2023 BUILD IT RIGHT SEMINAR

WHAT HAVE WE LEARNED IN THE LAST 50 YEARS TO HELP US MAKE SENSE OF HIGH-PERFORMANCE HOMES?

Workshop Focus

How has building science changed housing in the last 50 years?

Positive discussion

Agree that since I'm the oldest, I've made the most "opportunities for improvement!"

We're here to assist and have a fun day!!

Please Remember Most Of Us Were Trying Our Best

Sources of building knowledge – books and elders

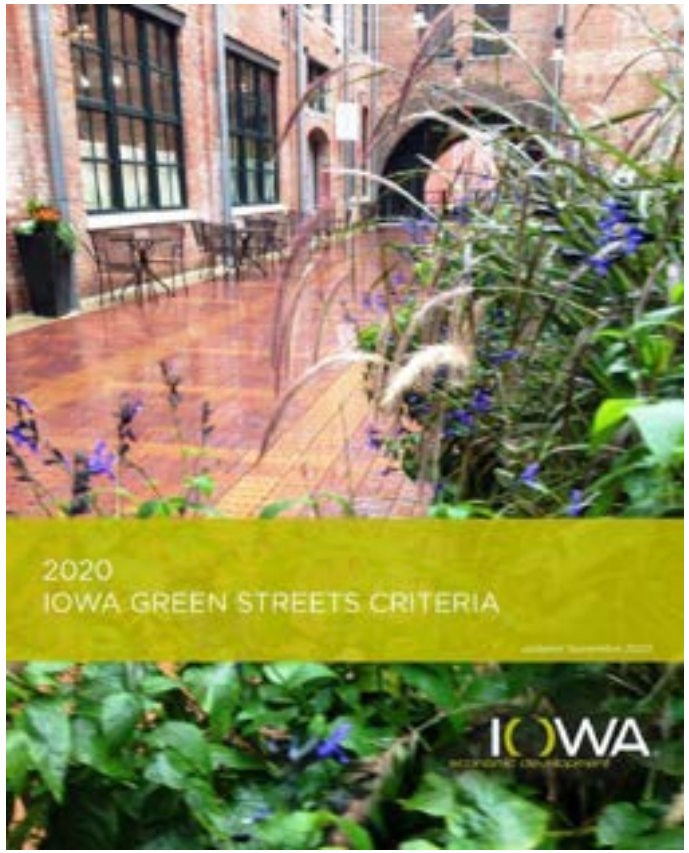
Skill sets – hammer, framing square, no cordless

Available materials – Fuzzboard and Visqueen

Focus on quality – trimwork, cabinets and paint

Market – 1200 to 1500 sq. ft. ranch with 4/12 pitch

Good Sources Of Knowledge



Iowa Green Streets Criteria

Midwest Energy Efficiency Alliance

Buildingscience.com

Green Building Advisor

Construction Instruction – Free app

Iowa Association For Energy Efficiency

Dave Ruffcorn

Building Enclosure Council

Sources

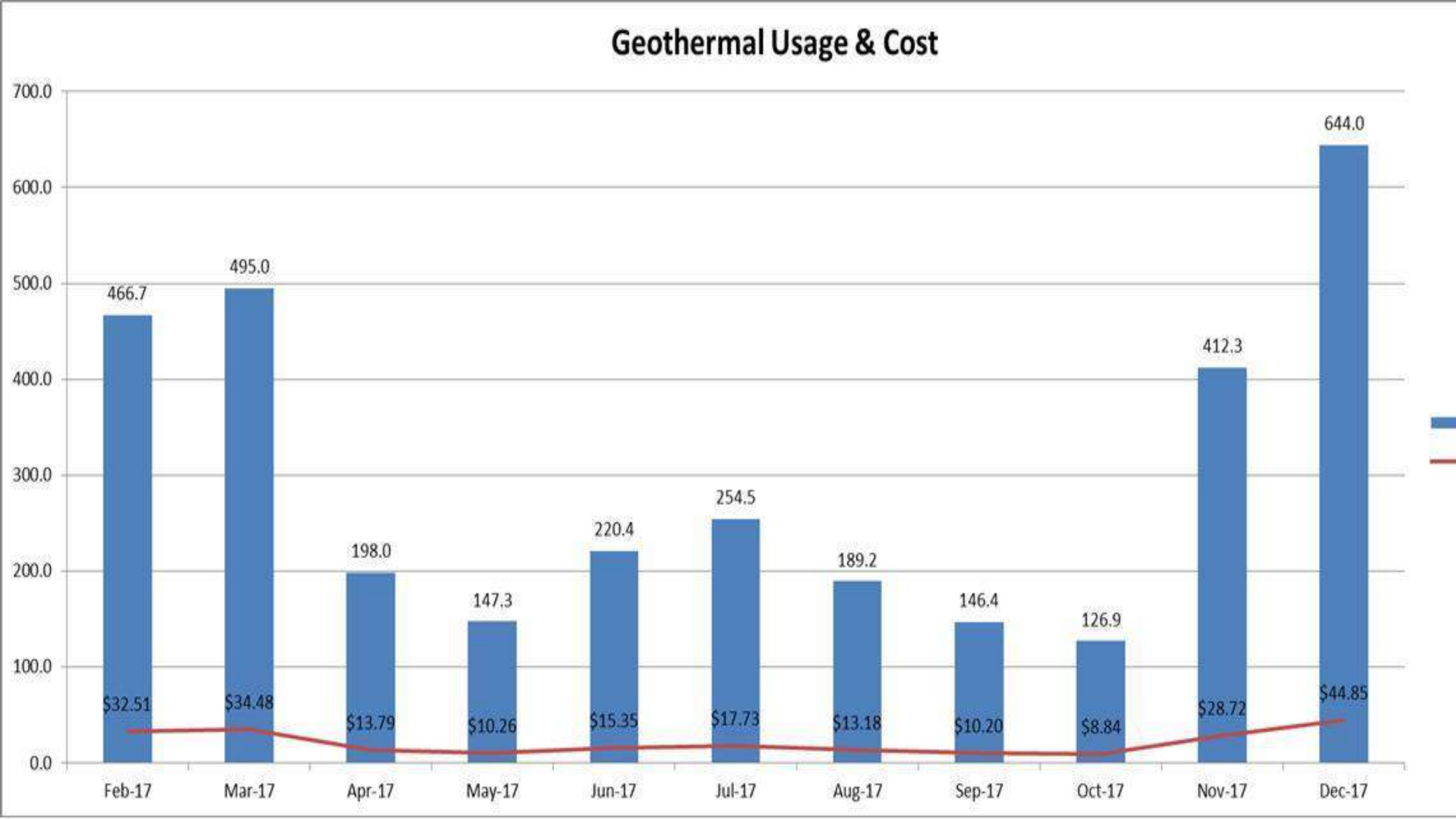
The Energy Group

Iowa Central Carpentry

Fine Homebuilding

Iowa State University

University of Minnesota Cold Climate Housing Program


Geothermal Usage & Cost
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
466.7
495.0
198.0
147.3
220.4
254.5
189.2
146.4
126.9
412.3
644.0
$32.51
$34.48
$13.79
$10.26
$15.35
$17.73
$13.18
$10.20
$8.84
$28.72
$44.85
Feb-17
Mar-17
Apr-17
May-17
Jun-17
Jul-17
Aug-17
Sep-17
Oct-17
Nov-17
Dec-17

What is Building Science?

