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WSEC-R 2021

Changes to the WSEC-R
Continuous Insulation

Minimize Thermal Bridging • Increase Thermal Resistance
Lower Heating Loads • Less Cost to Heat • Greater Durability
Less Maintenance • Happier Owner / Occupants

Rick Blumenthal
Program Coordinator,
Washington State University Energy Program

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LEARNING OBJECTIVES

- Continuous Insulation – What is it ?
- Water, Air and Thermal Control
- Application
- Options
- Cladding Attachment and Long Term Movement – Cladding Over Rigid
- Advanced Framing – Cost and Energy Savings – can offset costs of CI

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TODAY'S AGENDA

- Background
- Evolving Codes
- The Case for Continuous Insulation
- Options
- Cladding Attachment and Long Term Movement – Cladding Over Rigid
- Advanced Framing – Cost and Energy Savings – can offset costs of CI

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THE CASE FOR CONTINUOUS INSULATION

- Residential building sector consumes ± 21% of the primary energy used in the U.S.
- Effective thermal resistance is limited by stud cavity depth, framing and structural components
- Cost effective means of increasing thermal resistance of wall assemblies
- Better effective R-Value – with Advanced Framing cavity insulation + CI, R values are greater than just adding
- Energy code push for increased efficiency in energy consumption
- It is more cost-effective to add insulation during construction than to retrofit it after the house is finished
- Air barrier and drainage plane integrity
- Furring strips create a significant upgrade in water management
- Reduced risk of condensation and wood decay in cold climates
- Seasonal thermal and moisture variations of the wood frame are greatly reduced
- Freeze-thaw in masonry assemblies practically eliminated plus limits rainwater absorption
- Provides a substantial upgrade in water management and drying potential
- Saves $$$ over annual energy cost for space conditioning

Baker, P & Lepage, R. "Cladding Attachment Over Thick Exterior Insulating Sheathing", Building America Report – 1314, Building Science Corporation, July 2013 Building Science Press

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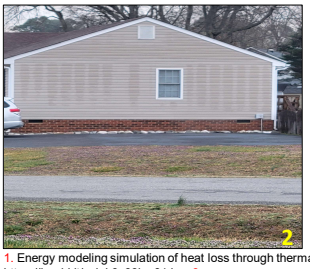
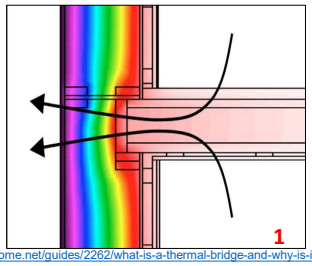
KEY DEFINITIONS: IECC 2021

- **CONTINUOUS INSULATION (CI) –** Uninterrupted insulating material installed across all structural members*
  - May be installed at interior or exterior
  - Installed to minimize Thermal Bridging
- **THERMAL BRIDGING –** a material with higher Thermal Conductivity than the surrounding materials, a path of least resistance for heat transfer into or out of conditioned space.
- **THERMAL CONDUCTIVITY –** Ability of a substance, (material) to transfer (heat) energy through materials that are in direct contact with each other.
- **EFFECTIVE R VALUE –** the overall thermal resistance of a complete assembly






1. Energy modeling simulation of heat loss through thermal bridging © Denis Boyer for Ecohome; https://www.ecohome.net/guides/2262/what-is-a-thermal-bridge-and-why-is-it-so-important-to-break-it/ 2. Reddit.com; https://i.redd.it/xgigh3y33km81.jpg 3. **PROJECT INVESTIGATING ACCURACY OF 3-D THERMAL BRIDGING MODELING OF ROOF FASTENERS TO BE CARRIED OUT IN BEST-LAB TEST CHAMBER, BUILDING ENCLOSURE SYSTEMS LAB GEORG REICHARD, VIRGINIA TECH. JULY 15, 2019;** 4. GREEN BUILDING ADVISOR, THERMAL BRIDGING, Thermal Bridging – GreenBuildingAdvisor PETER YOST, MARCH 19, 2009. 5. DAILY COMMERCE NEWS, THERMAL BRIDGING CAN IMPACT ENERGY PERFORMANCE, MOISTURE AT WALLS THROUGH METAL FRAMING, DON PROCTOR, JUNE 21, 2013

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SPEAKING THE SAME LINGO – 手に入れました？– WHAT *EXACTLY* DO WE MEAN

Fundamental Principals:

- Wall assemblies are one part of the *Building Enclosure* – function as an environmental separator
- Four principal layers needed for durability:
  - **Water control layer** – bulk (penetrating) water, (rain) most important in both design and construction, water repellant, located behind cladding, designed to drain water passed through the cladding, must be continuous, i.e., *drainage plane, water resistive barrier, water control layer* : 3/16” – 3/8” for rain
  - **Air control layer** – primary air enclosure boundary, separates *indoor conditioned* air from *outdoor and unconditioned* air. Must be continuous, impermeable to airflow, durable over lifetime of building, best practice is air control layer at both exterior and interior.
  - **Vapor control layer** – Keeping *water vapor* out of the assembly, let it out if it enters. Can be complicated, i.e., keeping water vapor out might trap it in. Best to design a *flow-through* assembly, vapor flow in both directions, warm side of insulation in winter.
  - **Thermal control layer** – Control temperature on condensing surface, best application is *exterior insulation*, (ci) higher surface temperature, (above dew point) interior water vapor will not condense

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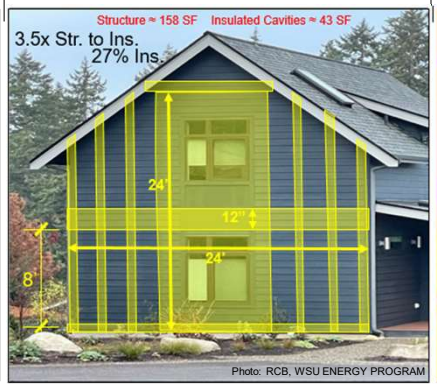
THERMAL BRIDGING

*"…thermal bridging through framing components reduces insulation performance by as much as 15-20 percent in wood frame construction and by 40-60 percent in metal framed buildings."**

Over-framed walls like this lose a substantial amount of energy via thermal bridging. Exterior insulation overcomes much of this loss.

Melted lines on a frosty wall show the heat passing through the wall at stud locations. Exterior foam insulation would make a difference.



This infrared image shows the cold studs in a heated house on a winter day. Exterior foam insulation could prevent this source of heat loss.

*builderonline.com/building/building-enclosure/exterior-foam-insulation-problems-and-solutions ,Exterior Foam Insulation: Problems and Solutions, July 30,2020
Echotape.com, Continuous Insulation – What is it and Why Do We Care?
Builder Magazine, Avoiding Common Callbacks, Exterior Foam Insulation: Problems and Solutions, Steve Easley, July 30, 2020

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THE JUSTIFICATION FOR CONTINUOUS INSULATION

- More thermally efficient enclosure assemblies
- Increased air tightness
- A means of reducing the condensation potential within exterior wall assemblies
- Decreased risk of moisture damage
- The base wall assembly generally remains unchanged
- Combined with advanced framing can provide cost savings from reduction of building materials, i.e., fewer studs
- Completely wraps the exterior of the building framing rather than insulation just added to cavities between studs
- Reduced thermal stress of the structure
- Ensures building will easily hit energy standards

Guide to Insulating Sheathing, Building Science Corporation, Revised January, 2007 buildingscience.com/sites/default/files/migrate/pdf/GM_Guide_Insulating_Sheathing.pdf

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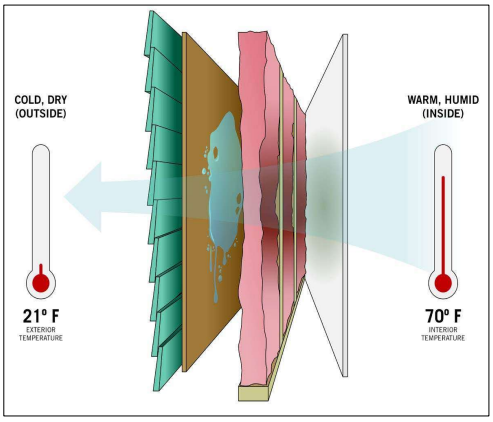
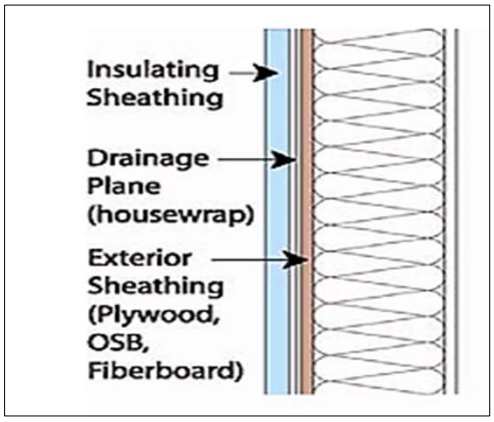
A BIT OF BUILDING SCIENCE





Huber Engineered Woods, Designing with Continuous Insulation for Thermal and Moisture Management, April 10, 2018
BuildingScience.com, Guide to Insulating Sheathing, Building America, U.S. Dept. of Energy. January 2007;

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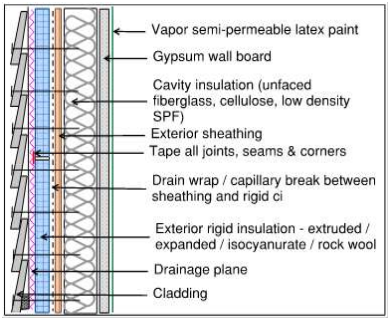
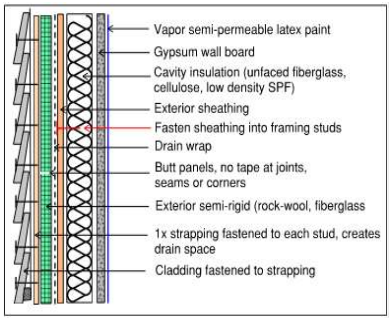
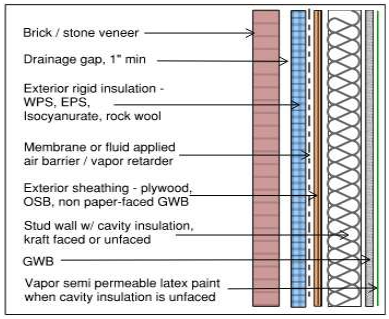
COMMON RERSIDENTIAL WALL ASSEMBLIES WITH CONTINUOIUS INSULATION



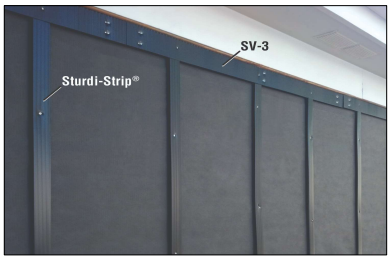
WOOD FRAME WALL W/ FOAM ci



WOOD FRAME WALL W/ ROCK WOOL ci



BRICK VENEER WALL W/ FOAM ci



Architect Newswire, Sturdi-Strip®, Cora Vent Inc. Steve Lowe, 2024;

Bluekin, BK Steel Nails;

Fine Homebuilding, May 16, 2016

Building Science Corp., BSI-120 Understanding Walls, December 15, 2020

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This foil-faced foam sheathing has taped seams and proper flashing details so it can serve as a drainage plane.

