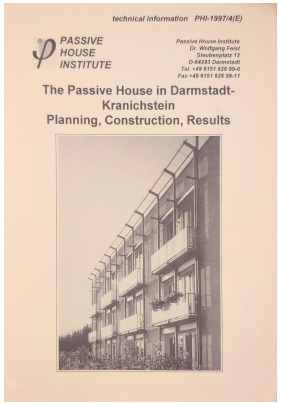
You don’t need to reinvent the wheel….

Passive House evolved out of previous building science developments, and we have 35 years of Passive House experience to learn from, utilize, adapt and evolve further….

….so don’t start with a blank piece of paper.

Learning from others experience...

Keep it simple.


technical information PHI-1997/4(E)

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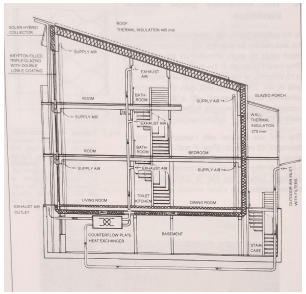
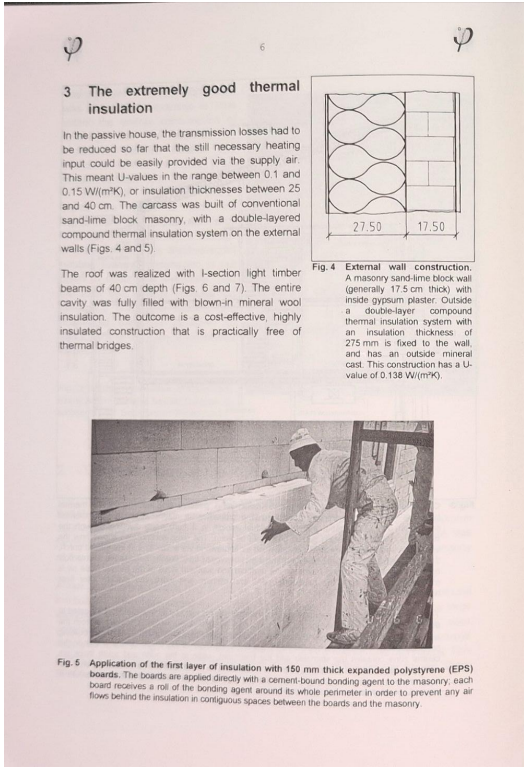
Tel. +49 6151 826 99-0
Fax +49 6151 826 99-11

The Passive House in Darmstadt-Kranichstein
Planning, Construction, Results




6

3 The extremely good thermal insulation

In the passive house, the transmission losses had to be reduced so far that the still necessary heating input could be easily provided via the supply air. This meant U-values in the range between 0.1 and 0.15 W/(m²K), or insulation thicknesses between 25 and 40 cm. The carcass was built of conventional sand-lime block masonry, with a double-layered compound thermal insulation system on the external walls (Figs. 4 and 5).

The roof was realized with I-section light timber beams of 40 cm depth (Figs. 6 and 7). The entire cavity was fully filled with blown-in mineral wool insulation. The outcome is a cost-effective, highly insulated construction that is practically free of thermal bridges.

Fig. 4 External wall construction. A masonry sand-lime block wall (generally 17.5 cm thick) with inside gypsum plaster. Outside a double-layer compound thermal insulation system with an insulation thickness of 275 mm is fixed to the wall, and has an outside mineral cast. This construction has a U-value of 0.138 W/(m²K).

Fig. 5 Application of the first layer of insulation with 150 mm thick expanded polystyrene (EPS) boards. The boards are applied directly with a cement-bound bonding agent to the masonry; each board receives a roll of the bonding agent around its whole perimeter in order to prevent any air flows behind the insulation in contiguous spaces between the boards and the masonry.

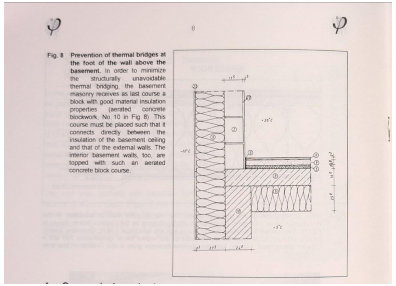
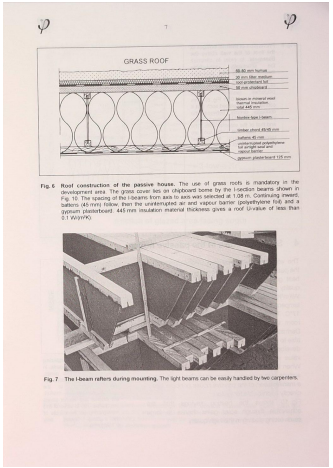

8

Fig. 8 Prevention of thermal bridges at the foot of the wall above the basement. In order to minimize the structurally unavoidable thermal bridging, the basement masonry receives as last course a block with good material insulation properties (aerated concrete blockwork, No 10 in Fig 8). This course must be placed such that it connects directly between the insulation of the basement ceiling and that of the external walls. The interior basement walls, too, are topped with such an aerated concrete block course.


7

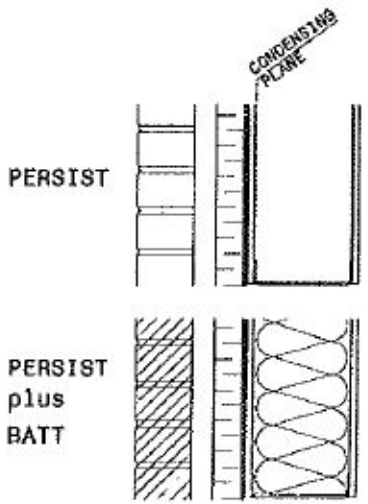
GRASS ROOF

Fig. 6 Roof construction of the passive house. The use of grass roofs is mandatory in the development area. The grass cover lies on chipboard some by the I-section beams shown in Fig. 10. The spacing of the I-beams from axis to axis was selected at 1.00 m. Continuing inward, battens (45 mm) follow, then the unventilated air and vapour barrier (polyethylene foil) and a gypsum (plasterboard) 445 mm insulation material thickness gives a roof U-value of less than 0.1 W/(m²K).

Fig. 7 The I-beam rafters during mounting. The light beams can be easily handled by two carpenters.

PERSIST, REMOTE, and Double Stud Wall Systems

Pressure Equalized Rain Screen Insulated Structure Technique (PERSIST)



Residential Exterior Membrane Outside-Insulation TEchnique (REMOTE)

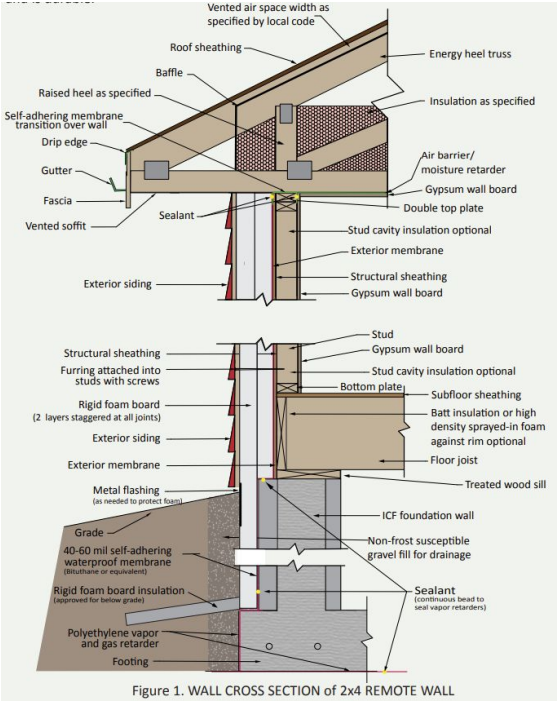
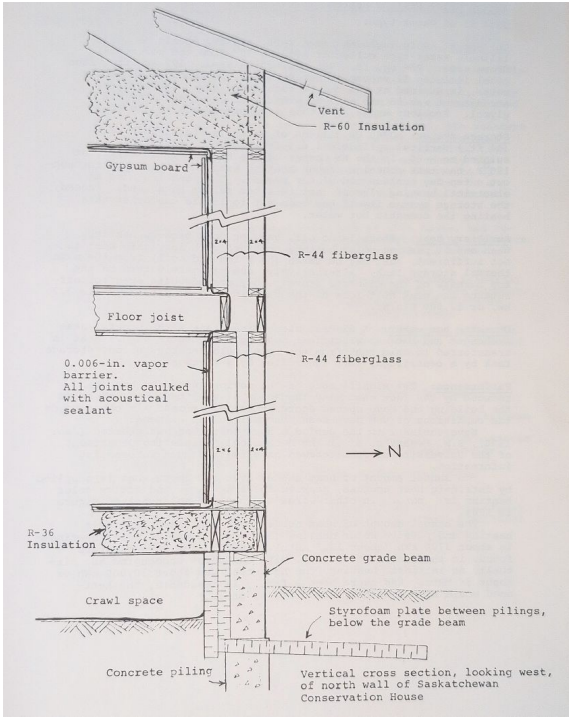
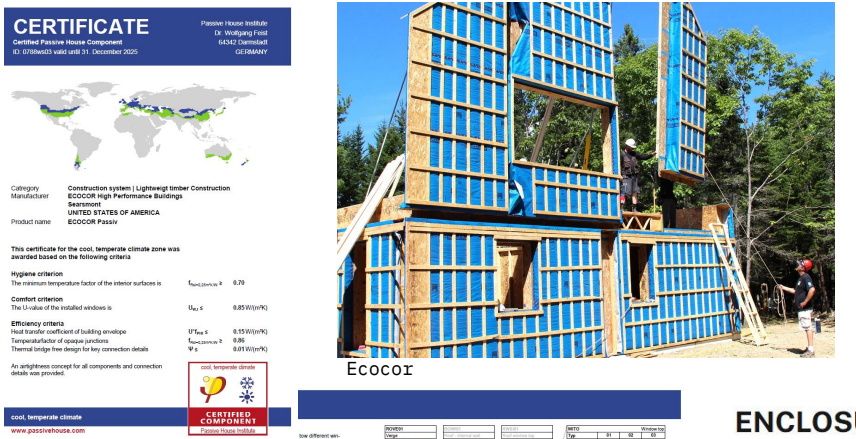