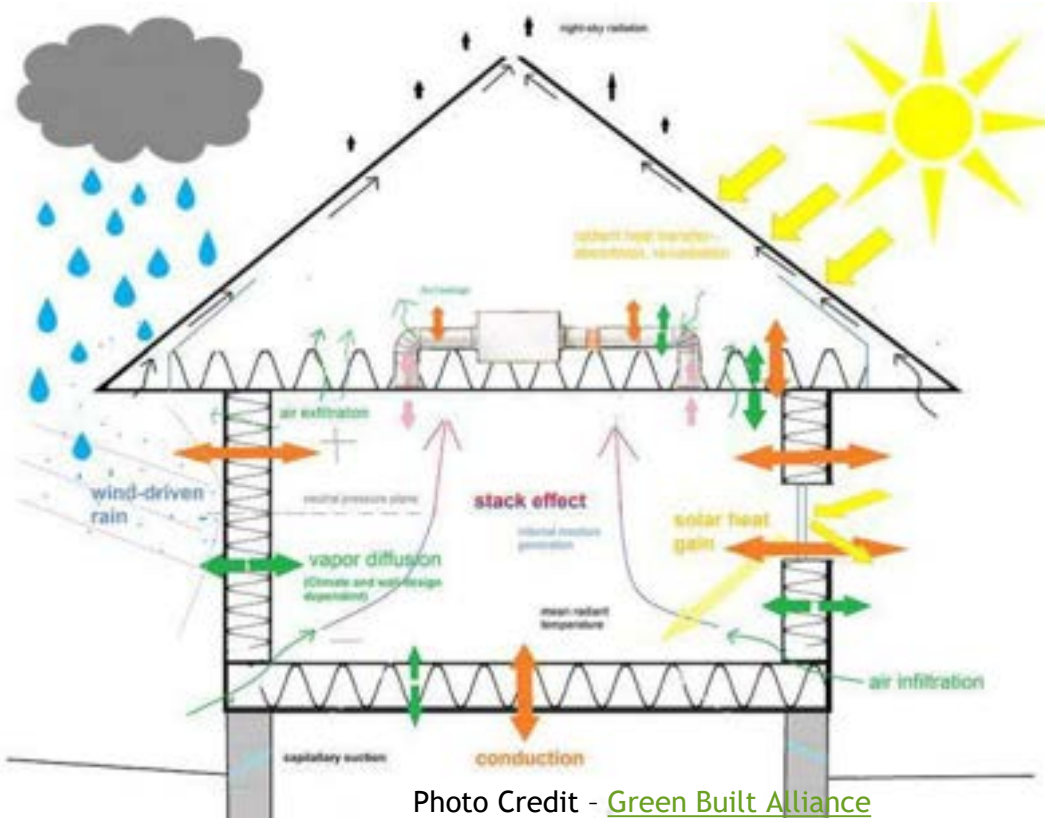
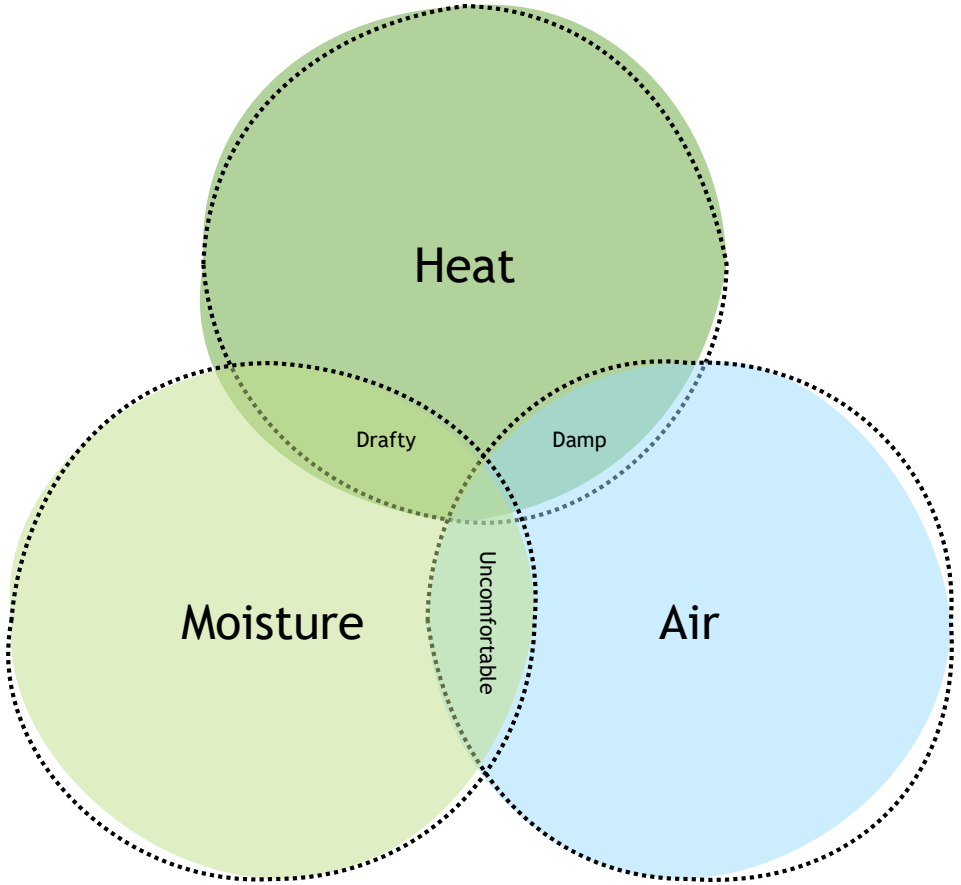


Photo Credit – Green Built Alliance

- Application of physical sciences to buildings
- Takes into consideration the house as a system, not individual components alone
- Building Science Hierarchy of Importance
  1) Bulk Water
  2) Air Infiltration
  3) Vapor Diffusion
  4) Heat/Thermal

Heat, Air and Moisture

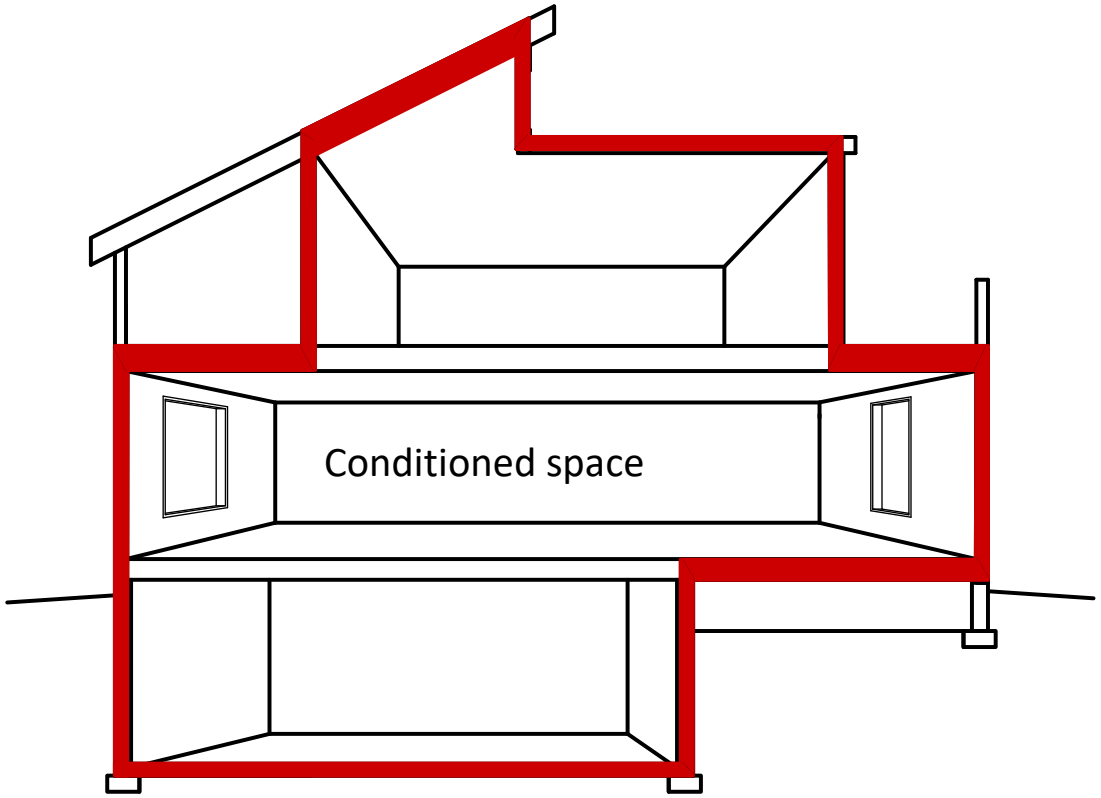


Main Building Science Topics

- Water and Vapor control
- Air Sealing
- Capillary Action and Breaks
- Thermal Bridging
- Insulation
- Product Installation
- Advanced Framing
- Windows and Doors
- Frost
- Ventilation
- Universal Design
- Education sources

Building Envelope

- Building Envelope consists of:
  - Fenestration
  - Roof
  - Ceilings
  - Walls
    - Above grade
    - Below grade
    - Mass walls
  - Floors
  - Slab
  - Crawl space



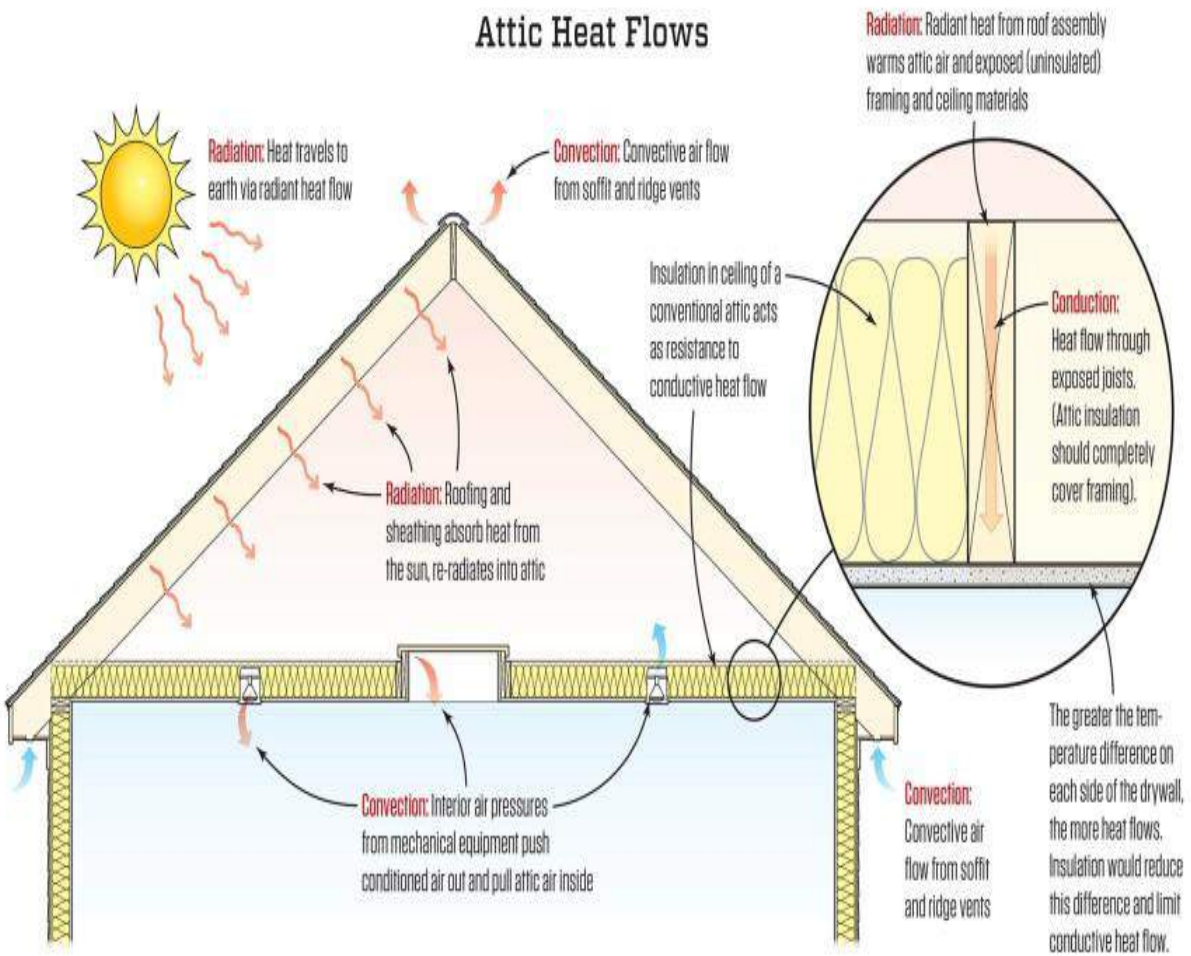


Photo Credit – Journal of Light Construction

- Three Main Methods of Heat Transport:
  - Convection, Conduction and Radiation
- High R-Value Walls
  - Continuous thermal insulation
  - Reduced Thermal Bridging
- High Performance Fenestration
  - Low U-Value
  - SHGC values engineered for orientation