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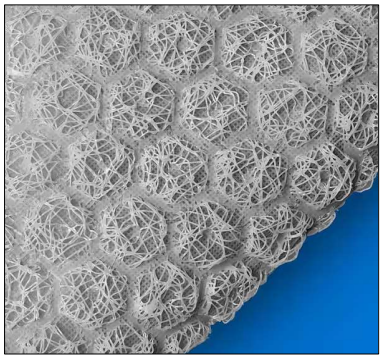


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SIMPLE MATH ? WHY AN R-25 WALL IS NOT EQUAL TO AN R-20 + 5 Ci

- Energy code math is no different than any other math, i.e., 1+1=2 still holds true
- Units must agree – 1 apple + 2 oranges ≠ 3 oranges; adding up R-Values for insulation located in different parts of a wall does not work either:
  - Cavity insulation is *interrupted* by framing - allows heat through more readily
  - Continuous insulation is *uninterrupted* – framing (heat) losses are minimized
  - Layer of Cavity insulation w/ same R value is less effective than layer of Continuous Insulation
- Method for calculating requires the *Parallel Path*
  - Determine R-Value for each different path, i.e., through two paths: cavity insulation, framing
  - Include all material and properties, i.e. *air films, cladding, sheathing, drywall*
  - Combine the total of the two paths to get overall R-Value of entire wall assembly
  - Totals = the sum of R-Values for each layer in each path

1.Crandell, J. & Ahrenholz, T. Foam Plastics Applications for Better Living, "Energy Code Math Lesson: Why an R-25 Wall is Not Equal to a R-20+5ci", August 7, 2017

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PARALLEL PATH EXAMPLES (Wood Framed Walls)

EXAMPLE - R25 (cavity) + RØ (ci) wall: and R20 + 5 (ci) wall

	R25 + 0ci Wall		R20 + 5ci Wall	
Layer	**Framing Path**	**Cavity Path**	**Framing Path**	**Cavity Path**
Outside Air Film	R-0.17	R-0.17	R-0.17	R-0.17
Siding	R-0.62	R-0.62	R-0.62	R-0.62
Continuous Insulation	---	---	R-5	R-5
7/16" OSB	R-0.62	R-0.62	R-0.62	R-0.62
SPF 2x6 Stud	R-6.875	---	R-6.875	---
Cavity Insulation	---	R-25	---	R-20
½" Drywall	R-0.45	R-0.45	R-0.45	R-0.45
Inside Air Film	R-0.68	R-0.68	R-0.68	R-0.68
Total	**R-9.415**	**R-27.54**	**R-14.415**	**R-27.54**

Same R-Value though R20 +5ci is *12% greater in thermal resistance* than R25 +Ø ci

NEXT STEPS and ASSUMPTIONS

- Combine the two parallel paths for overall value
- Assume 25% Framing Factor, *(f f)* = 21% studs, 4% headers
- 75% cavity area – typical for 16" o.c. framing
- Calculate the U-Factor:

$$U = ff_{framing} * \frac{1}{R_{framing}} + ff_{cavity} * \frac{1}{R_{cavity}}$$

R25 Cavity + Ø ci wall

*U = .25 * 1 / 9.45 + .75 * 1 / 27.54 = .25 * .1058 + .75 * .036 =*

Effective U Factor = 0.02645 + 0.027 = 0.05345

R = 18.7

R20 Cavity + 5 ci wall

*U = .25 * 1 / 14.45 + .75 * 1 / 27.54 = .25 * .0173 + .75 * .036 =*

Effective U Factor = 0.0173 + 0.0272 = 0.0443

R = 22.57

1.Crandell, J. & Ahrenholz, T. Foam Plastics Applications for Better Living, "Energy Code Math Lesson: Why an R-25 Wall is Not Equal to a R-20+5ci", August 7, 2017

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Ci COMBINED WITH ADVANCED FRAMING – WHAT'S THE DOWN SIDE ?

Advanced Framing . Advanced Wall Systems (AWS) . Optimum Value Engineering (OVE)

- ✓ Minimize the amount of wood, 5% to 10% less lumber, (Board Ft.)
- ✓ Faster build – uses 30% fewer pieces
- ✓ Framing factor is reduced from 25% to 17%
- ✓ Provides ≈ 2-1/2 Ft.^{3} additional insulation, (assumes single top plate, i.e. 94" 2x6 stud)
- ✓ Reduces the effect of thermal bridging
- ✓ Reduces air infiltration and exfiltration
- ✓ Includes increased header insulation
- ✓ Raised heal truss allows full insulation over exterior wall plate
- ✓ Structural members are stacked creating direct load paths, fewer structural beams
- ✓ Studs support floor, ceiling and roof
- ✓ Reduced resource consumption, less waste
- ✓ **BOTTOM LINE** – COST / ENERGY SAVINGS FOR GC, TRADES, OWNER

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SAME WALL ASSEMBLY WITH ADVANCED FRAMING

- Combine the two parallel paths for overall value
- Assume 17% Framing Factor– typical for 24" o.c. framing
- 83% cavity area – typical for 24" o.c. framing
- Calculate the U-Factor:

$$U = ff_{framing} * \frac{1}{R_{framing}} + ff_{cavity} * \frac{1}{R_{cavity}}$$

EXAMPLE - R25 (cavity) + RØ (ci) wall and R20 + 5 (ci) wall with Advanced Framing

The calculation remains the same

R25 Cavity + Ø ci wall

*U = .17 * 1 / 9.45 + .83 * 1 / 27.54 = .17 * .1058 + .83 * .036 =*

Effective U Factor = 0.0179 + 0.0301 = 0.048

R = 20.83

R20 Cavity + 5 ci wall

*U = .17 * 1 / 14.45 + .83 * 1 / 27.54 = .17 * .1058 + .83 * .036 =*

Effective U Factor = 0.0118 + 0.0301 = 0.0419

R = 23.86

	R25 + 0ci Wall		R20 + 5ci Wall	
Layer	**Framing Path**	**Cavity Path**	**Framing Path**	**Cavity Path**
Outside Air Film	R-0.17	R-0.17	R-0.17	R-0.17
Siding	R-0.62	R-0.62	R-0.62	R-0.62
Continuous Insulation	---	---	R-5	R-5
7/16" OSB	R-0.62	R-0.62	R-0.62	R-0.62
SPF 2x6 Stud	R-6.875	---	R-6.875	---
Cavity Insulation	---	R-25	---	R-20
½" Drywall	R-0.45	R-0.45	R-0.45	R-0.45
Inside Air Film	R-0.68	R-0.68	R-0.68	R-0.68
Total	**R-9.415**	**R-27.54**	**R-14.415**	**R-27.54**

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PROS AND CONS OF ADVANCED FRAMING

CONCERN	RESOLUTION
• Tile cracking due to joist spacing increase to 24”	• Increase joist depth, decrease spacing, blocking
• Increased joist depth at 2nd floor	• Accommodate added depth at stair rise / run
• Picture hanging, other wall decorations	• May require additional blocking
• Drywall support, flat walls	• ½” drywall, ½” ceiling board on walls, 5/8” drywall
• Shifting windows and partitions to 24” layout	• Optimal but not necessary to maintain aesthetics
• Code compliance acceptance	• IRC approved w/ specialized stipulations (A103)
• Owner acceptance	• No requirement to inform though identify benefits
• Energy savings	• Approximately equal to 13% annually
• Construction cost	• Simplicity of framing + less complicated for trades

Lstiburek, J. & Grin, A, Building Science Corporation, “Building America Special Research Project: Deployment of Advanced Framing at the Community Scale, Building America Report – 1004, November 15, 2010

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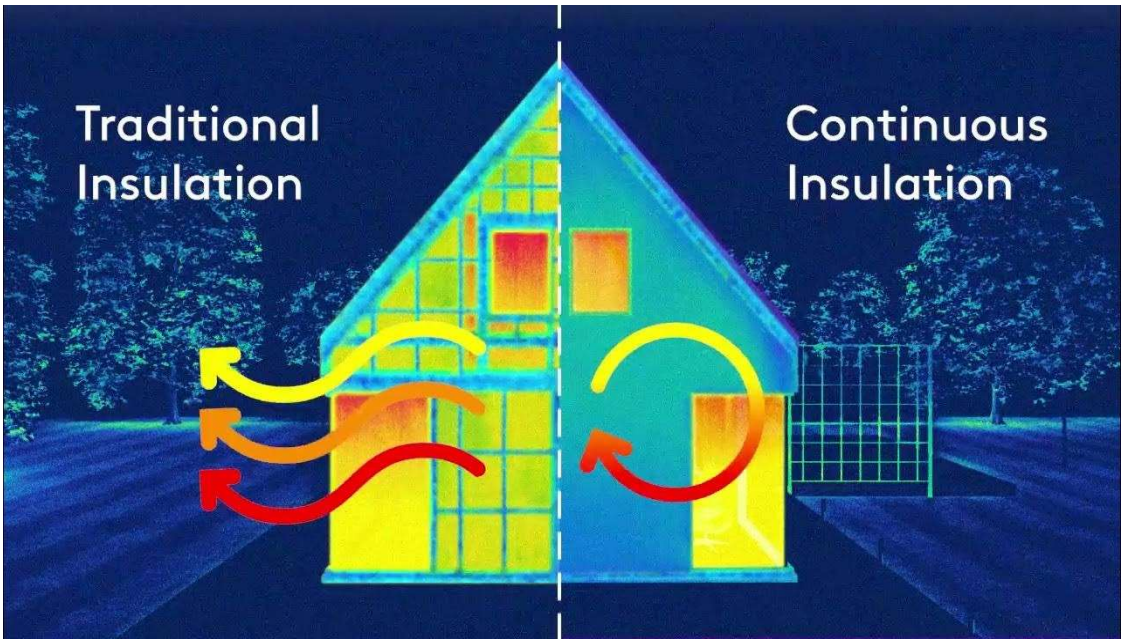
CONTINUOUS INSULATION



Kingspan, youtube.com/watch?v=1No6rtOexqk

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INSTALLING CONTINUOUS INSULATION

Choose a product that is easy to install and will withstand exposure until covered

Store according to manufacturer's recommendations prior to installation

Install according to manufacturer's recommendations and best practices:

- Install over clean, dry surface, do not trap moisture
- Install cladding with fasteners appropriate for type an length for the wall assembly
- WSEC-R defined – Section R402.1.4
  - Continuous insulation (ci) alone shall be used to determine compliance with the continuous insulation R-value requirements in Table R402.1.3.