Figure 1. WALL CROSS SECTION of 2x4 REMOTE WALL

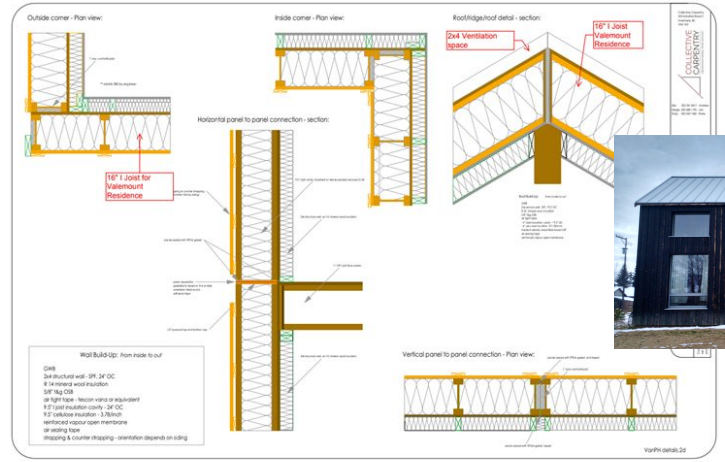
"Double Envelope"



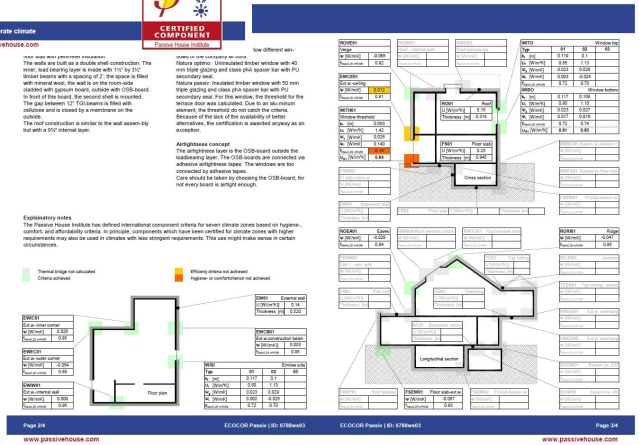
Enclosure systems



Ecocor



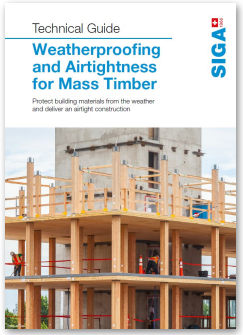
Collective Carpentry

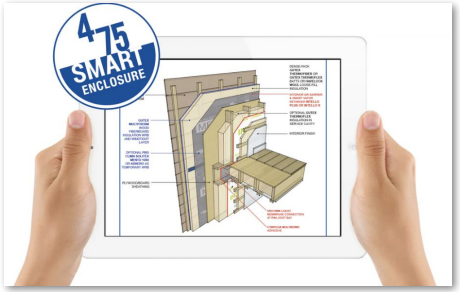


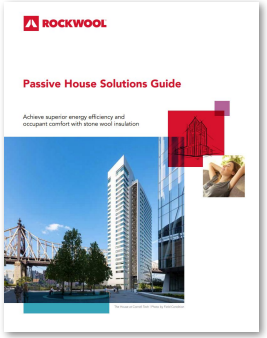
ENCLOSURE SYSTEMS

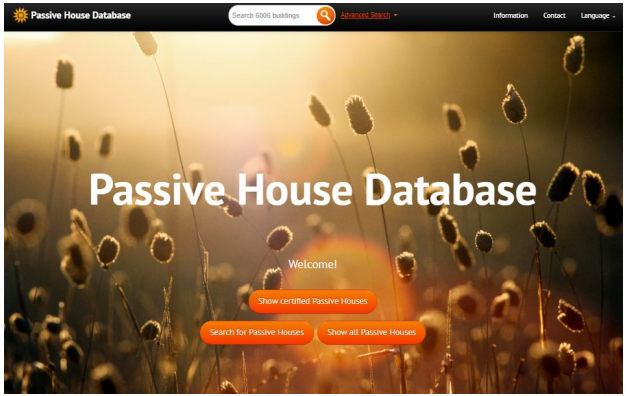
Manufacturer/Supplier	Specialty	Offers PHI Certified Components	HQ Location	Link
B.Public Prefab	panelized		New Mexico	https://www.bpublicprefab.com/
Blueprint Robotics	panelized		Maryland	https://www.blueprint-robotics.com/
BuildSmart	panelized	Yes	Kansas	https://buildsmartna.com/
Collective Carpentry	panelized		British Columbia	https://collectivecarpentry.com/
Ecococon	panelized / straw	Yes	Slovakia/NY	https://ecococon.eu/us/
Ecocor	panelized	Yes	Maine	https://ecocor.us/
EkoBuilt	panelized / kits		Ontario	https://ekobuilt.com/passive-house-kit/
GO Logic	panelized		Maine	https://www.gologic.us/thegohome
Holzraum System	panelized / mass timber		Pennsylvania	https://www.holzraumsystem.com/
Legalett	panelized	Yes	Quebec	https://legalett.ca/
NotchSB / Opal Shelter	mass timber		Maine	https://www.notchsb.com/ – https://opalshelter.us/
Pheonix Haus	panelized	Yes	Colorado	https://phoenixhaus.com/
Quantum Passivhaus	panelized	Yes	Ontario	https://www.quantumpassivhaus.com/

Examples from...

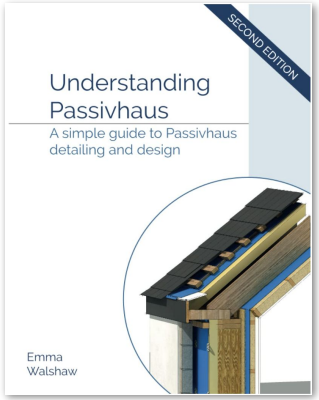


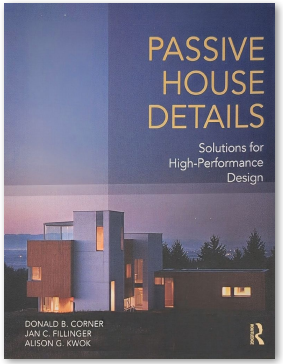


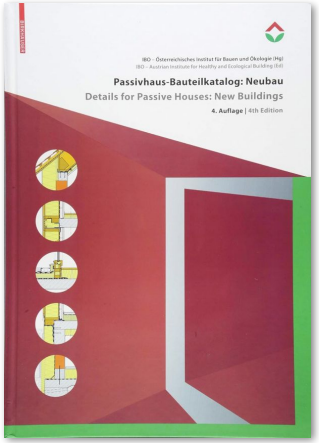


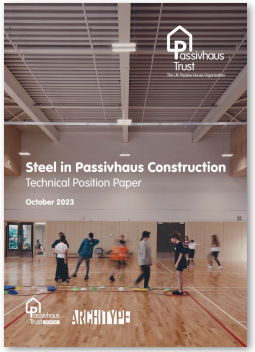


Secret: You can use the details and substitute the specs.

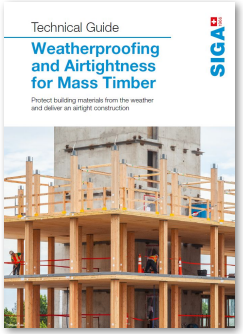


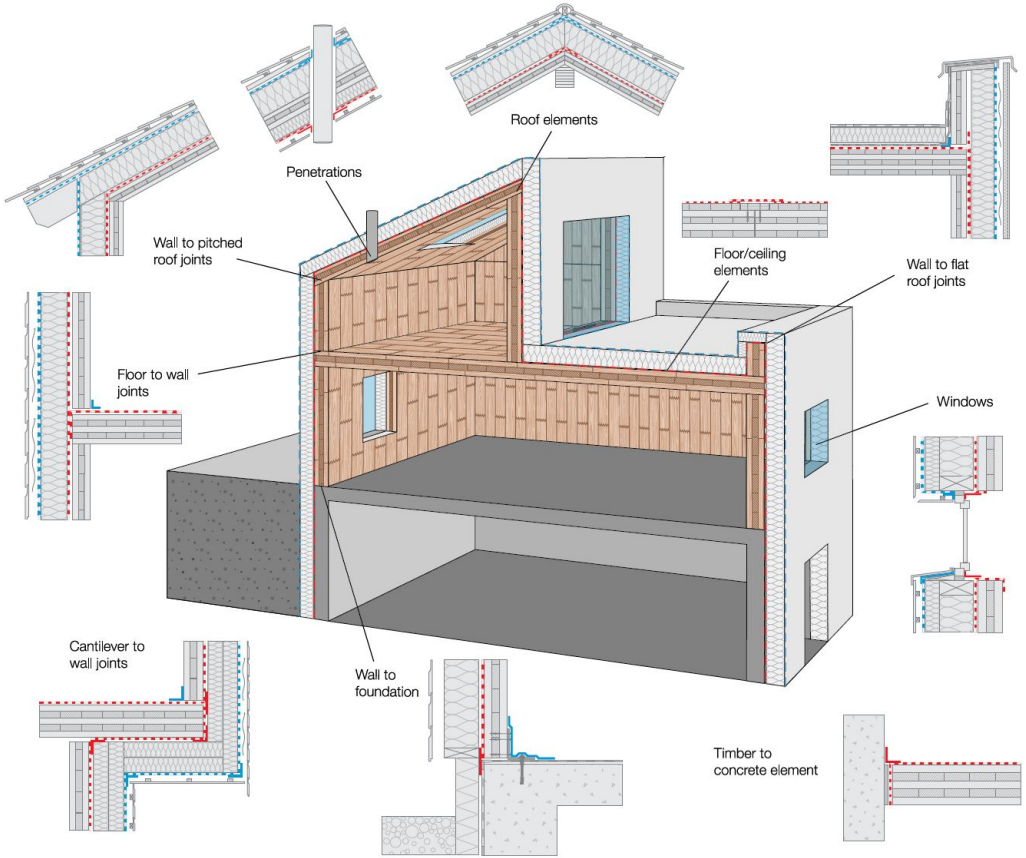




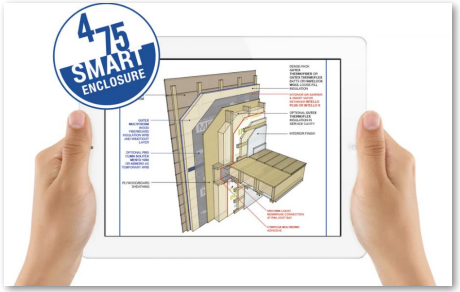


Mass Timber and Control Layers





Across Construction Types...