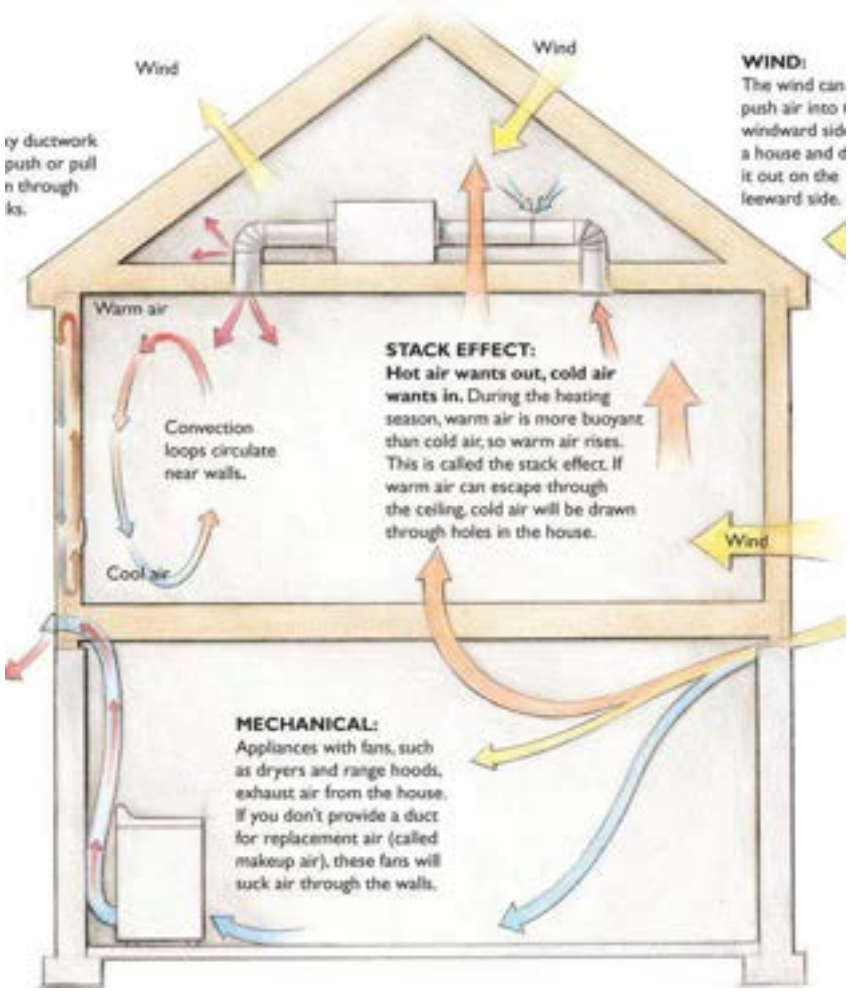


Photo Credit – Green Building Advisor

Air Flows

- Red Line Test During Design – Control layers
- Managed Building Pressures
  - Stack Effect
  - Mechanical Intake and Exhausts
- Unintentional Leakage Pathways
  - Holes in Building Envelope
- Intentional Air Flows
  - Attic Ventilation
  - Make Up Air
- Maximum Leakage of 3 ACH50 (Single Family and Multifamily)

Control Layers

Thermal

Air Barrier

Vapor Control

Water Control Layer

“Perfect” Assembly

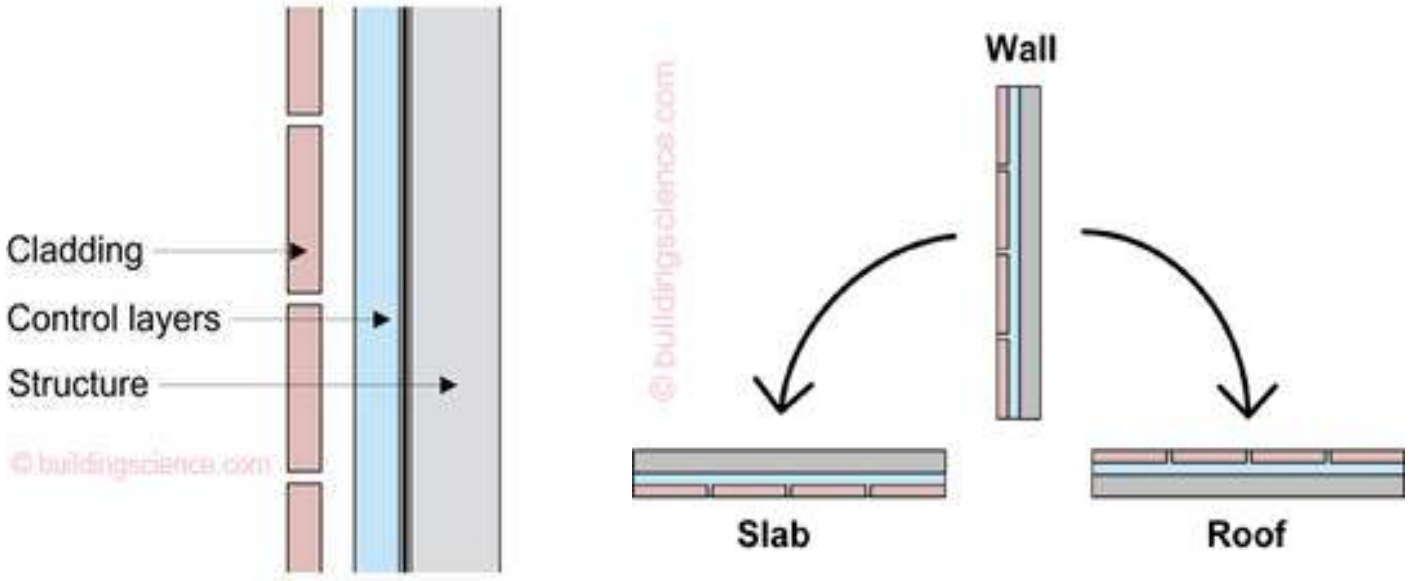


Photo Credit – Building Science Corporation

Knowledge Flow - Design to Field

R-values – from prints to actual performance

Air movement – “more caulk”

Vapor/Dew point – “huh?”

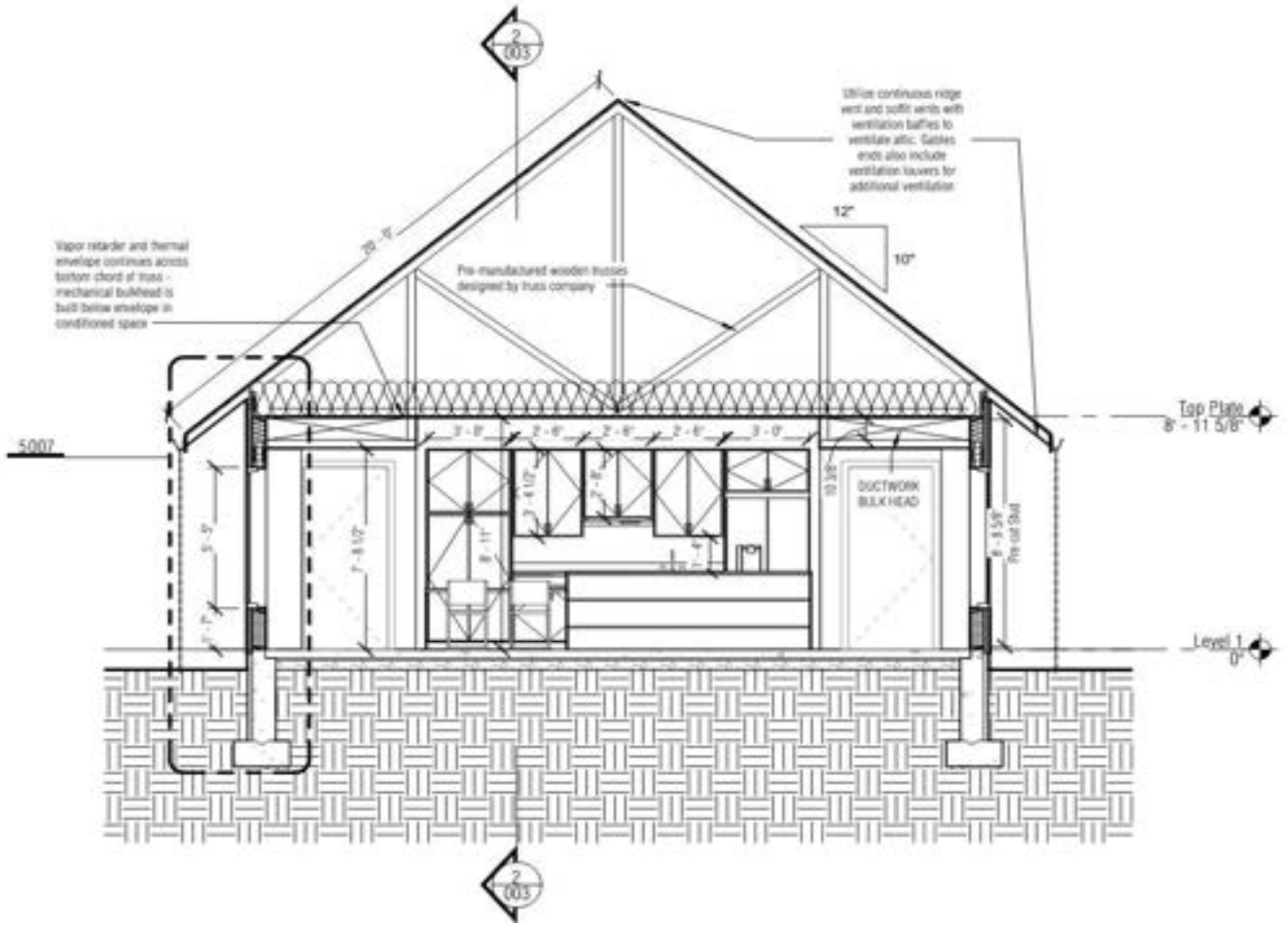
Water – “dang windows”

Flashings – “over under/under over”

Material compatibility – “Never had a problem before!”