TABLE R402.1.3
INSULATION MINIMUM R-VALUES AND FENESTRATION REQUIREMENTS BY COMPONENTS[a]

CLIMATE ZONE 5 AND MARINE 4	
Fenestration U-Factor[b,j]	0.30
Skylight[b] U-Factor	0.50
Ceiling R-Value[e]	60
Wood Frame Wall[g,i] R-Value	20+5 or 13+10
Floor R-Value	30
Below-Grade[c,h] Wall R-value	10/15/21 int + 5TB
Slab[d,f] R-Value & Depth	10, 4 ft

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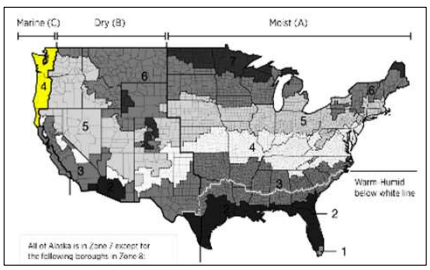
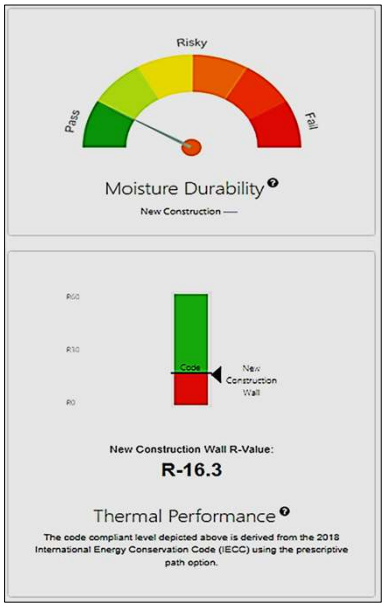


Typical Wood Frame Wall

Climate Zone: 4C - Marine

	New Wall Construction
Exterior Cladding	Fiber Cement Siding
Air Space	None
Continuous Insulation	None
Insulation Thickness	None
WRB Air Barrier	Housewrap/Building Paper (>= 10 perm)
Exterior Sheathing	Plywood/OSB/Fiberboard/Wood Plank
Wall Structure	2 x 6 16 inch o.c. Wood Frame
Cavity Insulation	Fiberglass/Cellulose/Open Cell Foam (R-13/R-21)
Interior Vapor Retarder	Kraft Paper
Interior Finish	Drywall/Latex Paint



The Building Science Advisor, Oak Ridge National Lab, bsa.ornl.gov

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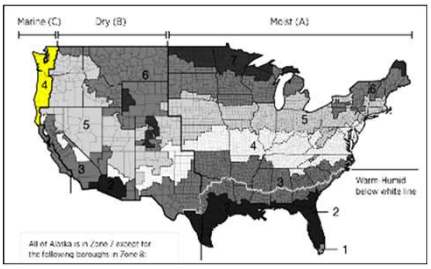
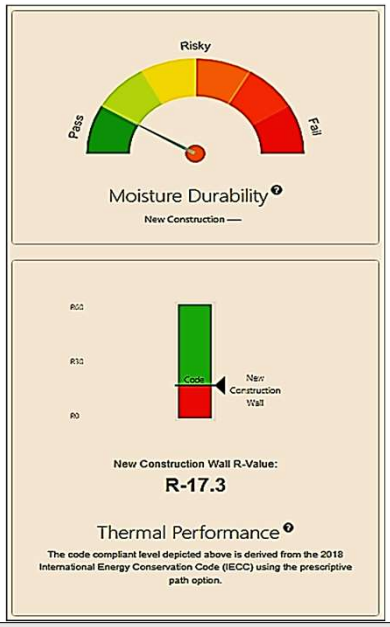


Typical Wood Frame Wall - 2X6 @ 16" O.C. + Air Space

Climate Zone: 4C - Marine

	New Wall Construction
Exterior Cladding	Fiber Cement Siding
Air Space	Drained/Ventilated
Continuous Insulation	None
Insulation Thickness	None
WRB Air Barrier	Housewrap/Building Paper (>= 10 perm)
Exterior Sheathing	Plywood/OSB/Fiberboard/Wood Plank
Wall Structure	2 x 6 16 inch o.c. Wood Frame
Cavity Insulation	Fiberglass/Cellulose/Open Cell Foam (R-13/R-21)
Interior Vapor Retarder	Kraft Paper
Interior Finish	Drywall/Latex Paint



Durability Guidance

This wall assembly has sufficient drying capacity and should perform adequately in the selected climate zone.

The Building Science Advisor, Oak Ridge National Lab, bsa.ornl.gov

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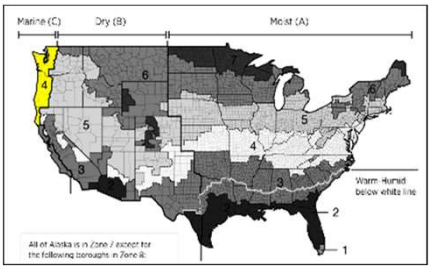
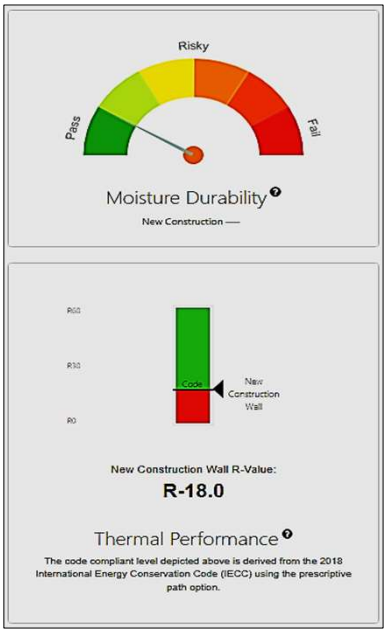


Typical Wood Frame Wall - 2X6 @ 24" O.C.

Climate Zone: 4C - Marine

	New Wall Construction
Exterior Cladding	Fiber Cement Siding
Air Space	Drained/Ventilated
Continuous Insulation	None
Insulation Thickness	None
WRB Air Barrier	Housewrap/Building Paper (>= 10 perm)
Exterior Sheathing	Plywood/OSB/Fiberboard/Wood Plank
Wall Structure	2 x 6 24 inch o.c. Wood Frame
Cavity Insulation	Fiberglass/Cellulose/Open Cell Foam (R-13/R-21)
Interior Vapor Retarder	Kraft Paper
Interior Finish	Drywall/Latex Paint



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This wall assembly has sufficient drying capacity and should perform adequately in the selected climate zone.

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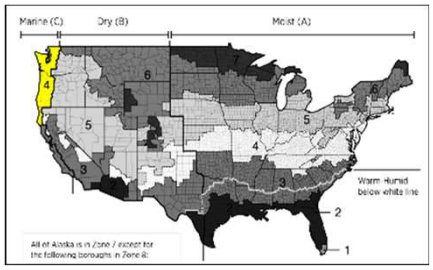
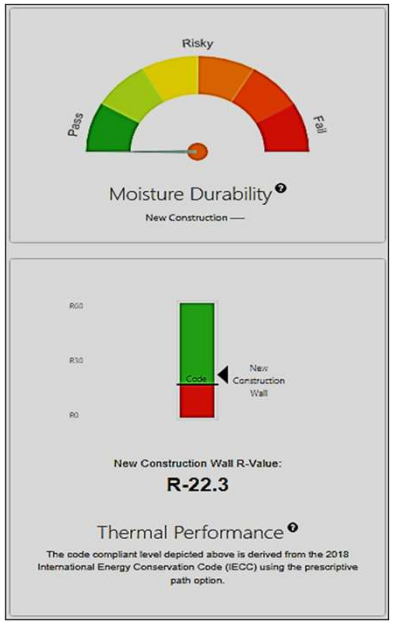


2x6 @ 16" O.C. + Air Gap + 1" XPS ci

Climate Zone: 4C - Marine

	New Wall Construction
Exterior Cladding	Fiber Cement Siding
Air Space	Drained/Ventilated
Continuous Insulation	Extruded Polystyrene
Insulation Thickness	1 in.
WRB Air Barrier	Housewrap/Building Paper (>= 10 perm)
Exterior Sheathing	Plywood/OSB/Fiberboard/Wood Plank
Wall Structure	2 x 6 16 inch o.c. Wood Frame
Cavity Insulation	Fiberglass/Cellulose/Open Cell Foam (R-13/R-21)
Interior Vapor Retarder	Kraft Paper
Interior Finish	Drywall/Latex Paint



Durability Guidance

This wall assembly has sufficient drying capacity and should perform adequately in the selected climate zone.