475 HIGH PERFORMANCE BUILDING SUPPLY

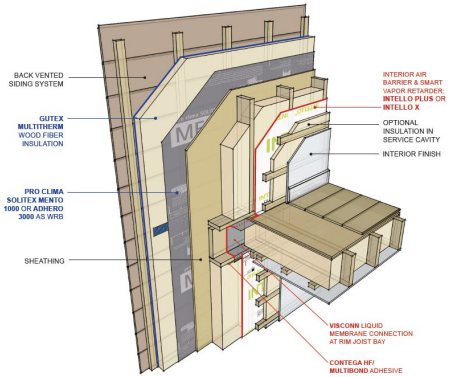
Smart Enclosure System Download

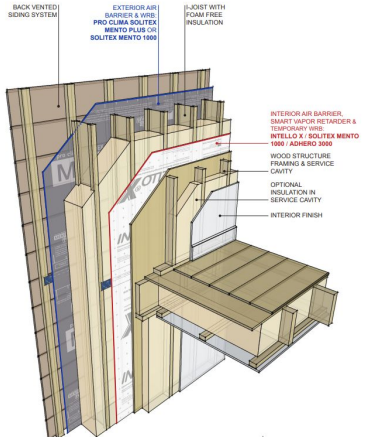
Assembly Type

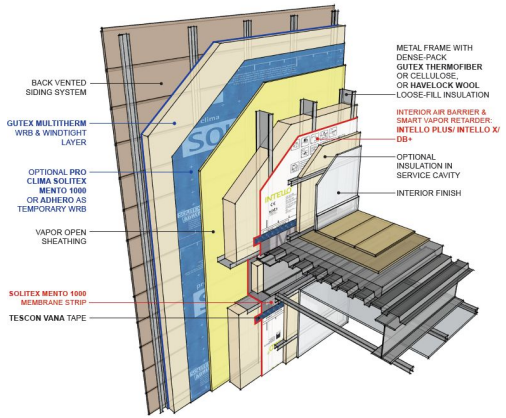
Masonry Retrofit | Wood Retrofit | 2X Framing | Double-Stud | I-Joist Outrigger | Metal Frame | Mass Timber

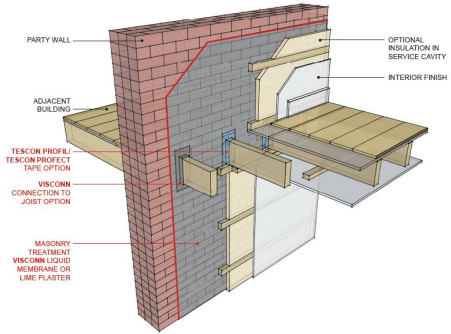
Download File

PDF - Page Layout | PDF - Spread Layout | DWG - CAD File

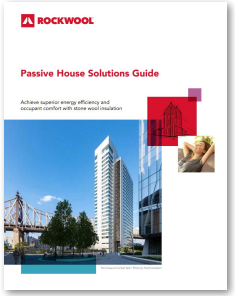


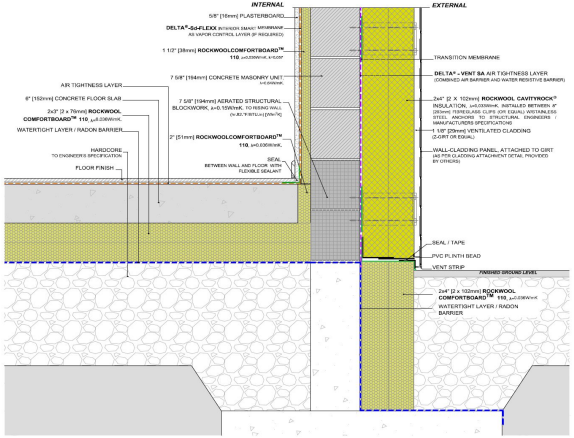


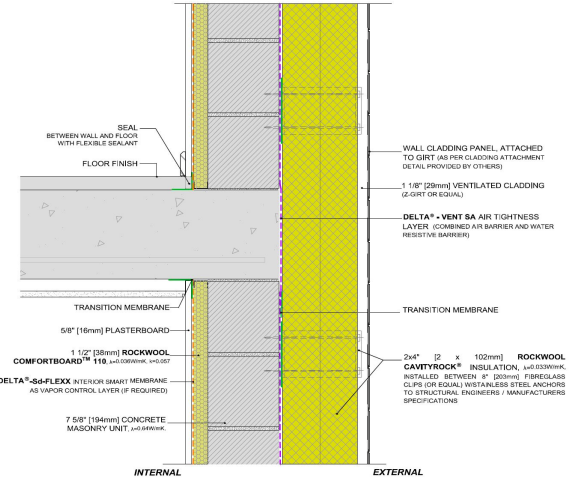


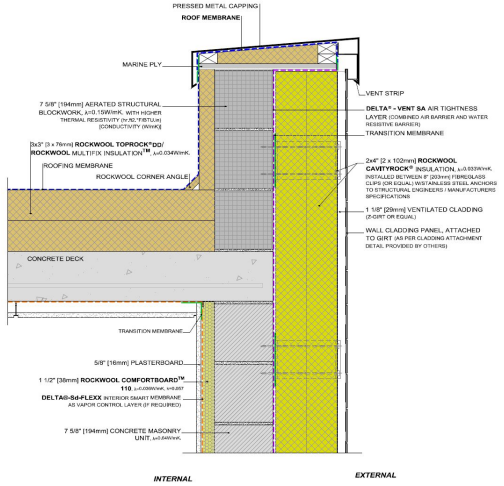


Block & Plank

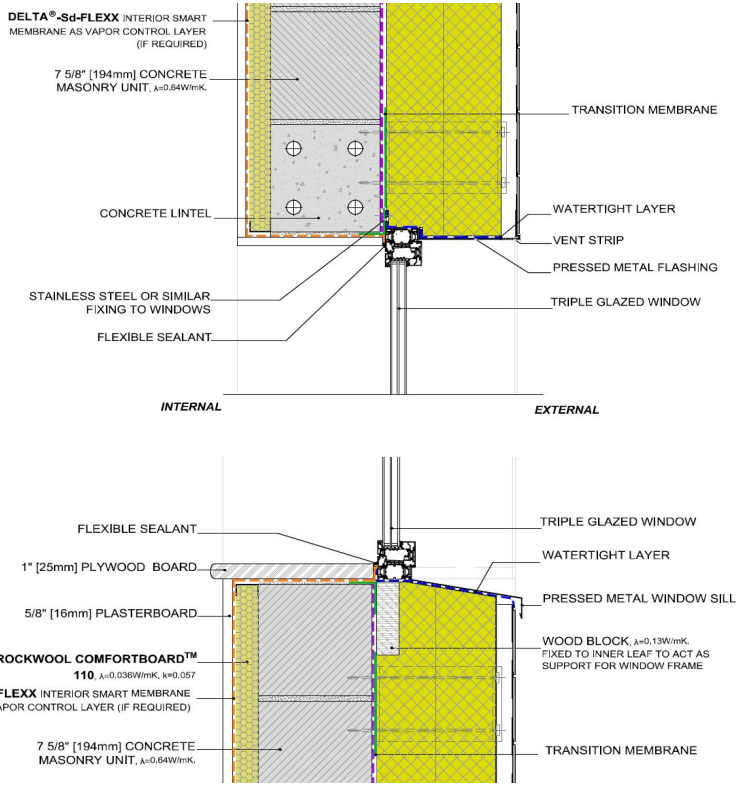

ROCKWOOL
Passive House Solutions Guide
Achieve superior energy efficiency and occupant comfort with stone wool insulation

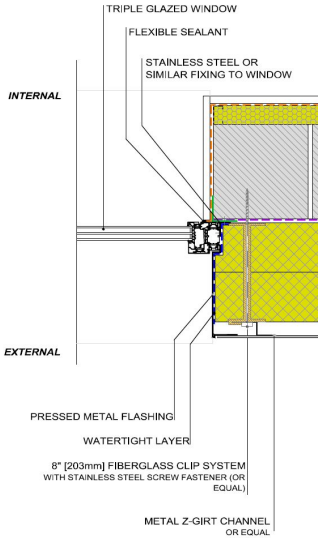

INTERNAL
EXTERNAL
5/8" [16mm] PLASTERBOARD
DELTA®-Sd-FLEXX INTERIOR SMART MEMBRANE
AS VAPOR CONTROL LAYER (IF REQUIRED)
1 1/2" [38mm] ROCKWOOL COMFORTBOARD™ 110, μ=0.036W/mK, k=0.037
7 5/8" [194mm] CONCRETE MASONRY UNIT k=0.64W/mK
8" [152mm] CONCRETE FLOOR SLAB
2x3" [2 x 76mm] ROCKWOOL COMFORTBOARD™ 110, μ=0.036W/mK
WATERTIGHT LAYER / RADON BARRIER
HARDCORE
TO ENGINEER'S SPECIFICATION
FLOOR FINISH
AIR TIGHTNESS LAYER
7 5/8" [194mm] AERATED STRUCTURAL BLOCKWORK, k=0.15W/mK, TO RISING WALL (k=82.7°F/BTU.in/[ft²hr])
2" [51mm] ROCKWOOL COMFORTBOARD™ 110, μ=0.036W/mK
SEAL
BETWEEN WALL AND FLOOR, WITH FLEXIBLE SEALANT
TRANSITION MEMBRANE
DELTA® - VENT SA AIR TIGHTNESS LAYER (COMBINED AIR BARRIER AND WATER RESISTIVE BARRIER)
2x4" [2 X 102mm] ROCKWOOL CAVITYROCK® INSULATION, μ=0.033W/mK, INSTALLED BETWEEN 8" [203mm] TIMBER/GLASS CLIPS (OR EQUAL) WISTAINLESS STEEL ANCHORS TO STRUCTURAL ENGINEERS / MANUFACTURERS SPECIFICATIONS
1 1/8" [29mm] VENTILATED CLADDING (Z-GIRT OR EQUAL)
WALL CLADDING PANEL, ATTACHED TO GIRT (AS PER CLADDING ATTACHMENT DETAIL PROVIDED BY OTHERS)
SEAL / TAPE
PVC PLINTH BEAD
VENT STRIP
FINISHED GROUND LEVEL
2x4" [2 x 102mm] ROCKWOOL COMFORTBOARD™ 110, μ=0.036W/mK
WATERTIGHT LAYER / RADON BARRIER