6. ALL MANUFACTURED ARTICLES, MATERIALS AND EQUIPMENT SHALL BE APPLIED, INSTALLED, CONNECTED, ERECTED, CLEANED AND CONDITIONED ACCORDING TO MANUFACTURERS' INSTRUCTIONS. IN CASE OF DISCREPANCIES BETWEEN MANUFACTURERS' INSTRUCTIONS AND THE CONTRACT DOCUMENTS, NOTIFY ARCHITECT / ENGINEER

Application of Building Science

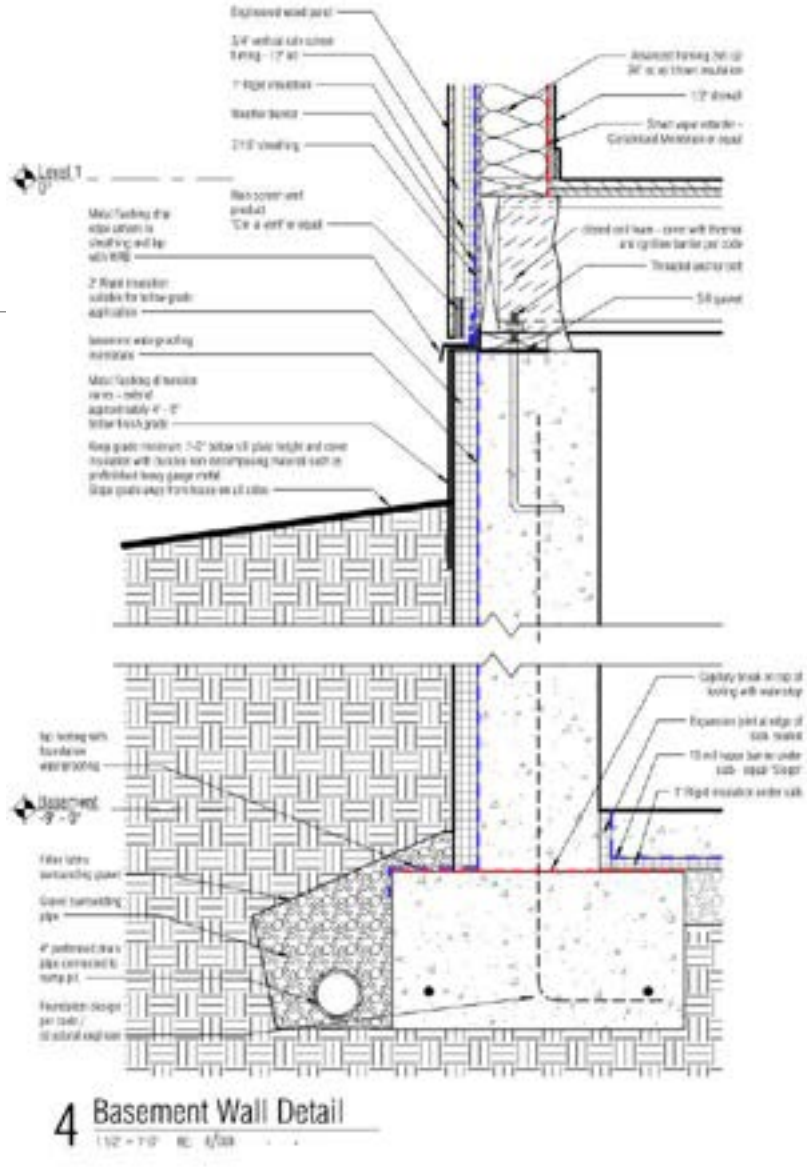


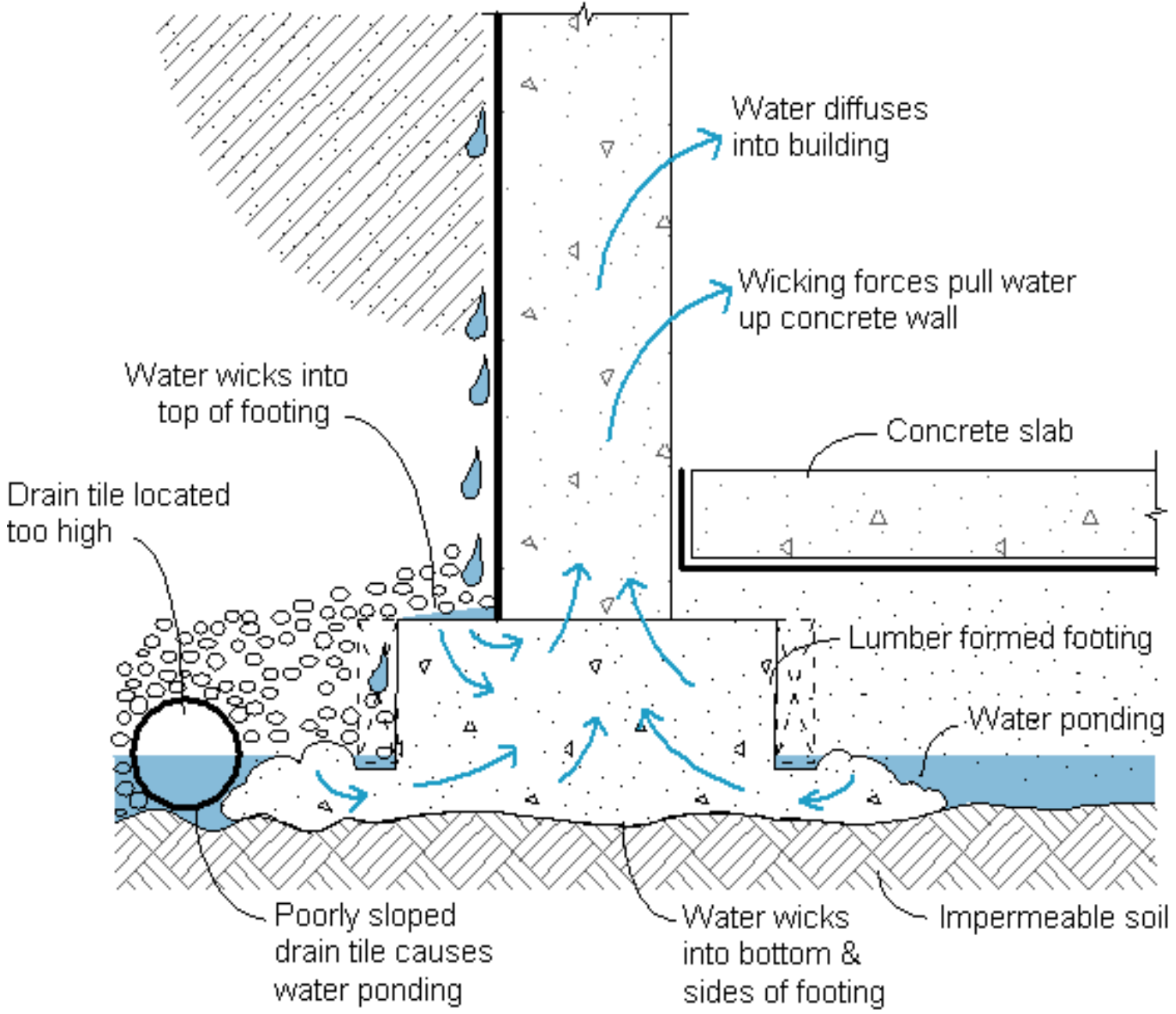
Basements/Below Grade

- Water, water everywhere
- Wall damp proofing vs waterproofing
- Slab condensation & capillary breaks - 1996
- Thermal bridges – not discussed residentially
- Too many wrong options – cheap & easy

What Makes A Good Below Grade Assembly?

- Bulk Water Managed
  - Proper Drainage
- Warm and Dry Slab
  - Insulated and Vapor Controlled
- Air Sealed
  - Mitigated Soil Gas Intrusion
- Insulated Walls
  - Continuous Insulation




Water diffuses into building
Wicking forces pull water up concrete wall
Water wicks into top of footing
Concrete slab
Drain tile located too high
Lumber formed footing
Water ponding
Poorly sloped drain tile causes water ponding
Water wicks into bottom & sides of footing
Impermeable soil