The Building Science Advisor, Oak Ridge National Lab, bsa.ornl.gov

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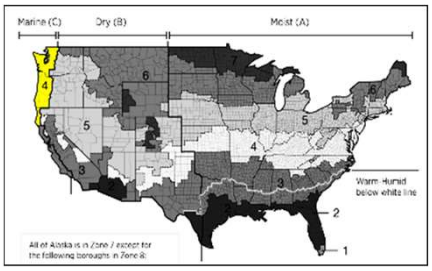
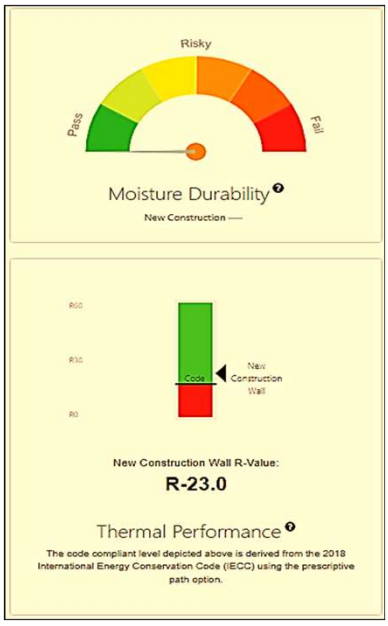


Typical Wood Frame Wall - 2X6 @ 24" O.C. + Air Space + 1" Continuous XPS

Climate Zone: 4C - Marine

	New Wall Construction
Exterior Cladding	Fiber Cement Siding
Air Space	Drained/Ventilated
Continuous Insulation	Extruded Polystyrene
Insulation Thickness	1 in.
WRB Air Barrier	Housewrap/Building Paper (>= 10 perm)
Exterior Sheathing	Plywood/OSB/Fiberboard/Wood Plank
Wall Structure	2 x 6 24 inch o.c. Wood Frame
Cavity Insulation	Fiberglass/Cellulose/Open Cell Foam (R-13/R-21)
Interior Vapor Retarder	Kraft Paper
Interior Finish	Drywall/Latex Paint



Durability Guidance

This wall assembly has sufficient drying capacity and should perform adequately in the selected climate zone.

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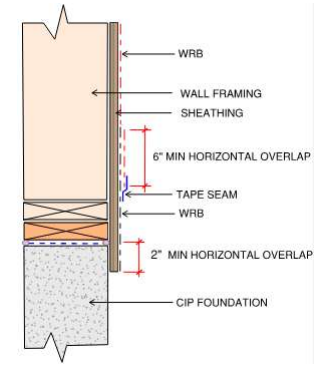
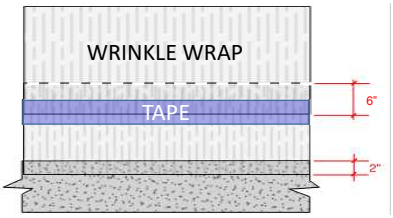
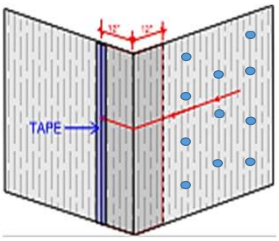
INSTALL WRB – DRAIN / WRINKLE WRAP



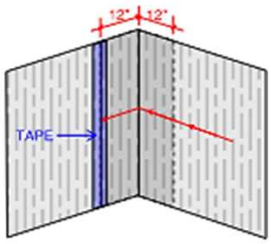


OUTSIDE CORNER WRB OVERLAP

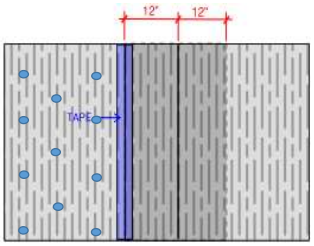
Fasteners (●) shown as examples only



INSIDE CORNER WRB OVERLAP



FIELD BUTT JOINT WRB OVERLAP



WRB INSTALLATION AND OVERLAP CONDITIONS

- Install wrinkle or drain wrap behind rigid exterior ci
- Install smooth and tight to sheathing avoiding wrinkles, bubbles, etc.
- Fasten to sheathing according to manufacturer's recommendations
- Overlap per WRB manufacturer's recommendations and best practices
- Tape / seal all seams and butt joints with Manufacturer's recommended tape or sealant

IMAGES: WSU Energy Program

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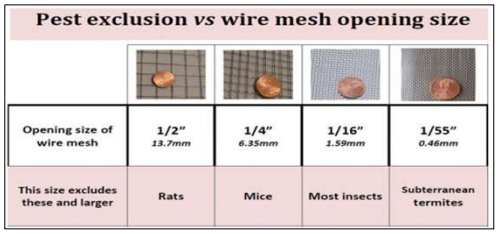
DEALING WITH FENESTRATIONS AND OTHER PROJECTIONS

https://buildingscience.com/documents/insights/bsi-085-windows-can-be-a-pain

REQUIREMENTS FOR SUCCESS

- ✓ Rough window buck extends so that it is flush with face of drainage gap furring
- ✓ If installing rigid foam insulation, install a drain or wrinkle wrap WRB to create a capillary break
- ✓ Fasten, overlap, tape and seal all materials according to manufacturer's recommendations
- ✓ Avoid installing wet materials, protect materials from weather and exposure limits per manufacturer's recommendations



https://polyguard.com/architectural/blog/what-is-a-weep-hole

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PROGRESSION SUMMARY

- Install extruded polystyrene or foil-faced polyisocyanurate
- Install sill flashings on windows and doors.
- Install flashings on all penetrations – no water bypassing drainage plane to the assembly
- Install windows and doors. Proper gravity/shingle lapping of the flashing tape
- Tape the exterior insulation as the drainage plane
- Install the exterior cladding over furring creating drainage plane gap – min 3/16”

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RECOMMENDATIONS FROM THE FIELD

- Drainage planes must be smooth or not significantly textured
- Superior thin tapes are acrylic based, 3 – 4 in. wide
- Superior flashing tapes are butyl based, 4 – 9 in. wide, 20 mil thick, have a compatible facer
- Z-flashings should be used on any high-risk horizontal joint:
  - – Butyl-based flashing tapes 6 – 9 in. wide are preferred
  - – No contractor recommends using polyethylene sheet as a Z-flashing.
- Where thick tapes (20-30 mil) are installed horizontally, a termination strip of thin acrylic tape should always be used
- On horizontal joints, the tape should be offset high; two-thirds of the tape should be on the top board and one-third lapped over the bottom board.

•Vertical joints should be on framing members and be taped with 3 – 4 in. wide thin tape and gravity lapped with the horizontal joint

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2021 INTERNATIONAL RESIDENTIAL CODE

R703.15 - CLADDING ATTACHMENT OVER FOAM SHEATHING TO WOOD FRAMING

- Installed in accordance with Section R703
- The cladding manufacturer's approved instructions including over foam plastic
- *Cladding or furring* attachments through foam sheathing to framing shall meet or exceed the minimum fastening requirements of Section R703.15.1, Section R703.15.2

EXCEPTIONS

- Cladding Mfg. has provided *approved* installation instructions over foam plastic
- EIFS – reference Section R703.9
- Anchored masonry / stone over foam – reference Section R703.8

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CLADDING ATTACHMENT OVER THICK EXTERIOR INSULATION

- Resistive capacity of fastener, i.e., screw, nail to bending or failure
- Bearing strength of furring
- Compressive strength of rigid insulation
- Static friction between layers
- Impact(s) of climate exposure on vertical movement of furring

RESEARCH AND TESTING

- 12 assemblies tested with four different insulation types in an outdoor exposed environment
- Loading at three different levels: 8lb/fastener, 15lb/fastener and 30lb/fastener spaced at 16 and 24 inches
- Measurements recorded at various intervals between July and September 2012

CONSIDERATIONS

- How much force is needed to cause long fasteners to fail under load.
- How does environment exposure impact the movement of furring strips attached through thick, rigid insulation and into a wood structure.

Baker, Peter & LePage, Robert; Cladding Attachment Over Thick Exterior Insulating Sheathing, BA-1314, Building Science Corporation July 15,2013

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CLADDING ATTACHMENT THROUGH 4 INCHES OF EXTERIOR INSULATION

Insulation types tested:

- Expanded Polystyrene – EPS
- Extruded Polystyrene – XPS
- Foil Faced Polyisocyanurate – PIC
- Rigid Mineral Fiber - MF

WHAT FORCES INFLUENCE VERTICAL SHIFT OF THE SYSTEM ?

- How much does (gravitational) force influence vertical shift of the system
- Environmental exposure affecting vertical shift of furring strips attached directly through insulation back to a wood structure

SHORT TERM INITIAL LOADING

- 4x8 panel
- 1x3 furring @24" O.C.
- #10 wood screws @16" O.C.
- 4" and 8" thick rigid insulation
- Load applied to furring strips
- Deflection, (shift) measured between stud framing and furring to capture furring deflection only

Baker, Peter & LePage, Robert; Cladding Attachment Over Thick Exterior Insulating Sheathing, BA-1314, Building Science Corporation July 15,2013

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LONG-TERM EXPOSURE TESTING

- Cladding weight resulting in 30 lbf. per fastener load was too great
- Unacceptable creep of the system was clearly observed
- Limiting cladding weight to 8lbf per fastener demonstrated stable performance.
- Assemblies loaded to 15 lbf. per fastener showed pretty stable performance, may slight indication of system creep
- Recommended to use max load / fastener of no more than 10 lbf. based on a standard #10 wood screw
- May be installed through up to 4 in. of insulation (Table 1).
- Higher capacities would be expected with larger screws or reduced insulation thickness.

Table 1. Recommended Vertical Fastener Spacing (Minimum #10 Wood Screw) Based on Cladding

Cladding Weight (psf)	16 in. o.c. Furring	24 in. o.c. Furring
5	18	12
10	9	6
15	6	4
20	4	3
25	3	2

- Insulation up to 1 ½ in. direct attachment of cladding through the insulation back to the structure is a practical technique
- Currently addressed in Table R703.4 International Residential Code (IRC 2012).
- Beyond 1 ½ in. of thickness, alternate means for cladding attachment is required
- Fastener lengths for cladding nail guns may be a challenge for projects looking to exceed 1 ½ in.
- Thick layers of exterior insulation (levels greater than 1 ½ in.),
- Use wood furring strips attached through the insulation back to the structure

(Straube and Smegal 2009; Pettit 2009; Joyce 2009, Ueno 2010).