SEAL
BETWEEN WALL AND FLOOR WITH FLEXIBLE SEALANT
FLOOR FINISH
TRANSITION MEMBRANE
5/8" [16mm] PLASTERBOARD
1 1/2" [38mm] ROCKWOOL COMFORTBOARD™ 110, μ=0.036W/mK, k=0.037
DELTA®-Sd-FLEXX INTERIOR SMART MEMBRANE AS VAPOR CONTROL LAYER (IF REQUIRED)
7 5/8" [194mm] CONCRETE MASONRY UNIT, μ=0.64W/mK
WALL CLADDING PANEL, ATTACHED TO GIRT (AS PER CLADDING ATTACHMENT DETAIL PROVIDED BY OTHERS)
1 1/8" [29mm] VENTILATED CLADDING (Z-GIRT OR EQUAL)
DELTA® - VENT SA AIR TIGHTNESS LAYER (COMBINED AIR BARRIER AND WATER RESISTIVE BARRIER)
TRANSITION MEMBRANE
2x4" [2 x 102mm] ROCKWOOL CAVITYROCK® INSULATION, μ=0.033W/mK, INSTALLED BETWEEN 8" [203mm] FIBREGLASS CLIPS (OR EQUAL) WISTAINLESS STEEL ANCHORS TO STRUCTURAL ENGINEERS / MANUFACTURERS SPECIFICATIONS
INTERNAL
EXTERNAL


PRESSED METAL CAPPING
ROOF MEMBRANE
MARINE PLY
7 5/8" [194mm] AERATED STRUCTURAL BLOCKWORK, k=0.15W/mK, WITH HIGHER THERMAL RESISTIVITY (k=82.7°F/BTU.in/[ft²hr]) (CONDUCTIVITY (W/mK))
3x3" [3 x 76mm] ROCKWOOL TOPROCK®DD/ ROCKWOOL MULTIFIX INSULATION™ λ=0.034W/mK
ROOFING MEMBRANE
ROCKWOOL CORNER ANGLE
CONCRETE DECK
TRANSITION MEMBRANE
5/8" [16mm] PLASTERBOARD
1 1/2" [38mm] ROCKWOOL COMFORTBOARD™ 110, μ=0.036W/mK, k=0.037
DELTA®-Sd-FLEXX INTERIOR SMART MEMBRANE AS VAPOR CONTROL LAYER (IF REQUIRED)
7 5/8" [194mm] CONCRETE MASONRY UNIT, μ=0.64W/mK
VENT STRIP
DELTA® - VENT SA AIR TIGHTNESS LAYER (COMBINED AIR BARRIER AND WATER RESISTIVE BARRIER)
TRANSITION MEMBRANE
2x4" [2 x 102mm] ROCKWOOL CAVITYROCK® INSULATION, λ=0.033W/mK, INSTALLED BETWEEN 8" [203mm] FIBREGLASS CLIPS (OR EQUAL) WISTAINLESS STEEL ANCHORS TO STRUCTURAL ENGINEERS / MANUFACTURERS SPECIFICATIONS
1 1/8" [29mm] VENTILATED CLADDING (Z-GIRT OR EQUAL)
WALL CLADDING PANEL, ATTACHED TO GIRT (AS PER CLADDING ATTACHMENT DETAIL PROVIDED BY OTHERS)
INTERNAL
EXTERNAL

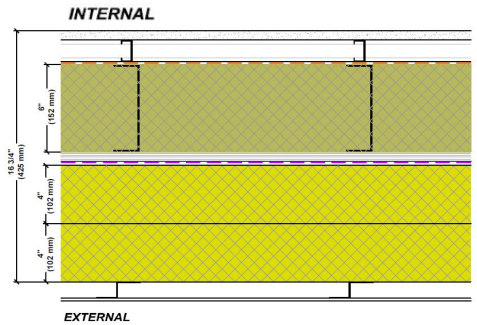
Block & Plank: Window





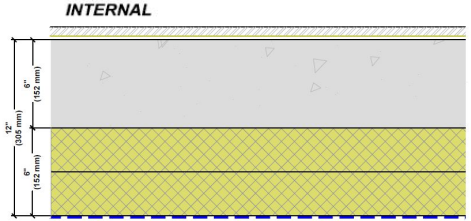
Steel

External Wall



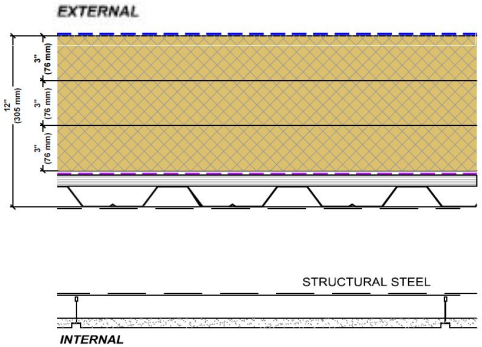
Installed R-Value	10.28 m^2k/W	(58.40 $ft^2 \cdot hr \cdot F°/BTU$)
Effective R-Value	7.69 m^2k/W	(43.68 $ft^2 \cdot hr \cdot F°/BTU$)
Overall U-Value	0.130 W/m^2k	(0.023 BTU/ $ft^2 \cdot hr \cdot F°$)

Slab



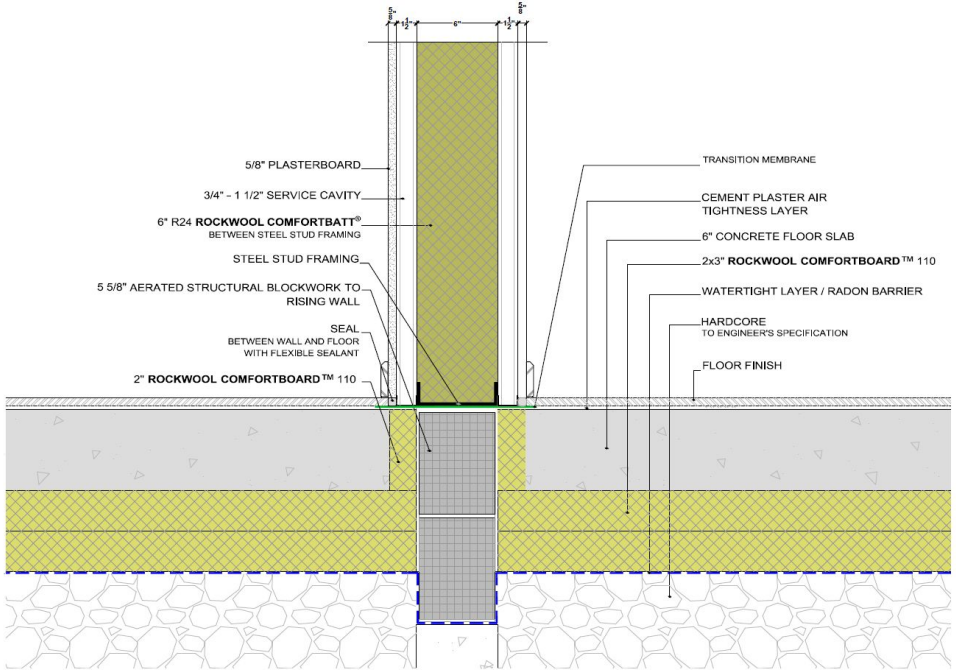
Installed R-Value	4.23 m^2k/W	(24.00 $ft^2 \cdot hr \cdot F°/BTU$)
Effective R-Value	4.46 m^2k/W	(25.35 $ft^2 \cdot hr \cdot F°/BTU$)
Overall U-Value	0.224 W/m^2k	(0.039 BTU/ $ft^2 \cdot hr \cdot F°$)

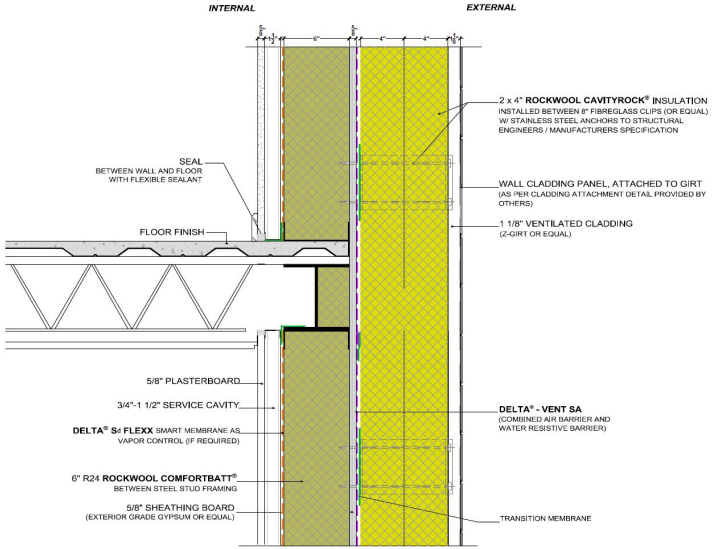
Flat Roof



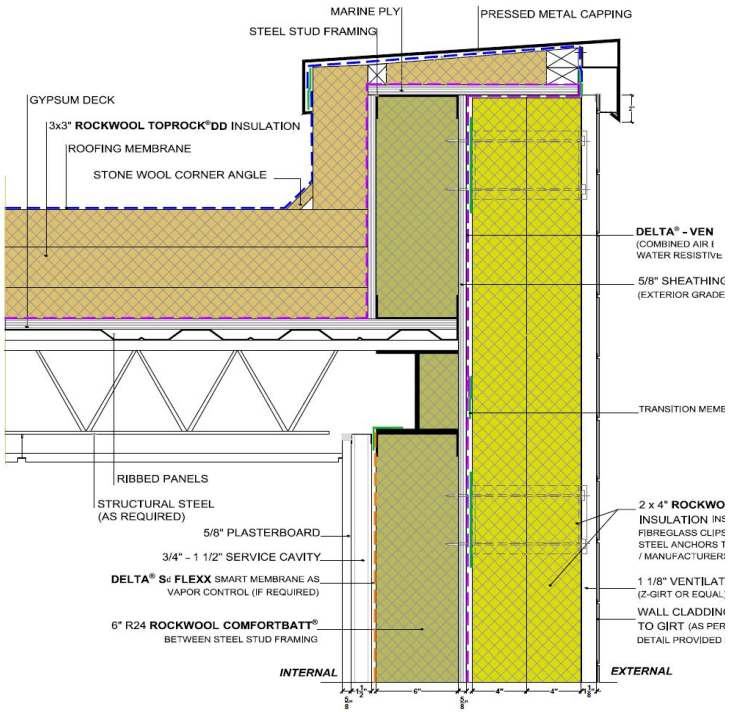
Installed R-Value	6.02 m^2k/W	(34.20 $ft^2 \cdot hr \cdot F°/BTU$)
Effective R-Value	6.45 m^2k/W	(36.63 $ft^2 \cdot hr \cdot F°/BTU$)
Overall U-Value	0.155 W/m^2k	(0.027 BTU/ $ft^2 \cdot hr \cdot F°$)