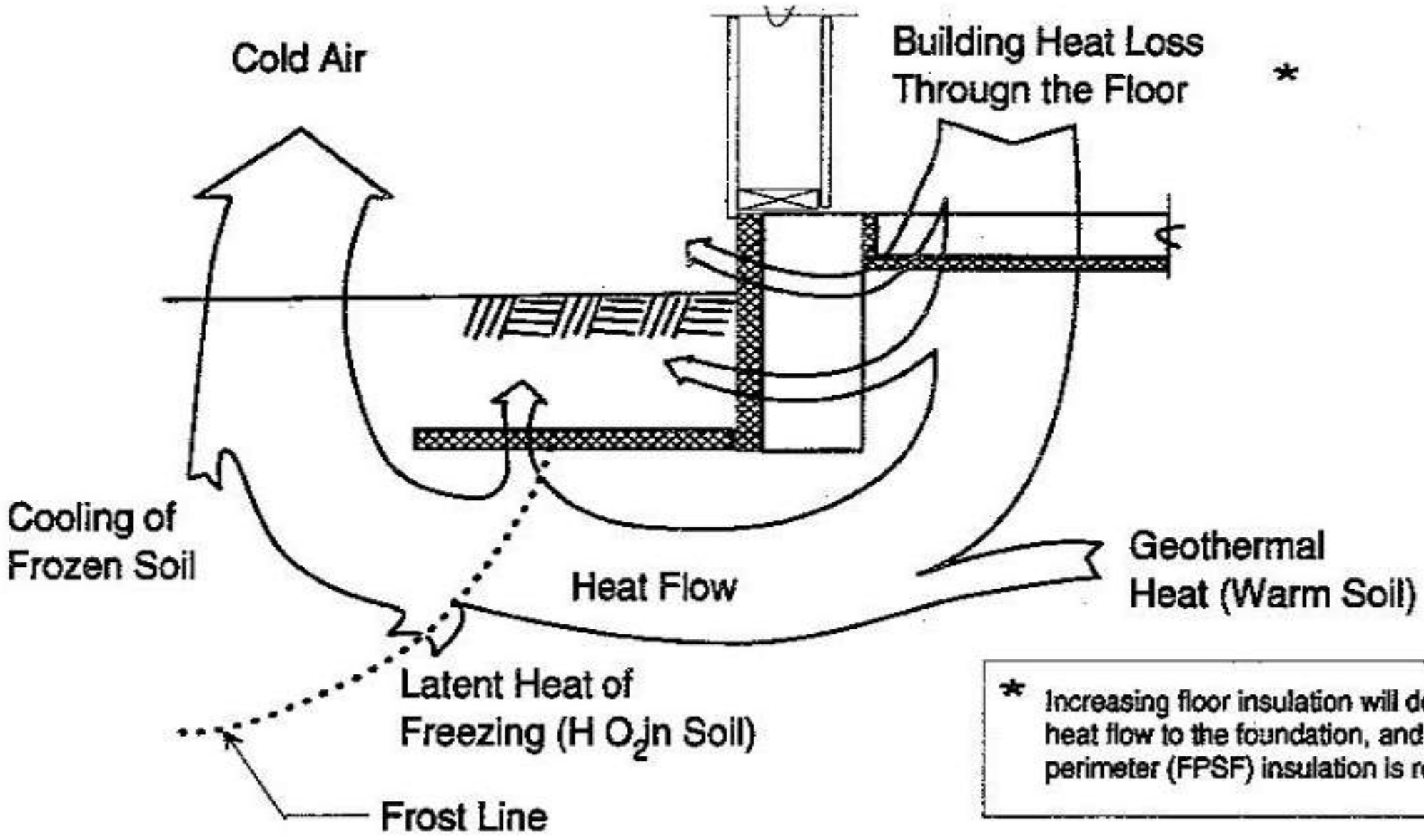


FIGURE 3. FPSF Heat Flow Diagram for a Heated Building with Optional Floor Insulation.


DOW
Styrofoam
Superior Walls

Treated Lumber Issues

- As early as June 2007 – Forest Products Journal and Environmental Building News
- New copper based treated wood prone to brown-rot fungi
- Loses 20%-60% of their mass
- Fastener and hanger corrosion
- May be a contributing factor to deck collapse

Corrosion Blocker

When WiseWrap® JoistTape™ is placed between ACQ, CA-B, or ACZA treated lumber and metal surfaces, such as galvanized metal and aluminum, it creates a physical barrier that prevents the corrosion of the metal surface caused by contact with the chemicals in treated lumber.


OWENS CORNING
FOAMULAR 250
R-5.0
1 inch Thickness
1 pouce d'épaisseur
B1206020
R-5

What's The Problem?


DUPONT
Tyvek


AMULAR 250

What Makes a Good Slab-on Grade Assembly?

- Frost Free
- Vapor Barrier – 10 mil+
- Insulated Slab
- Thermal Break Concerns
- Edge Protection and Elevation

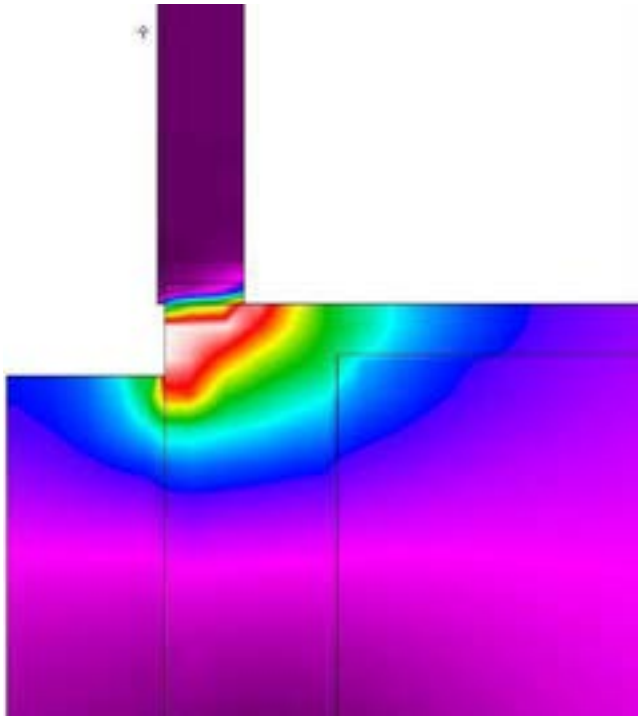
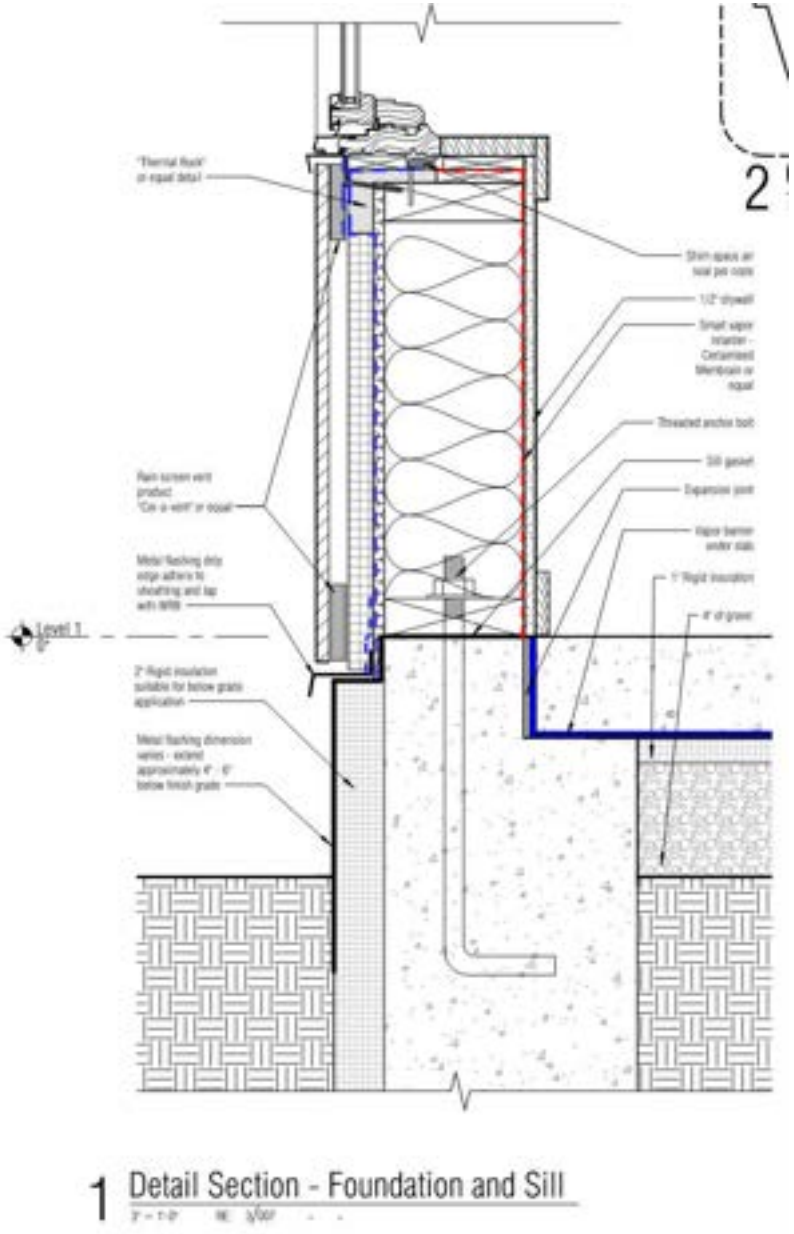
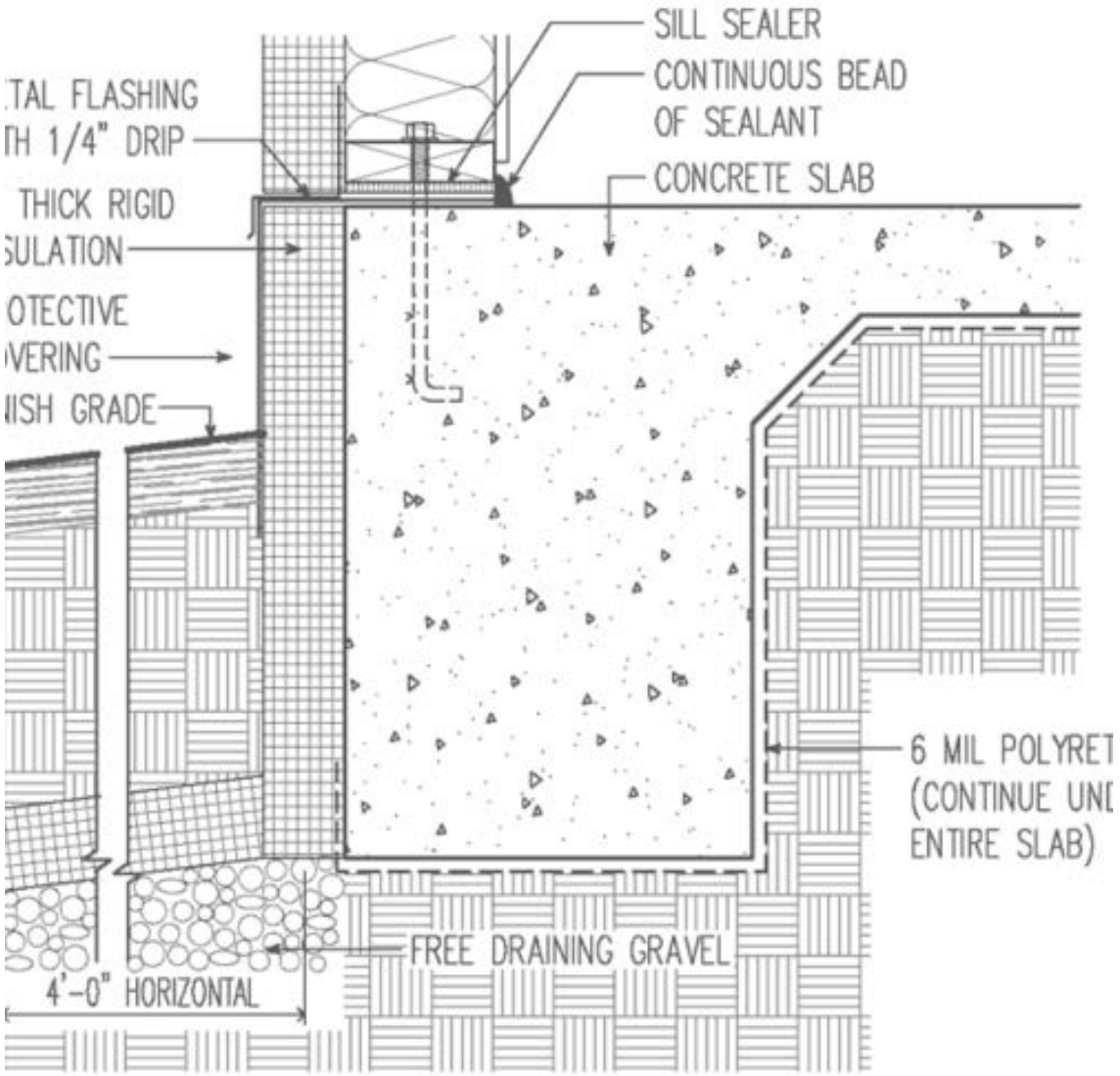