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TABLE R703.15.2 FURRING MINIMUM FASTENING REQUIREMENTS FOR APPLICATION OVER FOAM PLASTIC SHEATHING TO SUPPORT CLADDING WEIGHT[a, b]

FURRING MATERIAL	FRAMING MEMBER	FASTENER TYPE AND MINIMUM SIZE	MINIMUM PENETRATION INTO WALL FRAMING (inches)[c]	FASTENER SPACING IN FURRING (inches)	MAXIMUM THICKNESS OF FOAM SHEATHING[e] (inches)									
					16" o.c. Furring[f]					24" o.c. Furring[f]				
					Siding Weight:					Siding Weight:				
					3 psf	11 psf	15 psf	18 psf	25 psf	3 psf	11 psf	15 psf	18 psf	25 psf
Minimum 1× wood furring[d]	Minimum 2× wood stud	0.131" diameter nail	1 1/4	8	4.00	2.45	1.75	1.45	0.95	4.00	1.60	1.10	0.85	DR
				12	4.00	1.60	1.10	0.85	DR	4.00	0.95	0.55	DR	DR
				16	4.00	1.10	0.70	DR	DR	3.05	0.60	DR	DR	DR
		0.162" diameter nail	1 1/4	8	4.00	4.00	3.05	2.45	1.60	4.00	2.75	1.85	1.45	0.85
				12	4.00	2.75	1.85	1.45	0.85	4.00	1.65	1.05	0.75	DR
				16	4.00	1.90	1.25	0.95	DR	4.00	1.05	0.60	DR	DR
		No.10 wood screw	1	12	4.00	2.30	1.60	1.20	0.70	4.00	1.40	0.85	0.60	DR
				16	4.00	1.65	1.05	0.75	DR	4.00	0.90	DR	DR	DR
				24	4.00	0.90	DR	DR	DR	2.85	DR	DR	DR	DR
		1/4" lag screw	1 1/2	12	4.00	2.65	1.90	1.50	0.90	4.00	1.65	1.05	0.80	DR
				16	4.00	1.95	1.25	0.95	0.50	4.00	1.10	0.65	DR	DR
				24	4.00	1.10	0.65	DR	DR	3.25	0.50	DR	DR	DR

HARDIE PLANK LAP SIDING AVERAGE WEIGHT PER SQUARE FOOT OF AN 8.25" WIDE PLANK = 7LBS

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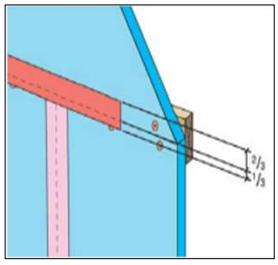
BUILDING AMERICA – TAPED INSULATING SHEATHING DRAINAGE PLANES

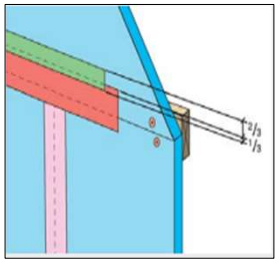
Best practice and product recommendations from the interviewed contractors and homebuilders, who identified three significant strategies for successfully using taped insulating sheathing as the drainage plane:

- Limit or eliminate horizontal joints wherever possible.
- Where a horizontal joint exists, use superior materials.
- Require frequent installation inspection and regular trade training to ensure proper installation.

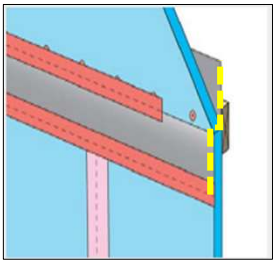
Recommended Taped Sheathing Practices



GOOD — 3 to 4 in. acrylic tape



BETTER — 4 to 6 in. wide butyl tape with 2 in. acrylic termination tape



BEST — Butyl Z-flashing with 2 in. acrylic termination tape

U.S. Dept. of Energy Building America Case Study, Measure Guideline: Guidance on Taped Insulating Sheathing Drainage Planes, DOE/GO-102014-4202 · November 2014

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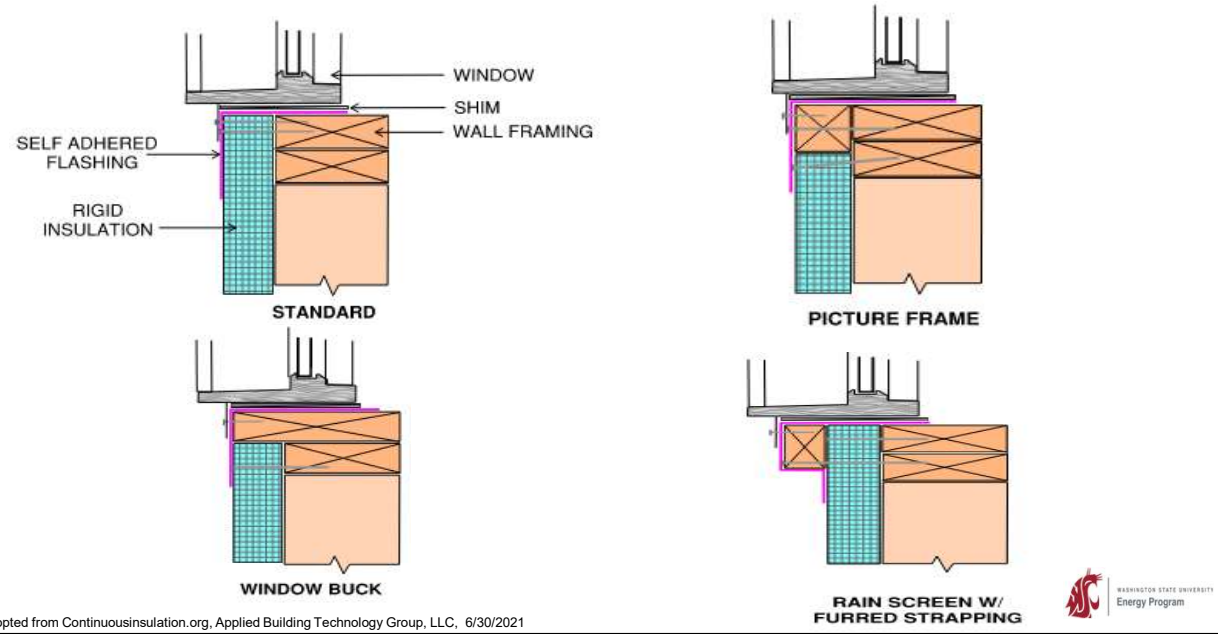
FOUR TYPICAL METHODS FOR WINDOW FRAMING WITH RIGID INSULATION



Adopted from Continuousinsulation.org, Applied Building Technology Group, LLC, 6/30/2021

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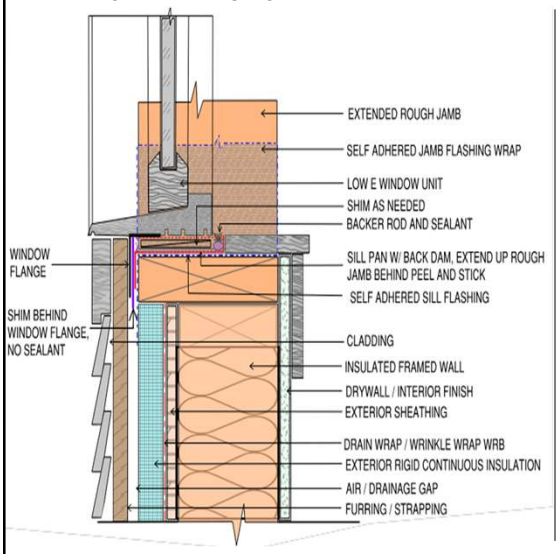
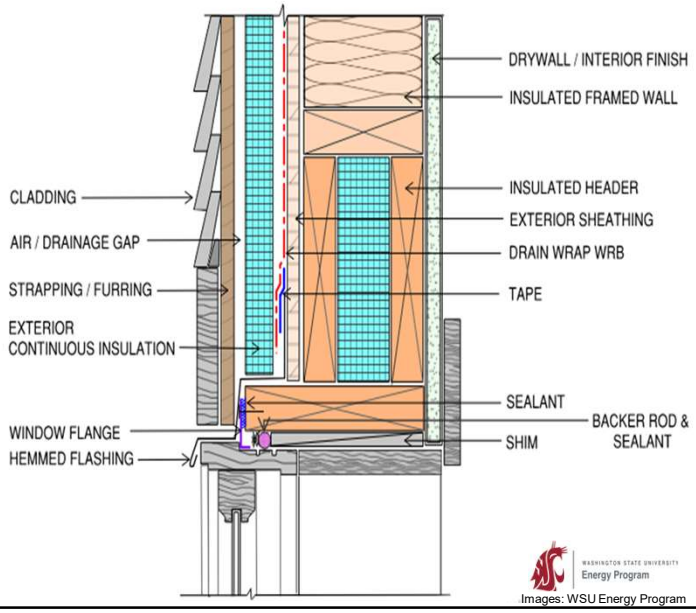
INTEGRATING FENESTRATIONS WITH EXTERIOR CONTINUOUS INSULATION

WINDOW SILL SECTION DETAIL



WINDOW HEAD SECTION DETAIL



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Images: WSU Energy Program

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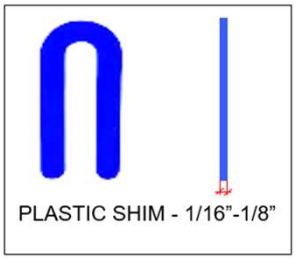
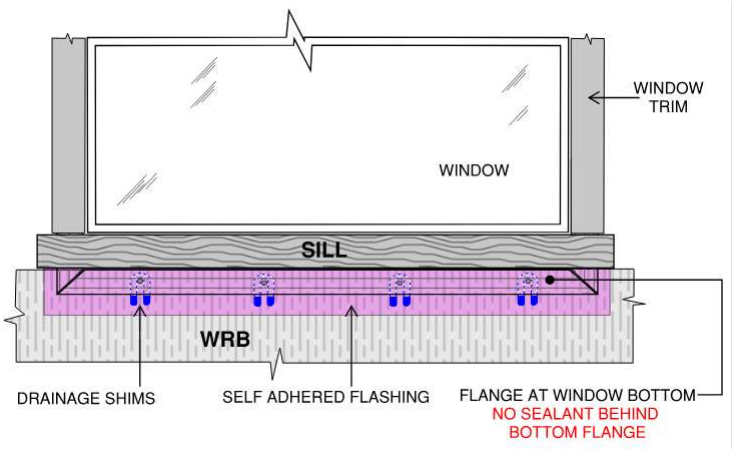
BOTTOM WINDOW FLANGE WITH DRAINAGE SHIMS





EXTERIOR ELEVATION

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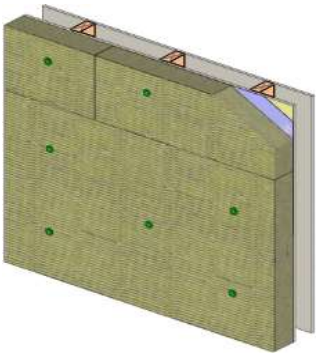
WHAT ABOUT MINERAL WOOL, RIGID AND SEMI - RIGID INSULATION ?