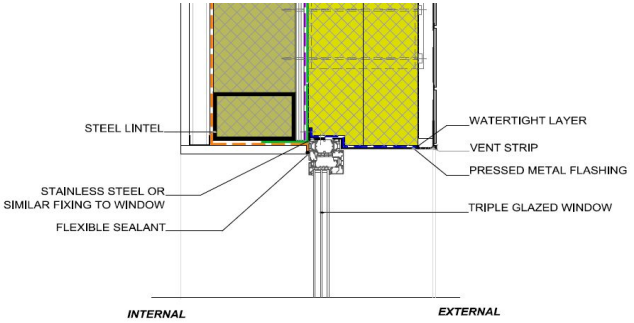
Steel

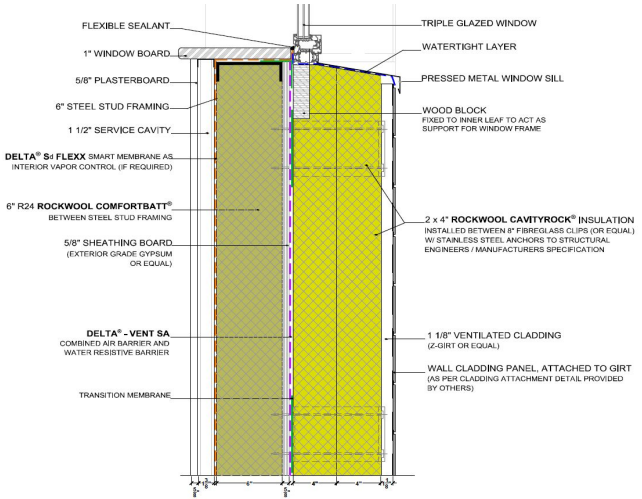

5/8" PLASTERBOARD
3/4" - 1 1/2" SERVICE CAVITY
6" R24 ROCKWOOL COMFORTBATT®
BETWEEN STEEL STUD FRAMING
STEEL STUD FRAMING
5 5/8" AERATED STRUCTURAL BLOCKWORK TO RISING WALL
SEAL
BETWEEN WALL AND FLOOR WITH FLEXIBLE SEALANT
2" ROCKWOOL COMFORTBOARD™ 110
TRANSITION MEMBRANE
CEMENT PLASTER AIR TIGHTNESS LAYER
6" CONCRETE FLOOR SLAB
2x3" ROCKWOOL COMFORTBOARD™ 110
WATERTIGHT LAYER / RADON BARRIER
HARDCORE
TO ENGINEER'S SPECIFICATION
FLOOR FINISH


INTERNAL
EXTERNAL
2 x 4" ROCKWOOL CAVITYROCK® INSULATION
INSTALLED BETWEEN 8" FIBREGLASS CLIPS (OR EQUAL)
W/ STAINLESS STEEL ANCHORS TO STRUCTURAL ENGINEERS / MANUFACTURERS SPECIFICATION
SEAL
BETWEEN WALL AND FLOOR WITH FLEXIBLE SEALANT
WALL CLADDING PANEL, ATTACHED TO GIRT
(AS PER CLADDING ATTACHMENT DETAIL PROVIDED BY OTHERS)
FLOOR FINISH
1 1/8" VENTILATED CLADDING
(Z-GIRT OR EQUAL)
5/8" PLASTERBOARD
3/4"-1 1/2" SERVICE CAVITY
DELTA® Sd FLEXX SMART MEMBRANE AS VAPOR CONTROL (IF REQUIRED)
DELTA® - VENT SA
(COMBINED AIR BARRIER AND WATER RESISTIVE BARRIER)
6" R24 ROCKWOOL COMFORTBATT®
BETWEEN STEEL STUD FRAMING
5/8" SHEATHING BOARD
(EXTERIOR GRADE GYPSUM OR EQUAL)
TRANSITION MEMBRANE

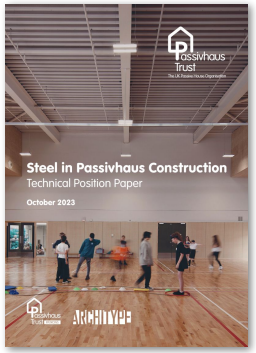
Steel

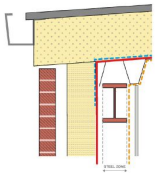

MARINE PLY
STEEL STUD FRAMING
PRESSED METAL CAPPING
GYPSUM DECK
3x3" ROCKWOOL TOPROCK®DD INSULATION
ROOFING MEMBRANE
STONE WOOL CORNER ANGLE
DELTA® - VEN
(COMBINED AIR &
WATER RESISTIVE
5/8" SHEATHING
(EXTERIOR GRADE
TRANSITION MEME
RIBBED PANELS
STRUCTURAL STEEL
(AS REQUIRED)
5/8" PLASTERBOARD
3/4" - 1 1/2" SERVICE CAVITY
DELTA® Sd FLEXX SMART MEMBRANE AS
VAPOR CONTROL (IF REQUIRED)
6" R24 ROCKWOOL COMFORTBATT®
BETWEEN STEEL STUD FRAMING
2 x 4" ROCKWO
INSULATION IN
FIBREGLASS CLIPS
STEEL ANCHORS T
/ MANUFACTURERS
1 1/8" VENTILAT
(Z-GIRT OR EQUAL
WALL CLADDIN
TO GIRT (AS PER
DETAIL PROVIDED
INTERNAL
EXTERNAL


STEEL LINTEL
WATERTIGHT LAYER
VENT STRIP
PRESSED METAL FLASHING
STAINLESS STEEL OR
SIMILAR FIXING TO WINDOW
TRIPLE GLAZED WINDOW
FLEXIBLE SEALANT
INTERNAL
EXTERNAL

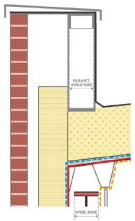

FLEXIBLE SEALANT
TRIPLE GLAZED WINDOW
1" WINDOW BOARD
WATERTIGHT LAYER
5/8" PLASTERBOARD
PRESSED METAL WINDOW SILL
6" STEEL STUD FRAMING
WOOD BLOCK
FIXED TO INNER LEAF TO ACT AS
SUPPORT FOR WINDOW FRAME
1 1/2" SERVICE CAVITY
DELTA® Sd FLEXX SMART MEMBRANE AS
INTERIOR VAPOR CONTROL (IF REQUIRED)
6" R24 ROCKWOOL COMFORTBATT®
BETWEEN STEEL STUD FRAMING
2 x 4" ROCKWOOL CAVITYROCK® INSULATION
INSTALLED BETWEEN 8" FIBREGLASS CLIPS (OR EQUAL)
W/ STAINLESS STEEL ANCHORS TO STRUCTURAL
ENGINEERS / MANUFACTURERS SPECIFICATION
5/8" SHEATHING BOARD
(EXTERIOR GRADE GYPSUM
OR EQUAL)
DELTA® - VENT SA
COMBINED AIR BARRIER AND
WATER RESISTIVE BARRIER
1 1/8" VENTILATED CLADDING
(Z-GIRT OR EQUAL)
WALL CLADDING PANEL, ATTACHED TO GIRT
(AS PER CLADDING ATTACHMENT DETAIL PROVIDED
BY OTHERS)
TRANSITION MEMBRANE

Steel Structure

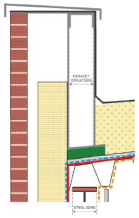




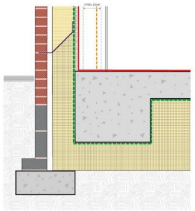
External Wall Roof Junction



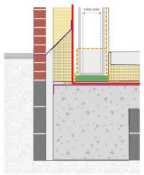
Roof Parapet - insulation continuous



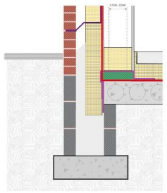
Roof Parapet - thermal break pad



Type A



Type B



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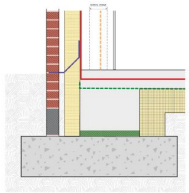


Type D

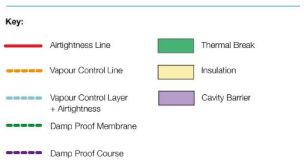
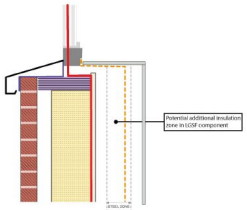
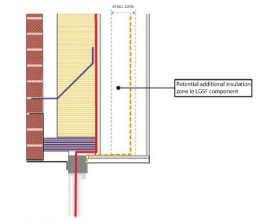


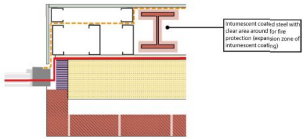
Figure 12: Four approaches to foundations