Photo Credit: Green Building Advisor




SILL SEALER
CONTINUOUS BEAD
OF SEALANT
CONCRETE SLAB
TAL FLASHING
TH 1/4" DRIP
THICK RIGID
SULATION
OTECTIVE
VERING
IISH GRADE
6 MIL POLYRET
(CONTINUE UNI
ENTIRE SLAB)
FREE DRAINING GRAVEL
4'-0" HORIZONTAL

Walls Terminology

Water – WRB new idea

Vapor – not understood

Penetrations – still overlooked

Air tightness and convective air loops

R-value – I mean total wall value, not the 2” wide rolled up piece of fiberglass between 4 studs!

Types of Exterior Walls

2x4, 2x6, double wall

SIPS – Structural Insulated Panels

ICFs – Insulated Concrete Foundations/Forms

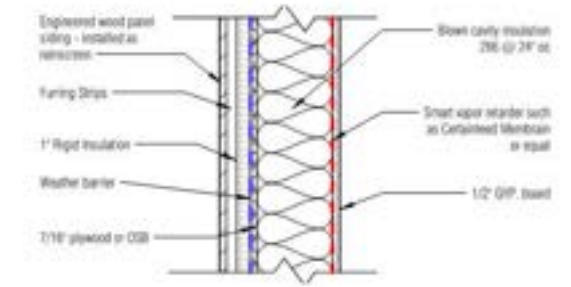
3D Printed

Advanced Framing – 1940’s, still fighting myths

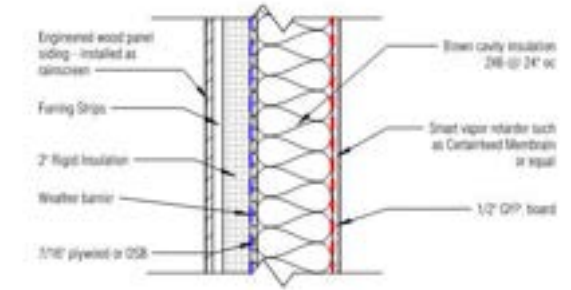
Quality installations – OUR BIGGEST HURDLE!!!!

What Make a Good Wall Assembly?

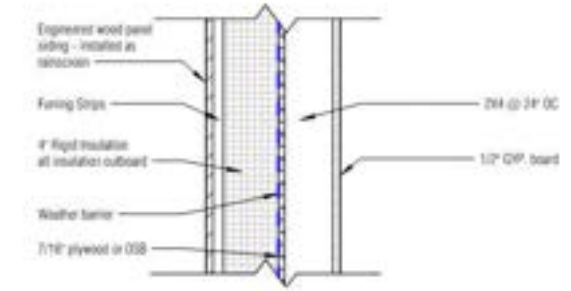
- High R-Value
  - Advanced Framing
  - Continuous Exterior Insulation
- Vapor Controlled
  - Sheathing Temperature Kept Above Dew Point
  - Interior “Smart” Vapor Control Layer Installed
- Bulk Water Controlled
  - WRB Installed According to Manufacturer Specifications
  - Flashed Properly
- Air Controlled
  - Air Sealed at All Penetrations and Material Transitions



1 Wall Type A - Home Plans as drawn



2 Wall Type B - High Performance Option



3 Wall Type C - High Performance Option

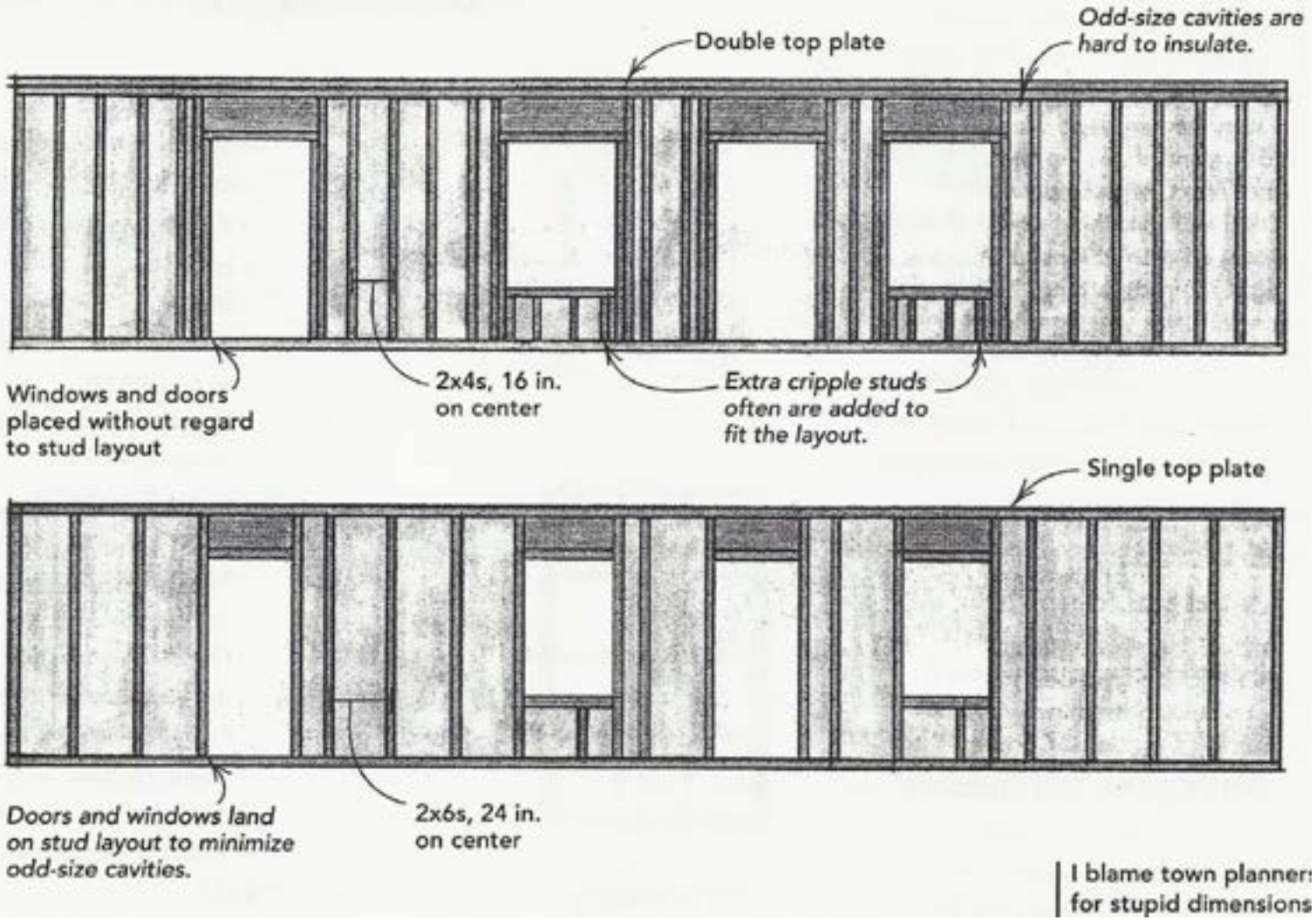
Advanced Framing

Standard wall framing

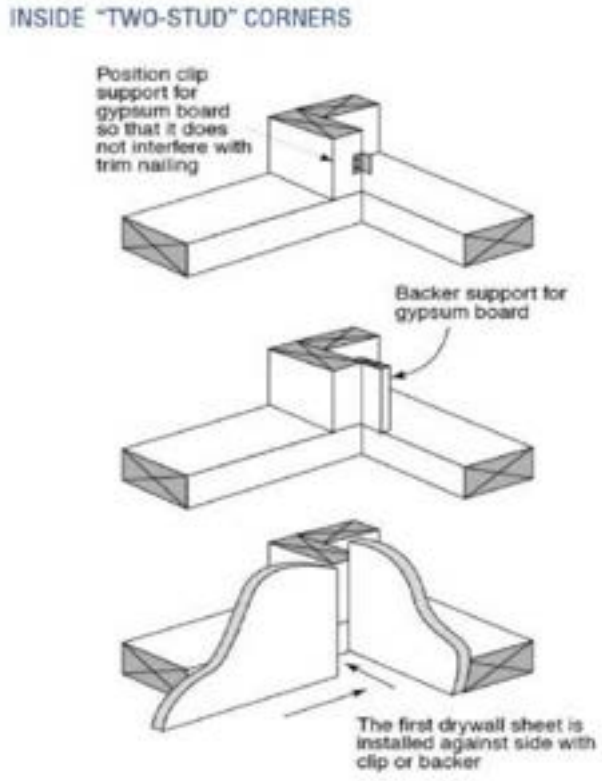
- Materials in 40-ft. wall: 35 studs, 10 cripples, 28 insulation pieces
- Amount of wall that can be insulated: 68%
- R-value: 13
- Cost of wall framing, sheathing, and housewrap for entire house: $4,039
- Annual heating and cooling costs: $1,003