- Effective thermal performance of wall assemblies using fibrous board insulation products will be impacted by the attachment method used and the installation.
- Must be installed in continuous, full contact with the substrate, i.e., sheathing.



- Min. 5 fasteners per board
- Chosen per substrate type
- Withstand pullout & shear
- Prevent insulation tear through
- Durable to environmental conditions
- General rule – embed min. 1.5” into stud and concrete
- Min. 2” diameter washers

Mineral wool board supported by 5 fasteners with washers over solid surface, (concrete) and over wood or metal studs – fasteners must penetrate studs.

Adopted from ROCKWOOL Board Insulation Attachment Guide, Version 1.0, July 2022

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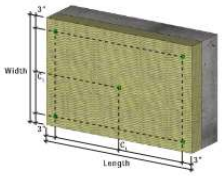
FASTENING PATTERNS – BOARD DIMENSION DICTATES NUMBER OF FASTENERS

Boards up to 96” in length and different width and thickness over solid wall and wood / metal studs:

Minimum 5 attachments required for solid and framed walls with the following board sizes

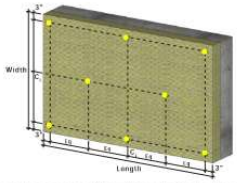
Thickness	Width	Length
1” to 6”	16”	48”
1” to 6”	24”	48”
3” to 5”	32”	48”



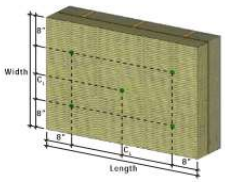
Fastening pattern over a solid surface with 5 attachments (32” x 48” ROCKWOOL insulation board over a concrete wall shown)

Minimum 8 attachments required for solid and framed walls with the following board sizes

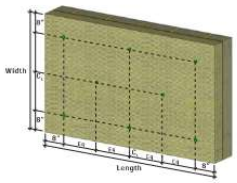
Thickness	Width	Length
1” to 3”	48”	72”
1” to 3”	48”	96”



Fastening pattern over a solid surface with 8 attachments (48” x 72” ROCKWOOL insulation board over a concrete wall shown)



Fastening pattern over a framed wall with 5 attachments (32” x 48” ROCKWOOL insulation board over a wood stud wall shown)



Fastening pattern over a framed wall with 8 attachments (48” x 72” ROCKWOOL insulation board over a wood stud wall shown)

Adopted from ROCKWOOL Board Insulation Attachment Guide, Version 1.0, July 2022

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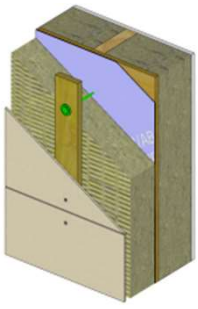
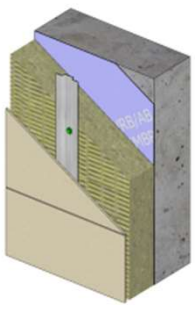
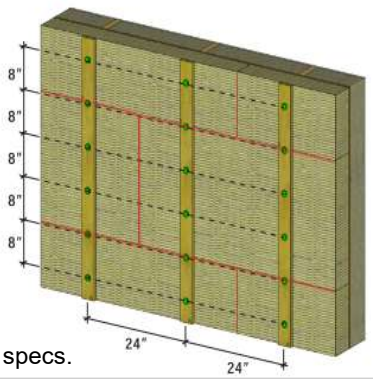
ATTACHMENT METHOD FOR CONTINUOUS INSULATION WITH STRAPPING

- Fastened with long screws into the backup wall structure, i.e., studs
- Cladding is attached with separate fasteners into the strapping, (furring)
- Vertical strapping is best for ventilation and drainage, install perforated metal if horizontal





Fastening Patterns



✓ Fastening patterns based on project specific specs.

Exterior Insulation Thickness	Maximum Vertical Screw Spacing	Minimum Screw Diameter	Minimum Screw Embedment	Minimum Strapping Size
16” o.c. Wood-Frame Wall Assemblies				
Light Weight Cladding < 5 lbs/ft²				
up to 3”	24”	#10	1-1/2”	3/4” × 2-1/2”
>3” to 6”	16”			
>6” to 9”	16”	#12		
>9” to 12”	8”			
Medium Weight Cladding 5 lbs/ft² to < 10 lbs/ft²				
up to 3”	16”	#12	1-1/2”	3/4” × 3”
>3” to 6”	12”			
>6” to 9”	12”	#14		
>9” to 12”	8”			
Heavy Weight Cladding 10 lbs/ft² to < 15 lbs/ft²				
up to 3”	16”	#14	1-1/2”	3/4” × 3-1/2”
>3” to 6”	12”			
>6” to 9”	12”	5/16”		
>9” to 12”	10”			
24” o.c. Wood-Frame Wall Assemblies				
Light Weight Cladding < 5 lbs/ft²				
up to 3”	16”	#10	1-1/2”	3/4” × 2-1/2”
>3” to 6”	12”			
>6” to 9”	12”	#12		
>9” to 12”	6”			
Medium Weight Cladding 5 lbs/ft² to < 10 lbs/ft²				
up to 3”	12”	#12	1-1/2”	3/4” × 3”
>3” to 6”	8”			
>6” to 9”	8”	#14		
>9” to 12”	6”			
Heavy Weight Cladding 10 lbs/ft² to < 15 lbs/ft²				
up to 3”	16”	#14	1-1/2”	3/4” × 3-1/2”
>3” to 6”	12”			
>6” to 9”	12”	5/16”		
>9” to 12”	6”			
16” o.c. Steel Stud Wall Assemblies				
Light Weight Cladding < 5 lbs/ft²				
up to 3”	16”	#12	through stud flange	7/8” × 1-1/4” 20ga hat track
>3” to 6”	12”			
>6” to 9”	10”			
Medium Weight Cladding 5 lbs/ft² to < 10 lbs/ft²				
up to 3”	12”	#12	through stud flange	7/8” × 1-1/4” 20ga hat track
>3” to 6”	10”			
>6” to 9”	8”			
Heavy Weight Cladding 10 lbs/ft² to < 15 lbs/ft²				
up to 3”	12”	#14	through stud flange	7/8” × 1-1/4” 20ga hat track
>3” to 6”	8”			
>6” to 9”	6”			

Adopted from ROCKWOOL Board Insulation Attachment Guide, Version 1.0, July 2022

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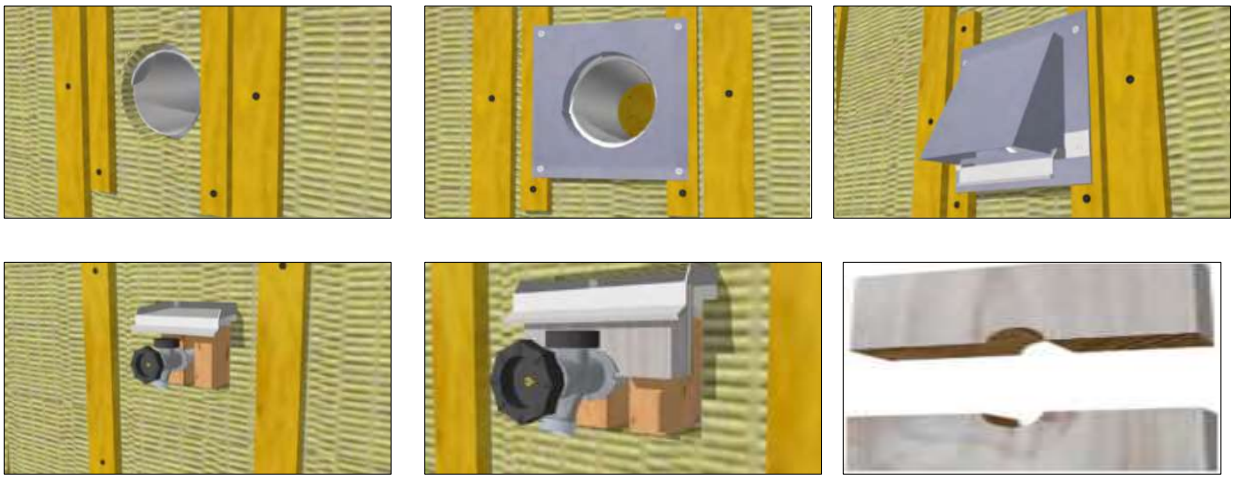
PENETRATIONS



Adopted from: Rockwool Comfortboard 80 Installation Guide, e-edition 02/2018

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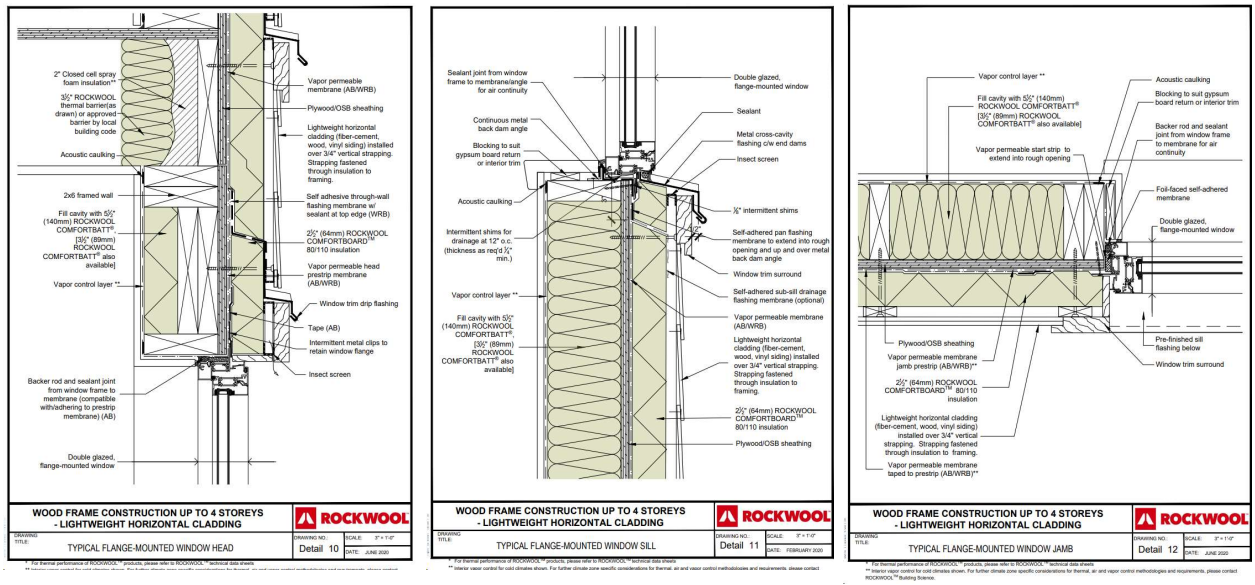
INTEGRATING FENESTRATIONS WITH EXTERIOR MINERAL FIBER CONTINUOUS INSULATION



Wood Frame Construction Up To 4 Stories: Lightweight Cladding, Rockwool, Details 10, 11, 12. June, 2020.