Window cill detail masonry



Window head detail masonry



Window jamb detail masonry

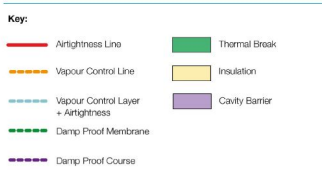
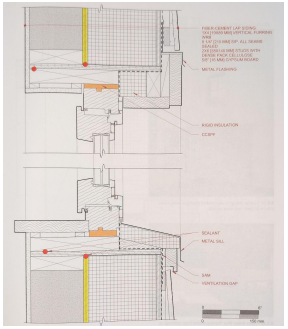
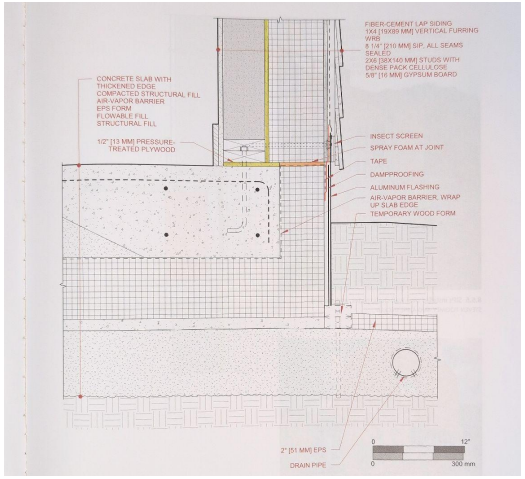


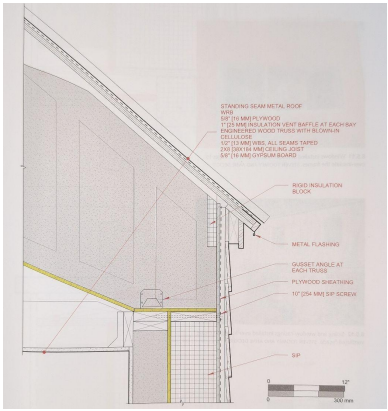
Figure 14: Examples of window cill, head and jamb details

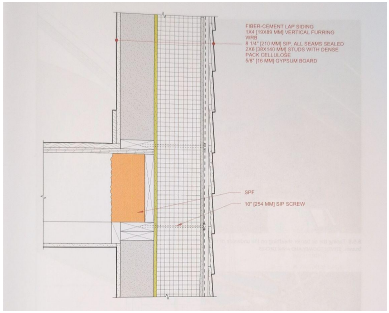
SIP on Wood Frame

GO Logic / Opal Architecture









Larsen Truss

Carly Coulson Architect

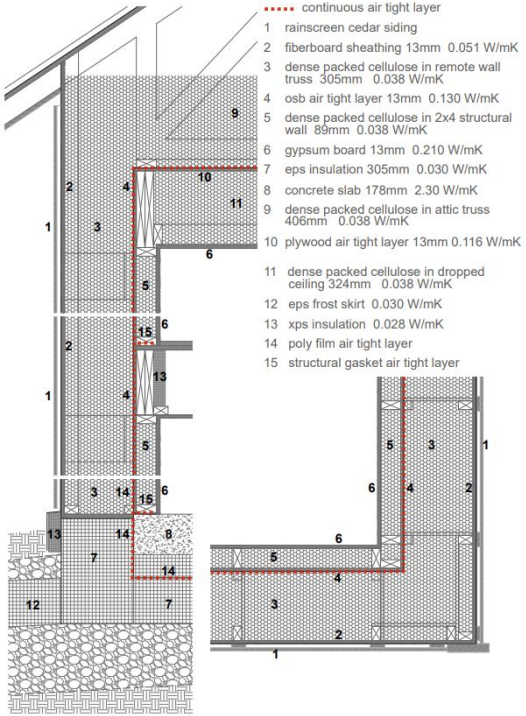


Photo of remote wall wood truss installed on east wall with poly film air tight layer lapped up wall OSB sheathing.

Photo of weather barrier on east wall with rainscreen battens, fiberboard sheathing on south wall.

Photo of EPS foam around concrete slab-on-grade, EPS frost skirt, and poly film air tight layer.

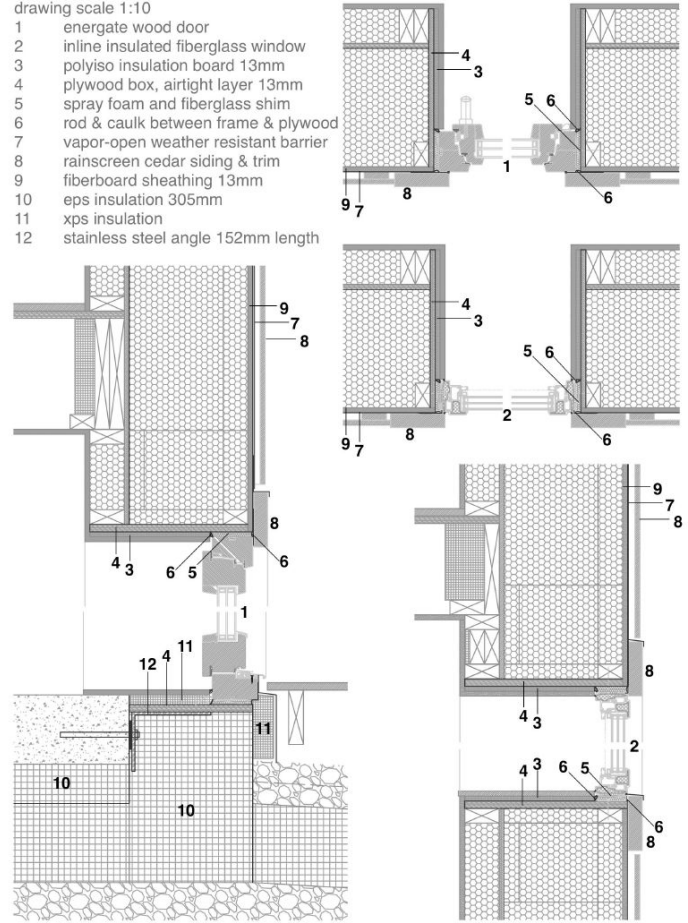
Photo of dense packed cellulose installed in 2x4 stud wall and insulation between floor joists.

Photo of roof plywood air tight layer seams taped, roof trusses before insulation install.

Photo of OSB air tight layer seams taped, plywood window box, and remote wall trus

drawing scale 1:10

1 energate wood door
2 inline insulated fiberglass window
3 polyiso insulation board 13mm
4 plywood box, airtight layer 13mm
5 spray foam and fiberglass shim
6 rod & caulk between frame & plywood
7 vapor-open weather resistant barrier
8 rainscreen cedar siding & trim
9 fiberboard sheathing 13mm
10 eps insulation 305mm
11 xps insulation
12 stainless steel angle 152mm length



Insulated Concrete Forms

Project Designer Dipl.-Ing. Tim Delhey Eian - TE Studio, Ltd. (http://testudio.com)

The Passive House in the Woods is a single family home located in the Town of Hudson, Wisconsin (USA). The insulated concrete form substructure was built in the winter of 2009/10, and the home finished in September of 2010. The project is Wisconsin's first certified Passive House and at the time, one of only a handful of certified Passive House projects in the United States of America.

Special features

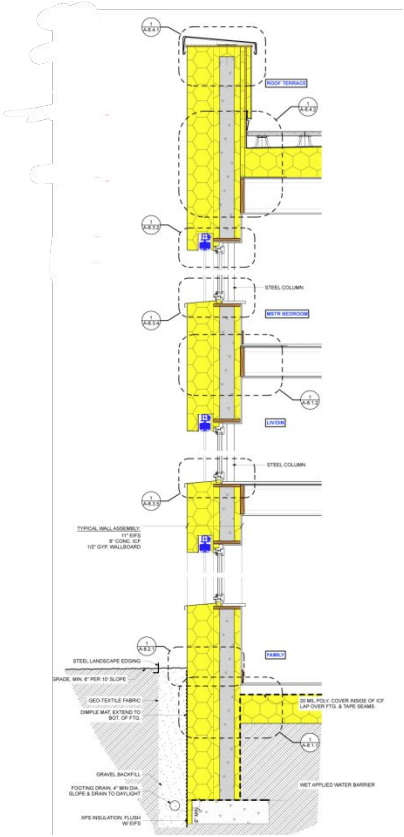
Renewable systems to target carbon-neutral operation
Rooftop terrace, exterior deck and stair structure
Earth-friendly interior and exterior finishes throughout
Automated ventilation system with earthloop preheating/ precooling system

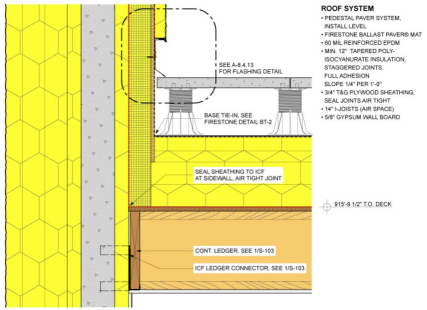
U-value exterior wall	0,083 W/(m²K)
U-value basement slab	0,097 W/(m²K)
U-value roof	0,06 W/(m²K)
U-value window	0.82 W/(m²K)
Effective heat recovery	80.4%

PHPP annual heating demand 11 kWh/(m²a)

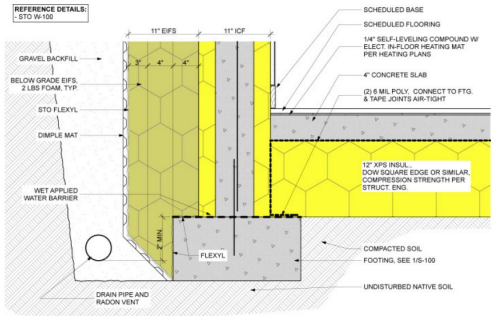
PHPP primary energy demand 106kWh/(m²a)*
Pressure test n_{50} 0.25h⁻¹
*) Verification mode; 66 kWh/(m²a) in design mode for 2-person household