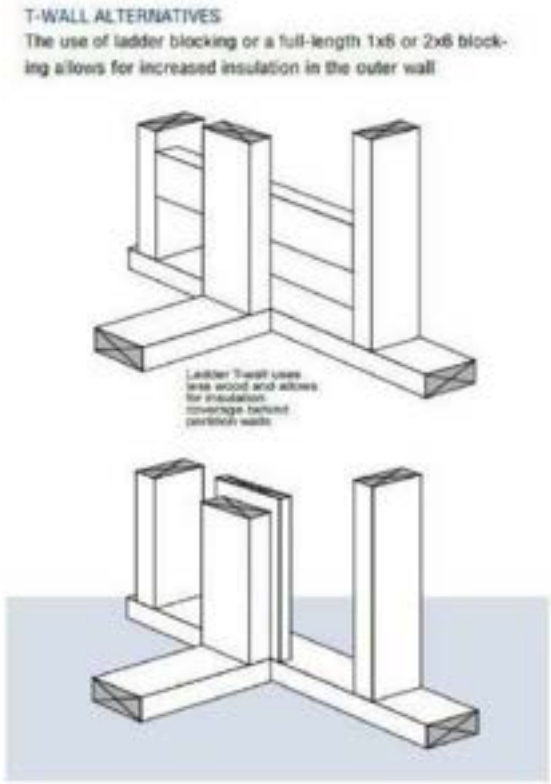
Smart wall framing

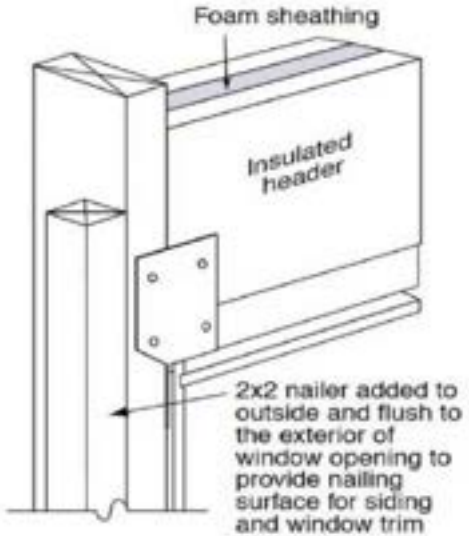
- Materials in 40-ft. wall: 21 studs, 2 cripples, 20 insulation pieces
- Amount of wall that can be insulated: 75%
- R-value: 24 (R-19 fiberglass batts, plus R-5 foam sheathing)
- Cost of wall framing and sheathing for entire house: $1,927
- Annual heating and cooling costs: $710



Advanced Framing







Advanced Framing Details - Example

Details can be found on www.buildingscience.com and DOE Building America Website

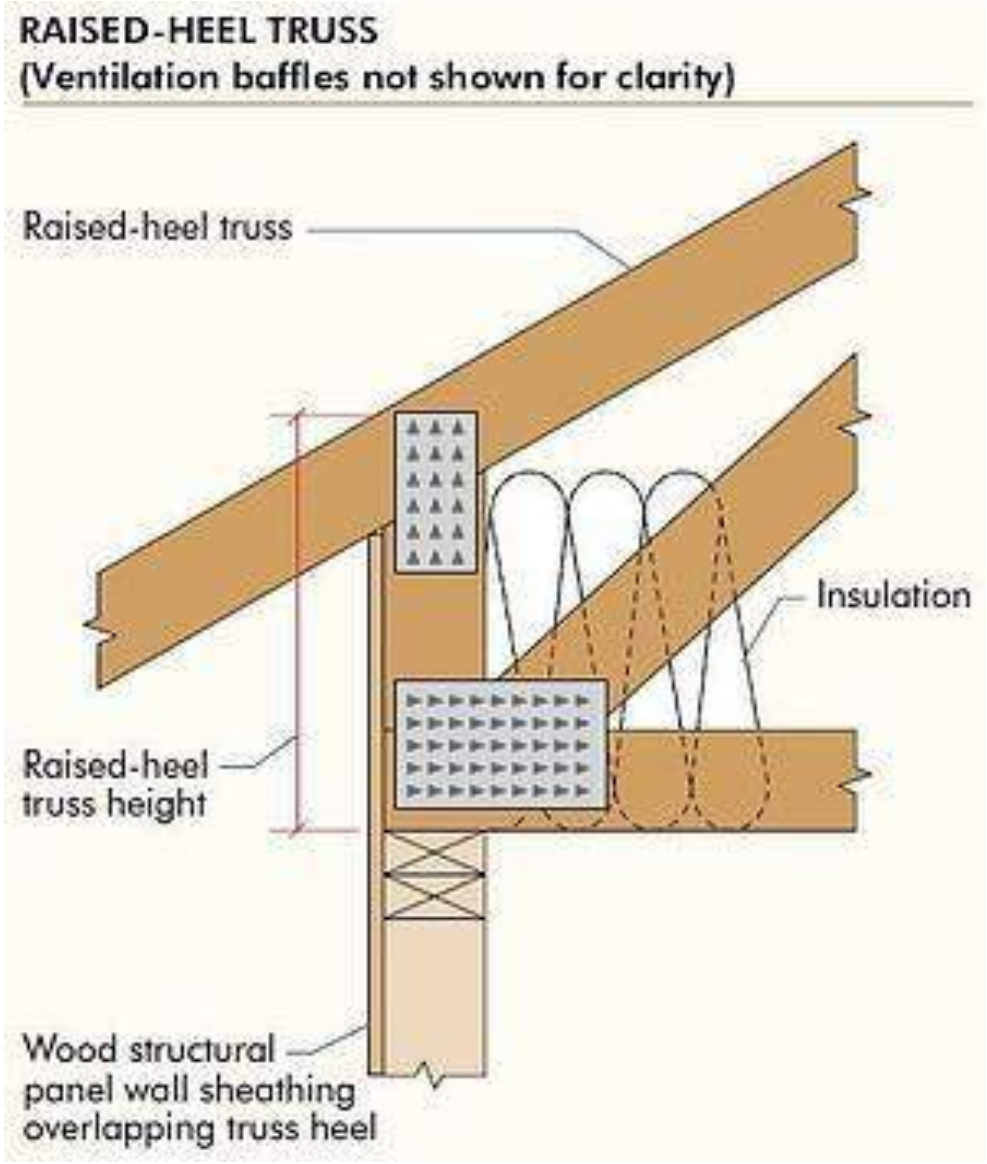
As-Built Framing Package:

- Framing Percentage: 32.4%
- Effective R-Value: 24.36

Advanced Framing Package:

- Framing Percentage: 14.2%
- Effective R-Value: 26.82
  - This is assuming 1" of rigid foam (R-5) and a 2-ply header...R-27.75 if it is a 1-ply header and 3" of foam is installed


ULATION BOARD
HAYFIELD


RAISED-HEEL TRUSS
(Ventilation baffles not shown for clarity)
Raised-heel truss
Insulation
Raised-heel
truss height
Wood structural
panel wall sheathing
overlapping truss heel

Materials

OSB – Sunday flier

OSB Hybrids – Actually perform

Plywood

Foam or Rockwool

WRBs – Water Resistive Barriers

Rainscreens - 1989

Moisture Damage – Why??


R VALUE 1.32
WARNING
COMPLETELY.
ASTM


STUDENT CENTER

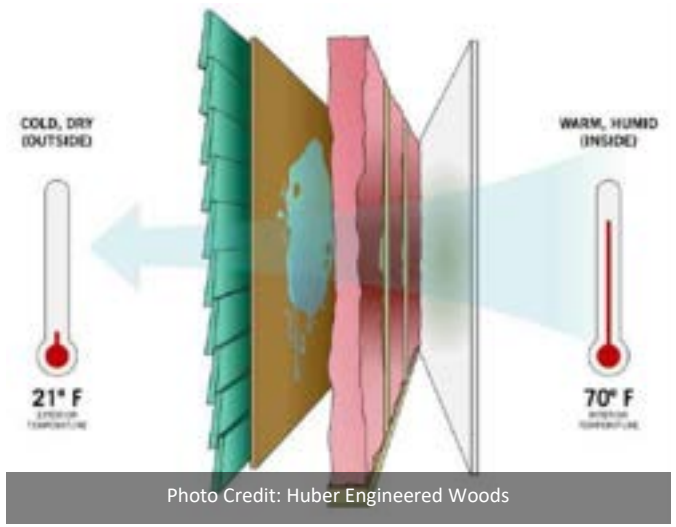


Photo Credit: Huber Engineered Woods

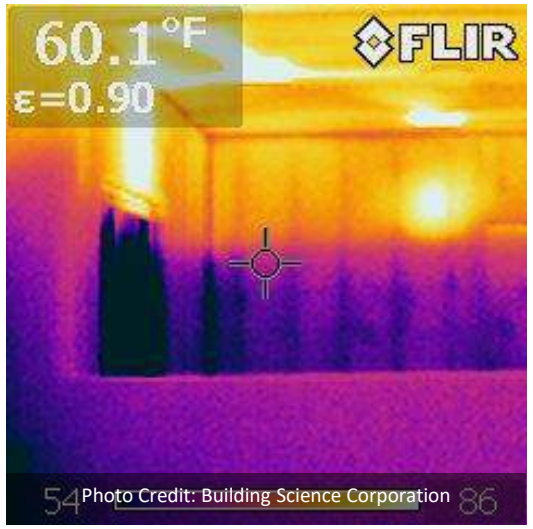


Photo Credit: Building Science Corporation

Continuous Exterior Insulation

- Reduced Thermal Bridging
  - Condensation Control
  - Rigid Foam vs. ZIP-R/LP Novacore
  - Rockwool