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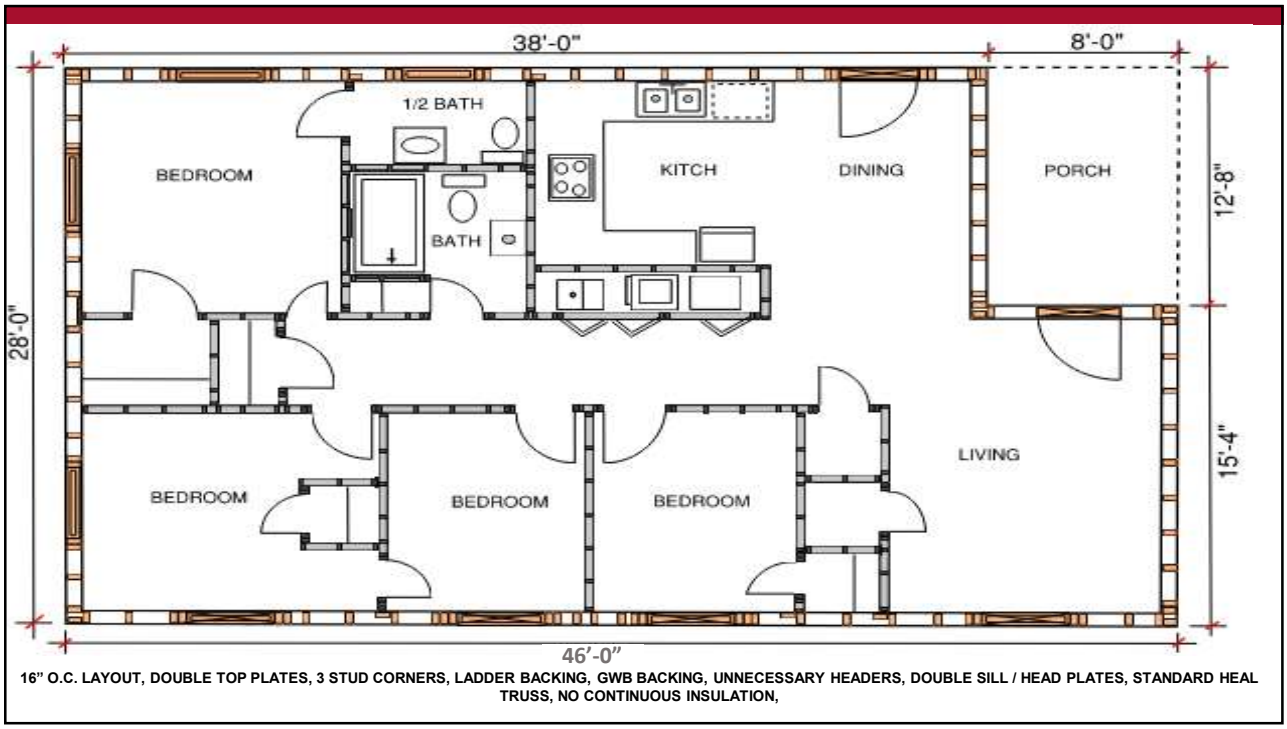

16" O.C. LAYOUT, DOUBLE TOP PLATES, 3 STUD CORNERS, LADDER BACKING, GWB BACKING, UNNECESSARY HEADERS, DOUBLE SILL / HEAD PLATES, STANDARD HEAL TRUSS, NO CONTINUOUS INSULATION,

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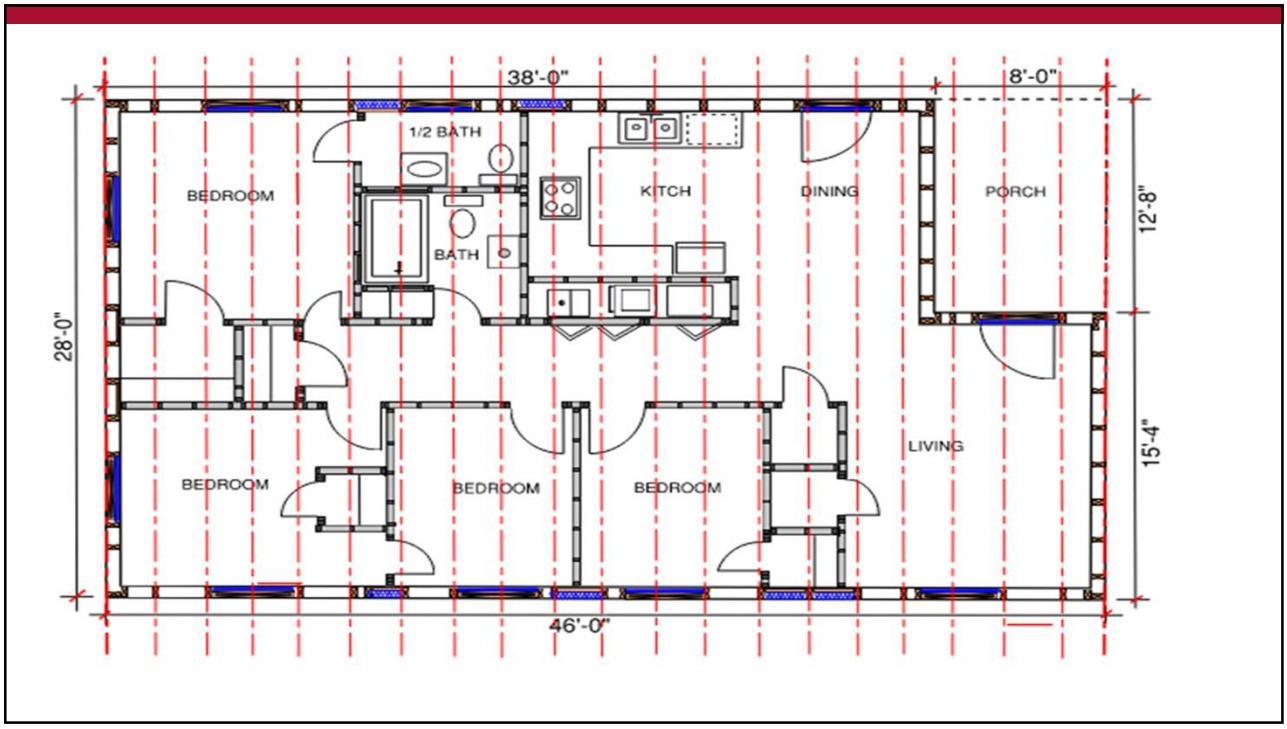

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Structural Integrity - align the vertical framing members under the roof trusses or rafters, a direct load path is created where compression and tension loads are directly transferred through the vertical framing members.

Cost Effectiveness - more resource efficient than conventional framing. By optimizing framing material use, the builder can cut floor and wall framing material costs by up to 30 percent while reducing framing installation labor.

Sustainability - delivers even greater environmental dividends by optimizing material usage and reducing construction waste.

Energy Efficiency- proven method for cost-effectively meeting energy code requirements by maximizing space for cavity insulation and minimizing the potential for insulation voids, advanced framing delivers significant energy performance for the homeowner and cost savings for the builder.

CONVENTIONAL FRAMING	ADVANCED FRAMING
2x4 or 2x6 wood framing spaced 16 inches on center	2x6 wood framing spaced 24 inches on center
Double top plates	Single top plate
Three-stud corners	Two-stud corners
Multiple jack studs	Minimal jack studs
Double or triple headers	Single headers
Multiple cripple studs	Minimal cripple studs

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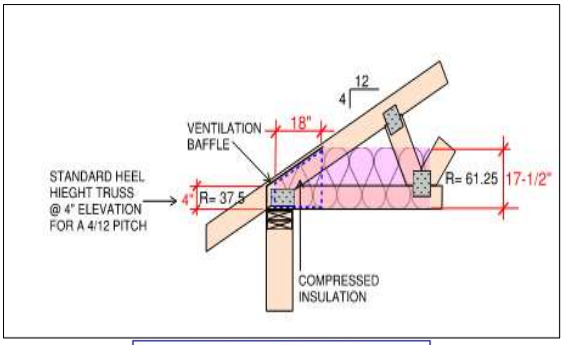
RAISED HEEL TRUSSES AND ENERGY SAVINGS