Specific Demands with Reference to the Treated Floor Area				
Treated Floor Area:	164. 5 m²			
	Applied	Annual Method	PH Certificate:	Fulfilled?
Specific Space Heat Demand:	11	kWh/(m²a)	15 kWh/(m²a)	Yes
Annual Heat Demand QH	1819	kWh/a		
Pressurization Test Result:	0.3	h⁻¹	0.6 h⁻¹	Yes
Specific Primary Energy Demand (DHW, Heating, Cooling, Auxiliary and Household Electricity)	105	kWh/(m²a)	120 kWh/(m²a)	Yes
Specific Primary Energy Demand (DHW, Heating and Auxiliary Electricity)	55	kWh/(m²a)		
Specific Primary Energy Demand Energy Conservation by Solar Electricity:	82	kWh/(m²a)		
Heating Load:	18	W/m²		
Heating Load PH	2980	W		
Frequency of Overheating:	2	%	over 25 K to	
Specific Useful Cooling Energy Demand:	1	kWh/(m²a)	15 kWh/(m²a)	Yes
Cooling Load:	7	W/m²		

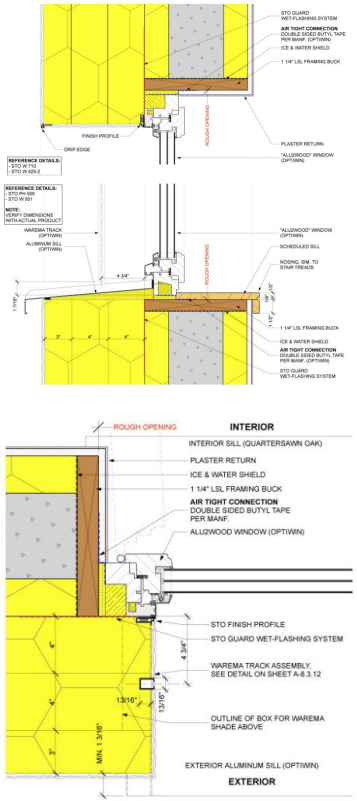




2.7.3 Exterior wall to roof connection



2.7.1 Slab to basement wall detail



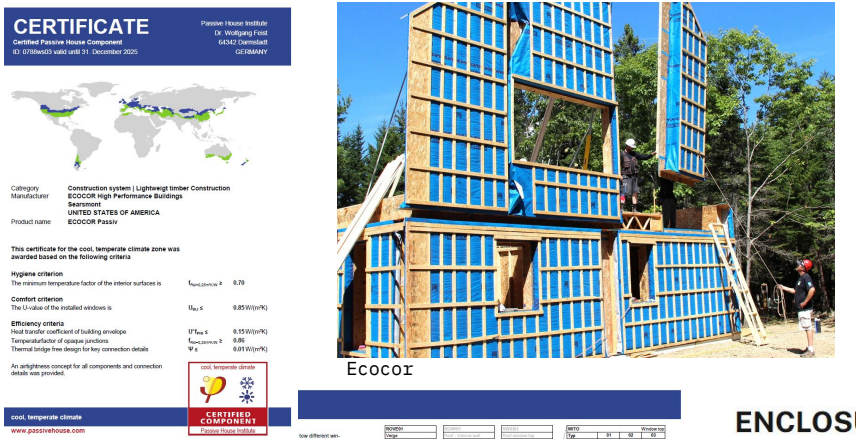
1. Context of Passive House
2. The Work of Enclosures
3. Efficient Design & High Quality
4. Details
5. **Execution**

Site Built

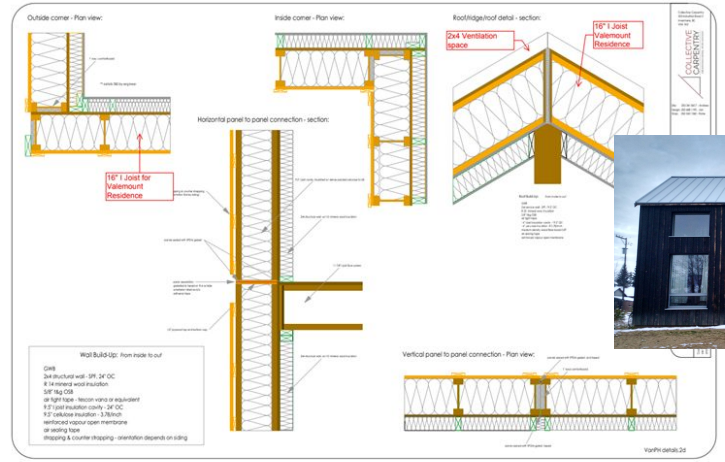
Fort St. John Passive House, BC

Panelized Systems

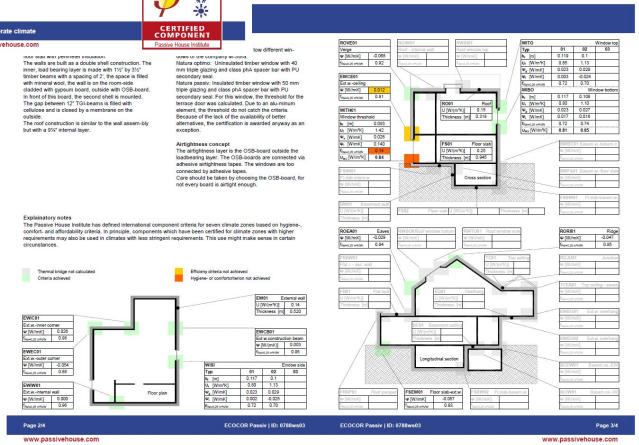
Enclosure systems



Ecocor



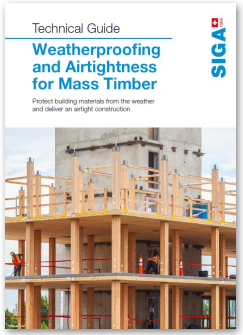
Collective Carpentry

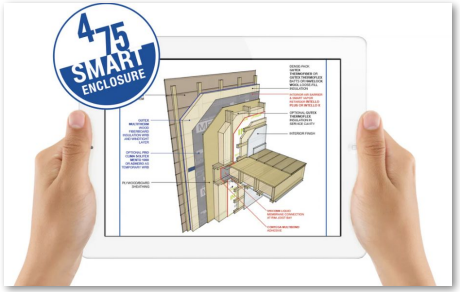


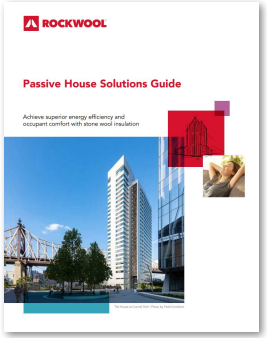
ENCLOSURE SYSTEMS

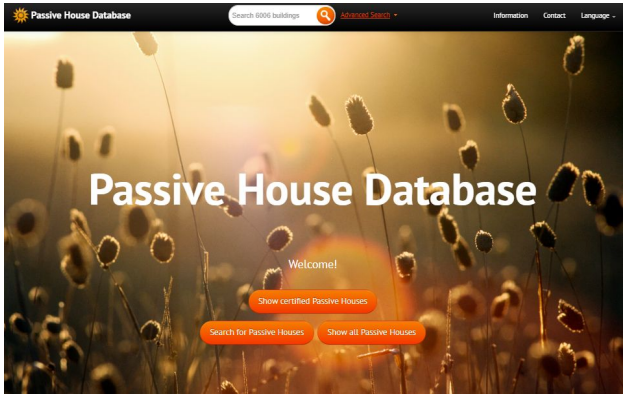
Manufacturer/Supplier	Specialty	Offers PHI Certified Components	HQ Location	Link
B.Public Prefab	panelized		New Mexico	https://www.bpublicprefab.com/
Blueprint Robotics	panelized		Maryland	https://www.blueprint-robotics.com/
BuildSmart	panelized	Yes	Kansas	https://buildsmartna.com/
Collective Carpentry	panelized		British Columbia	https://collectivecarpentry.com/
Ecococon	panelized / straw	Yes	Slovakia/NY	https://ecococon.eu/us/
Ecocor	panelized	Yes	Maine	https://ecocor.us/
EkoBuilt	panelized / kits		Ontario	https://ekobuilt.com/passive-house-kit/
GO Logic	panelized		Maine	https://www.gologic.us/thegohome
Holzraum System	panelized / mass timber		Pennsylvania	https://www.holzraumsystem.com/
Legalett	panelized	Yes	Quebec	https://legalett.ca/
NotchSB / Opal Shelter	mass timber		Maine	https://www.notchsb.com/ – https://opalshelter.us/
Pheonix Haus	panelized	Yes	Colorado	https://phoenixhaus.com/
Quantum Passivhaus	panelized	Yes	Ontario	https://www.quantumpassivhaus.com/

Key Resources...

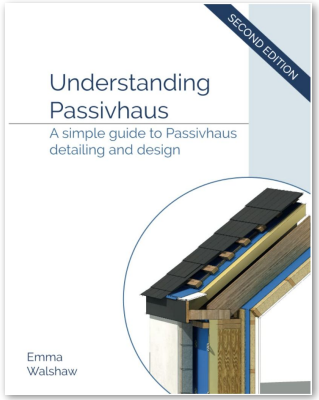


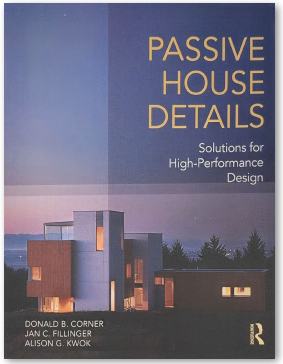


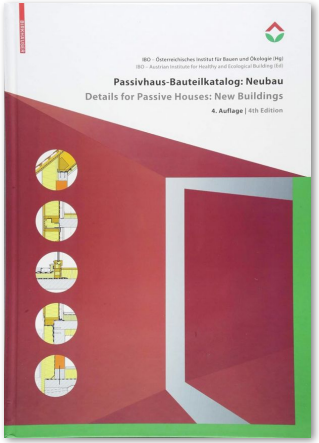


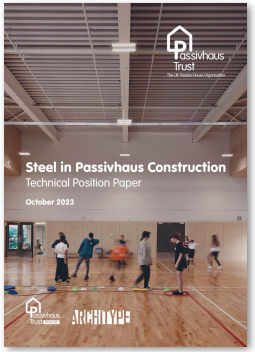


Secret: You can use the details and substitute the specs.









Resources

Resources

1. A Comparison of Canadian and European Energy Standards for Household Appliances - https://passivehousenetwork.org/featured/appliance-modeling-guide/
2. BC Hydro Building Envelope Thermal Bridging - https://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/power-smart/builders-developers/building-envelope-thermal-bridging-guide-v1-6.pdf
3. Building Certifier Scope of Services - https://passivehousenetwork.org/wp-content/uploads/2024/07/Building-Certifier-Scope-of-Services-JULY-2024-UPDATE.pdf
4. Building Database - https://passivehouse-database.org/index.php?lang=en
5. Building for People - https://islandpress.org/books/building-people#desc
6. Certification Criteria - https://passivehouse.com/03_certification/02_certification_buildings/08_energy_standards/08_energy_standards.html
7. Certification Guide - https://passivehouse.com/03_certification/02_certification_buildings/09_guide/09_guide.html
8. Certified Components - https://database.passivehouse.com/en/components/
9. Certifiers Globally - https://passivehouse.com/03_certification/02_certification_buildings/03_certifiers/01_accredited/01_accredited.html
10. Certified Passive House Designer Training - https://passivehousenetwork.org/designer-training/
11. Certified Passive House Tradesperson Training - https://passivehousenetwork.org/tradesperson-training/
12. Construction Cost Analysis of High-Performance Multi-Unit Residential Buildings in British Columbia - https://passivehousenetwork.org/wp-content/uploads/2024/10/CONSTRUCTION-COST-ANALYSIS-OF-HIGH-PERFORMANCE-MULTI-UNIT-RESIDENTIAL-BUILDINGS-IN-BRITISH-COLUMBIA-V3.1.pdf
13. Details for Passive Housees: New Buildings - https://www.thriftbooks.com/w/passivhaus-bauteilkatalog-neubau--details-for-passive-houses-new-buildings-kologisch-bewertete-konstruktionen--a-catalogue-of-ecologically-rated-constructions-german-edition/54431586/item/83148133/
14. Details for Passive Houses: Renovation - https://birkhauser.com/en/book/9783035607543
15. Easi Guide to Passivhaus Design - https://www.levittbernstein.co.uk/site/assets/files/3553/passivhaus-easi-guide_screen_portrait.pdf
16. High Performance Walls Study by Steven Winter Associates - http://swinter.com/wp-content/uploads/High-Performance-Walls-2019-reformatted.pdf
17. Is Cost the Barrier to Passive House Performance? - https://passivehousenetwork.org/wp-content/uploads/2022/10/Is-Cost-the-Barrier-to-Passive-House-Performance-May-2021-PHN.pdf
18. ISO 9972 - https://www.iso.org/standard/55718.html
19. Legalizing Mid-Rise Single-Stair Housing in Massachusetts - https://www.jchs.harvard.edu/sites/default/files/research/files/harvard_jchs_utile_boston_indicators_single-stair_housing_october_10_2024.pdf
20. Manager Declaration Sample - https://passipedia.org/_media/picopen/construction_manager_declaration.pdf
21. Manufacturers Directory - https://passivehousenetwork.org/manufacturers-directory/
22. National Definition of Zero Emissions Building: https://www.energy.gov/sites/default/files/2024-06/bto-national-definition-060524.pdf
23. North American Certifiers Circle - https://passivehousenetwork.org/wp-content/uploads/2023/01/NACC-Brochure-Jan-2023.pdf
24. Passipedia - https://passipedia.org/start
25. Passive Architecture - https://issuu.com/lafamillecarbonic/docs/passive_architecture_en
26. Passive House Certification - https://passivehousenetwork.org/certification/
27. Passive House Criteria for Buildings - https://passivehouse.com/03_certification/02_certification_buildings/08_energy_standards/08_energy_standards.html
28. Passive House Definition - https://passipedia.org/basics/the_passive_house_-_definition
29. Passive House Details - https://www.amazon.com/Passive-House-Details-Solutions-High-Performance/dp/1138958263
30. Passive House - Historical Review - https://passipedia.org/basics/the_passive_house_-_historical_review
31. Passive House Planning Package (PHPP) - https://passivehouse.com/04_phpp/04_phpp.htm
32. Safe at Home PHN Report - https://passivehousenetwork.org/safe-at-home/
33. Sample Submission Documents - https://passipedia.org/certification/certified_passive_houses/example_documents
34. Summer Comfort - https://passipedia.org/planning/summer_comfort
35. The Greenest Home - https://www.amazon.com/Greenest-Home-Superinsulated-Passive-Design/dp/1616891246
36. Thermal Comfort - https://passipedia.org/basics/building_physics_-_basics/thermal_comfort
37. Understanding Passivhaus - https://www.firstinarchitecture.co.uk/understanding-passivhaus/
38. Unlocking livable, resilient, decarbonized housing with Point Access Blocks - https://www.larchlab.com/wp-content/uploads/2022/01/Eliason_CoV-Point-Access-Blocks-report_v1.2.pdf
39. Vancouver Passive House Verification Plan Checklist - https://passivehousenetwork.org/wp-content/uploads/2024/07/Vancouver-Passive-House-Verification-Plan-Checklist-2023.pdf
40. Ventilation Duct Leakage Testing - https://passivehousenetwork.org/product/multifamily-ventilation-duct-leakage-targets-strategies-and-lessons-learned/

Thank you.

www.passivehousenetwork.org

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Ventura, CA

Sep 29 - Oct 3, 2025

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- Architects, Designers
- Construction Professionals

Registration

- Upon approval, tuition fees are covered by 3C-REN for professionals operating in the counties of Santa Barbara, San Luis Obispo, and Ventura (scan QR code for more info)
- Some spots available for purchase for participants from outside the 3C-REN territory ($2490/person)

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FOCUS BOOT CAMP

Format: **In-person**

Typical Schedule:

- **Building Science Course -** Sep 29+30
- **Hands-on Workshop -** Oct 1+2
- **Passive House Certification Exam -** Oct 3

Application Deadline: **Sep 19**

In-person days are 8am-5pm

Lunches are provided (Mon-Thu)

www.emupassive.com

Format: **Hybrid**

Typical Schedule:

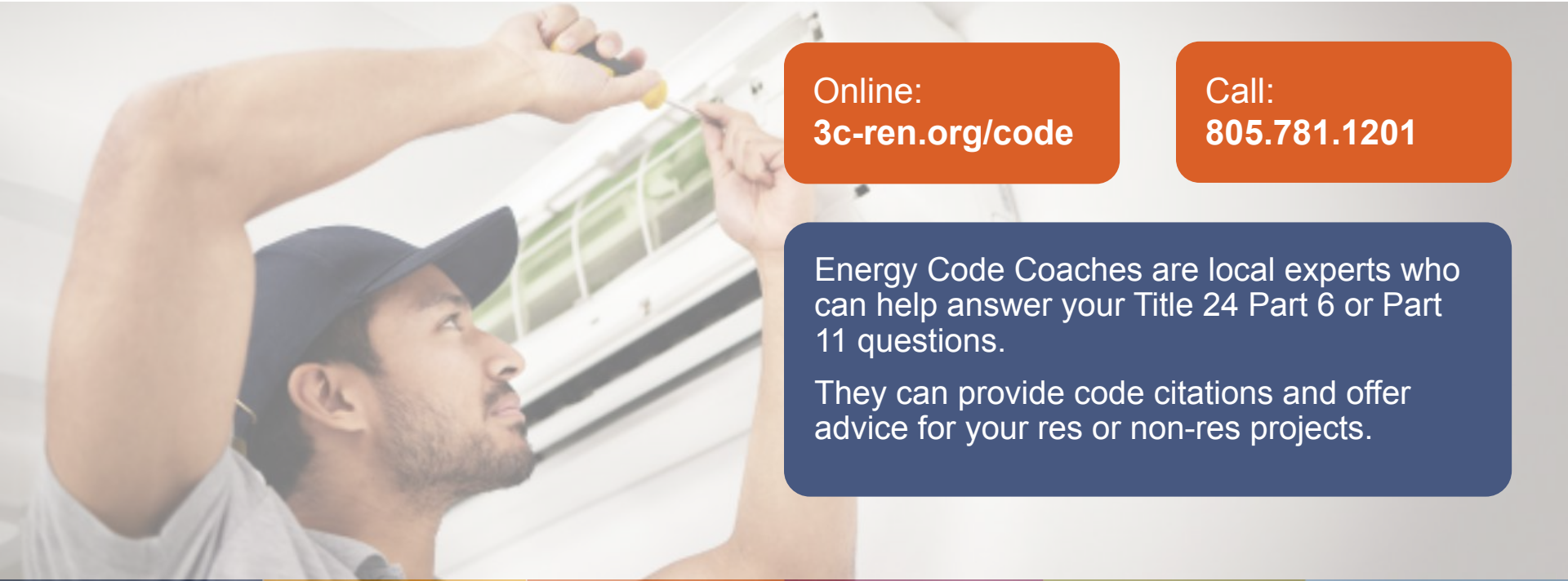
- **Building Science Course –** 16hr self-paced on-demand, before coming in for the hands-on workshop
- **Hands-on Workshop -** Oct 1+2
- **Passive House Certification Exam -** Oct 3

Application Deadline: **Sep 1**

www.emupassive.com

Questions about Title 24?

3C-REN offers a *free* Code Coach Service



Online:
3c-ren.org/code

Call:
805.781.1201

Energy Code Coaches are local experts who can help answer your Title 24 Part 6 or Part 11 questions.

They can provide code citations and offer advice for your res or non-res projects.

Closing

Continuing Education Units Available

- Contact dresurreccion@co.slo.ca.us for AIA LUs

Coming to Your Inbox Soon!

- Slides & Recording

Get Passive House Certified (*FREE)!

- Certified Passive House Designer/Consultant Pacific Fall 2025 Cohort
- 5-Day Passive Design/Build Bootcamp in Santa Barbara Ventura (Sept 29 – Oct 3)

Upcoming PHN Courses:

- Aug 12 – Next Generation Passive Solar (IN PERSON in Santa Barbara, CA)
- Aug 14 – Intro to Passive House Trades

Any phone numbers who joined? Please share your name!

Thank you!

More info: **3c-ren.org**

Questions: **info@3c-ren.org**

Email updates: **3c-ren.org/newsletter**

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