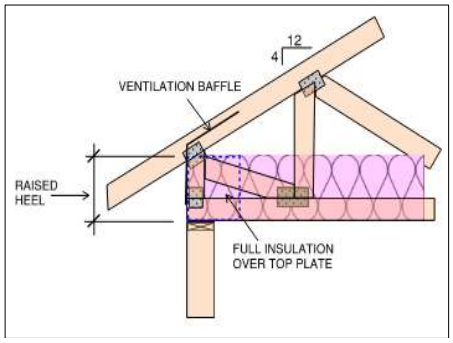
$$U_{avg} = \frac{U_1 + U_2}{A_{tot}}$$

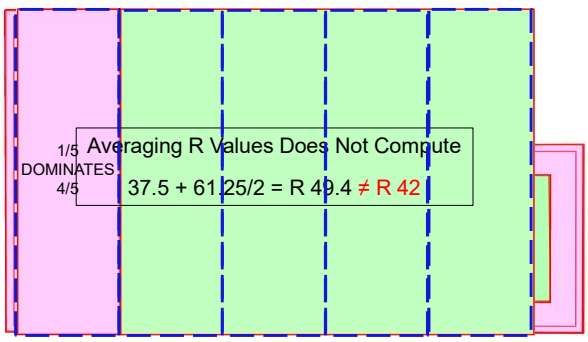
$$U_{avg} = \frac{\frac{1}{37.5} \times 222 + \frac{1}{61.25} \times 1064}{1187}$$

$$U_{avg} = \frac{0.03 \times 222 + 0.02 \times 1064}{1187}$$

$$U_{avg} = 6.66 + 21.28 = 27.94$$

$$U_{avg} = 27.94/1187 = 0.024 = R\ 42$$





Images:
WSU Energy Program

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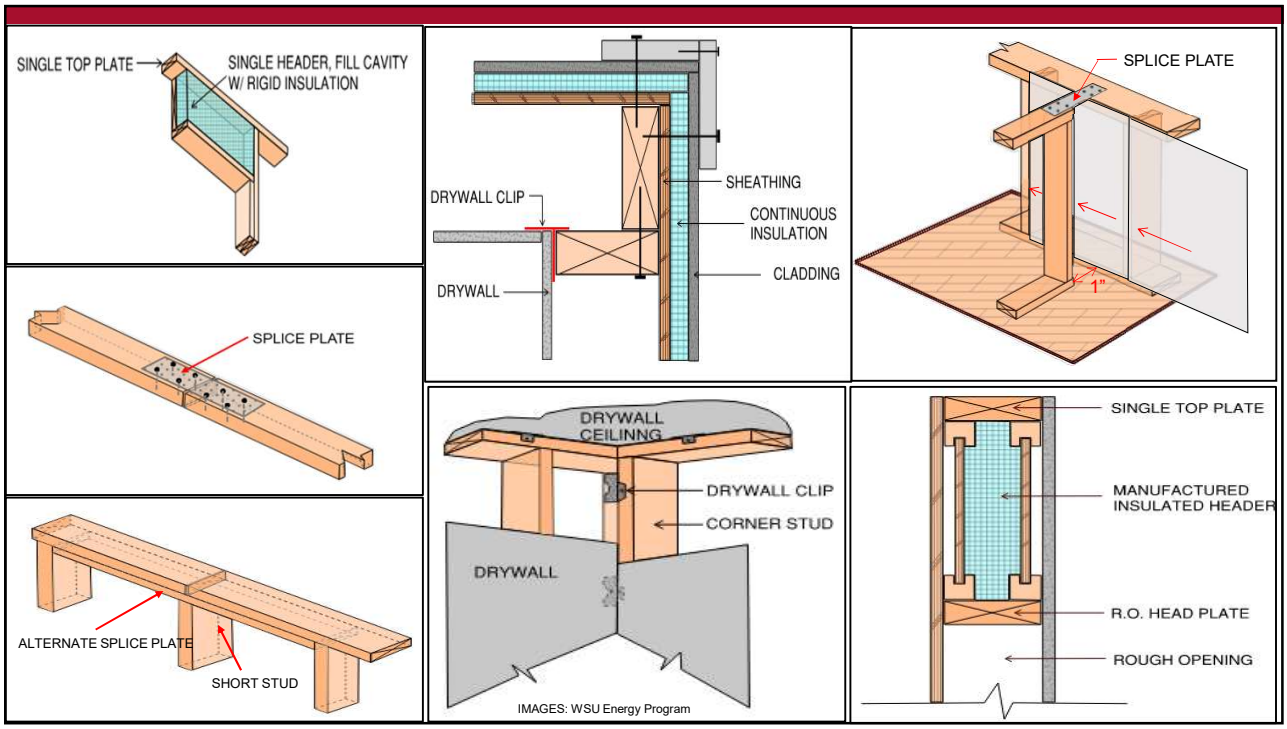
SINGLE TOP PLATE
SINGLE HEADER, FILL CAVITY W/ RIGID INSULATION
SPLICE PLATE
ALTERNATE SPLICE PLATE
SHORT STUD
DRYWALL CLIP
SHEATHING
CONTINUOUS INSULATION
DRYWALL
CLADDING
SPLICE PLATE
1"
DRYWALL CEILINNG
DRYWALL CLIP
CORNER STUD
DRYWALL
SINGLE TOP PLATE
MANUFACTURED INSULATED HEADER
R.O. HEAD PLATE
ROUGH OPENING
IMAGES: WSU Energy Program

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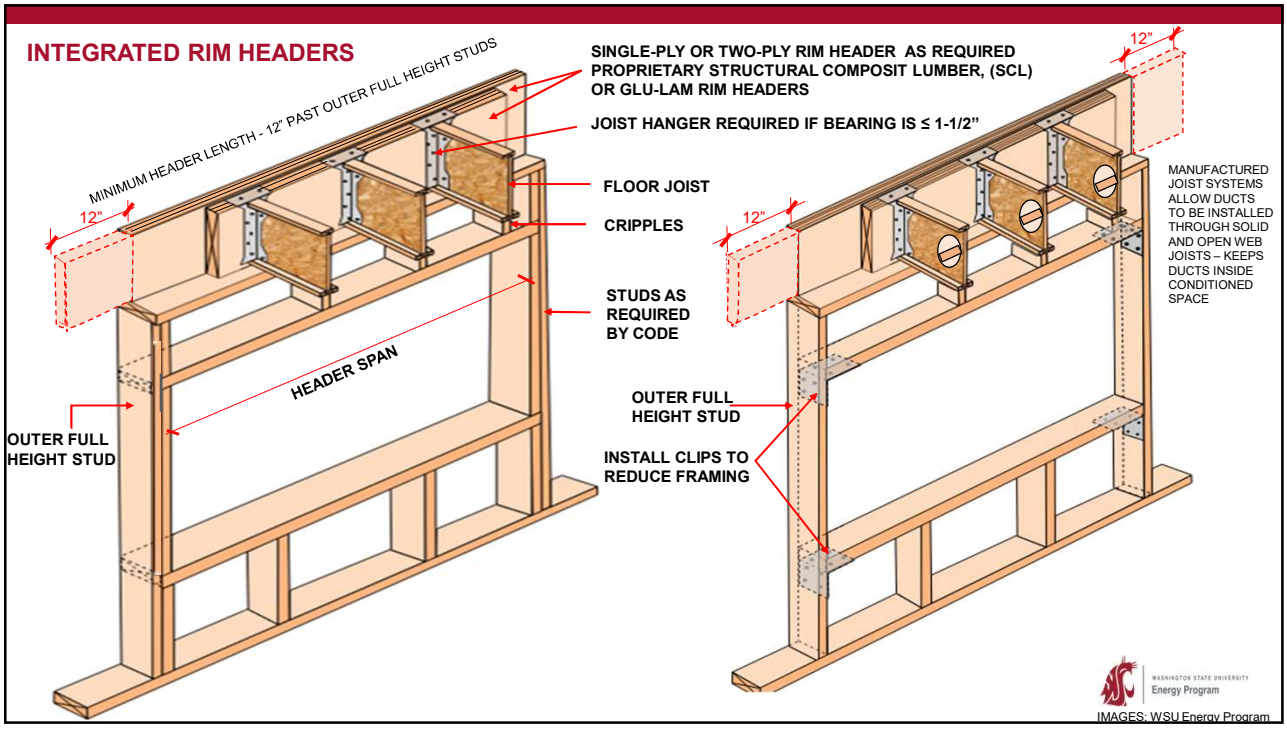
INTEGRATED RIM HEADERS
MINIMUM HEADER LENGTH - 12" PAST OUTER FULL HEIGHT STUDS
12"
SINGLE-PLY OR TWO-PLY RIM HEADER AS REQUIRED PROPRIETARY STRUCTURAL COMPOSIT LUMBER, (SCL) OR GLU-LAM RIM HEADERS
JOIST HANGER REQUIRED IF BEARING IS ≤ 1-1/2"
FLOOR JOIST
CRIPPLES
STUDS AS REQUIRED BY CODE
HEADER SPAN
OUTER FULL HEIGHT STUD
INSTALL CLIPS TO REDUCE FRAMING
12"
12"
MANUFACTURED JOIST SYSTEMS ALLOW DUCTS TO BE INSTALLED THROUGH SOLID AND OPEN WEB JOISTS – KEEPS DUCTS INSIDE CONDITIONED SPACE
WASHINGTON STATE UNIVERSITY Energy Program
IMAGES: WSU Energy Program

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REAL WORLD

Photo: ptbotruss.com, Engineered Joists

Photo: Glavin Homes, Ducts in Conditioned Space, Amanda Glavin, April 25, 2014

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RESOURCES

- Converting to Advanced Framing: Learn from Experience, American Plywood Association, (APA) www.apawood.org/converting-to-advanced-framing
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- Advanced Framing Construction Guide, *APA - The Engineered Wood Association, January, 2014* https://www.apawood.org/advanced-framing
- ROCKWOOL Board Insulation Attachment Guide, Version 1.0, July 2022 https://www.rockwool.com/syssiteassets/o2-rockwool/documentation/technical-guides/commercial/board-insulation-attachment-guide.pdf?f=20230606172923
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- U.S. Dept. of Energy Building America Case Study, Measure Guideline: Guidance on Taped Insulating Sheathing Drainage Planes, DOE/GO-102014-4202 · November 2014
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- Lstiburek, J. & Grin, A, Building Science Corporation, "Building America Special Research Project: Deployment of Advanced Framing at the Community Scale, Building America Report – 1004, November 15, 2010
- Crandell, J. & Ahrenholz, T. Foam Plastics Applications for Better Living, "Energy Code Math Lesson: Why an R-25 Wall is Not Equal to a R-20+5ci", August 7, 2017
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- Guide to Insulating Sheathing, Building Science Corporation, Revised January, 2007 buildingscience.com/sites/default/files/migrate/pdf/GM_Guide_Insulating_Sheathing.pdf

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Questions?

Thank You!

For additional information, visit our website at
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