Green Building Advisor

Batt Insulation

- Fiberglass – 3.7 R/inch
- Mineral Wool – 3.6 R/inch
- What is a Grade I install?
  - Limited Compression
  - Cut Around Obstacles/Split Around Wires
  - In contact with all sides of cavity
  - 98% perfect installation

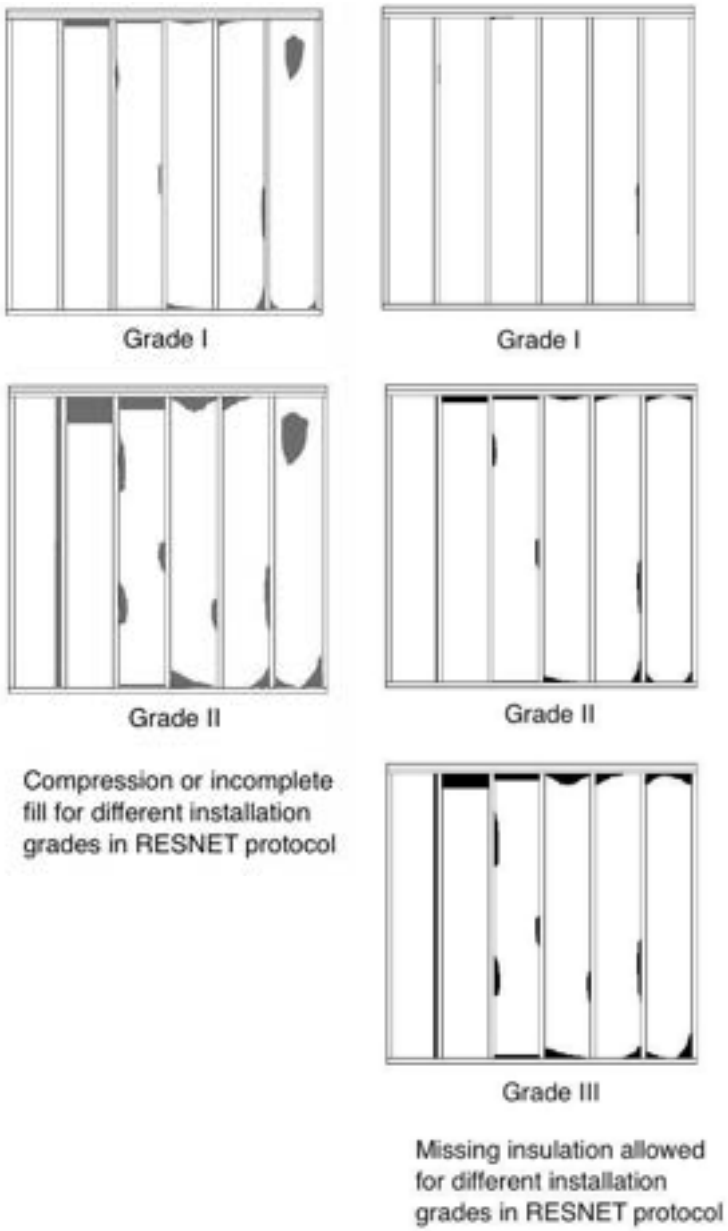


Photo Credit: Energy Vanguard

Blown Insulation

Cellulose: 3.7 R/inch

Fiberglass: 4.1 R/inch

Pros:

- Fills Cavity
- Higher R-value/inch

Cons:

- Settling
- Installation Density
- Additional Netting Needed

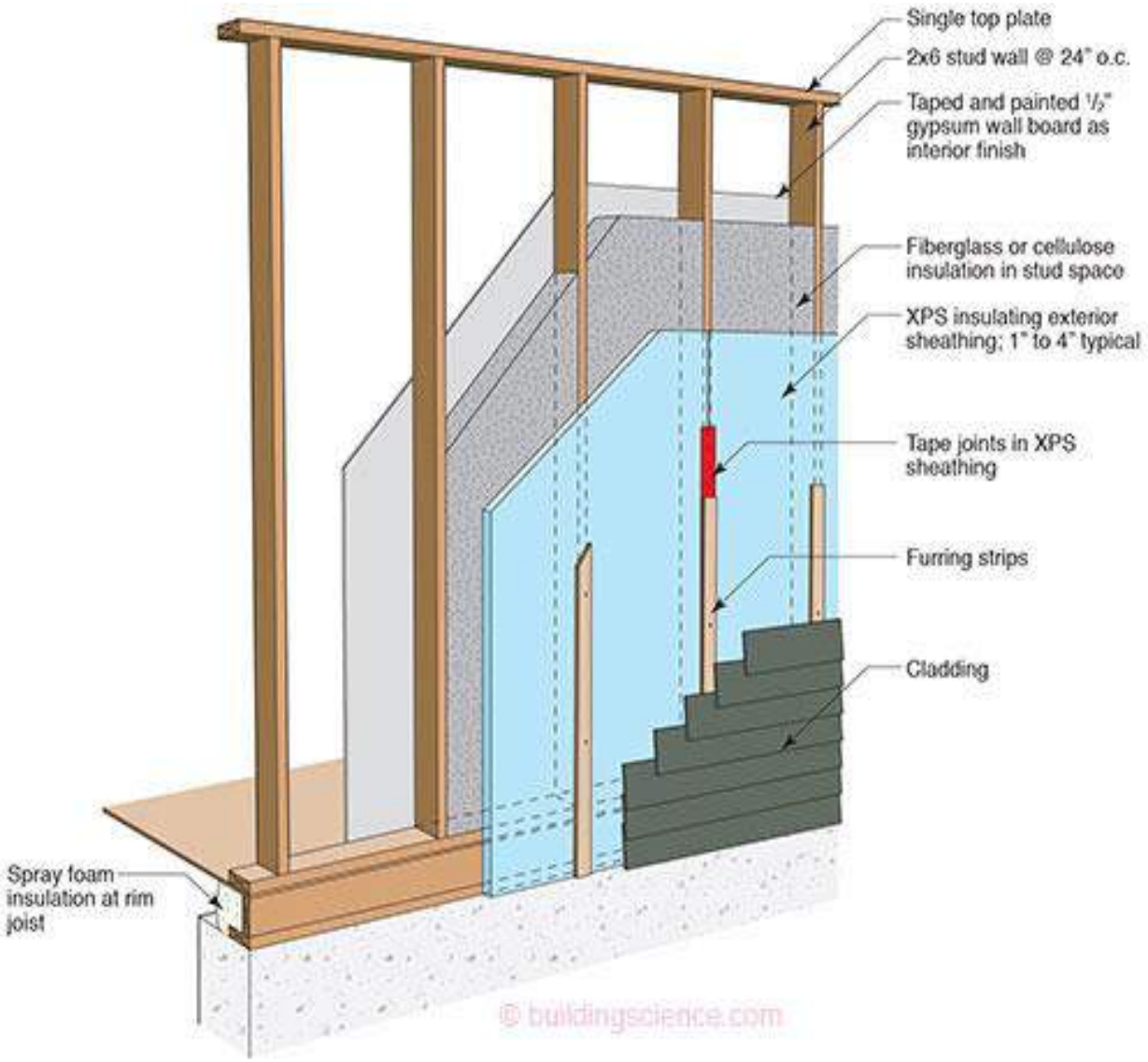


Photo Credit: Building Science Corporation

Spray Foam

Closed Cell – 6.5 R/inch

Open Cell – 3.7 R/inch

Pros

- High R-value/inch
- Helps with air sealing

Cons

- Installation is hard to control temps, mixing conditions, etc
- Derated R-value over time
- Offgassing

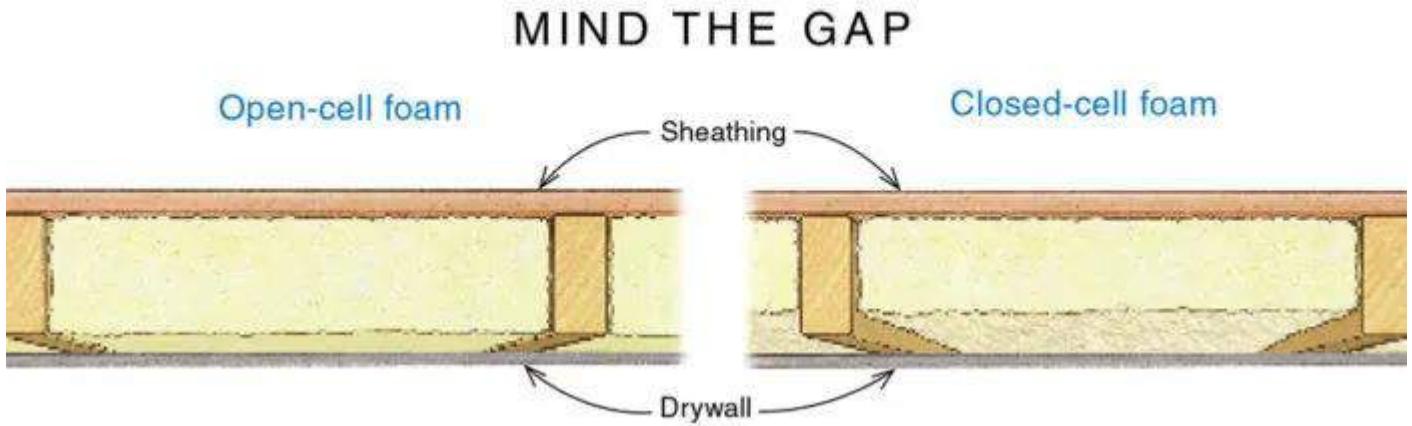


Photo Credit: Fine Homebuilding

Spray Foam

- Turns out it is kind of like “rocket science”
- Which one goes where?
- Temperature
- Moisture
- INSTALLER!!!

Double Vapor Barrier

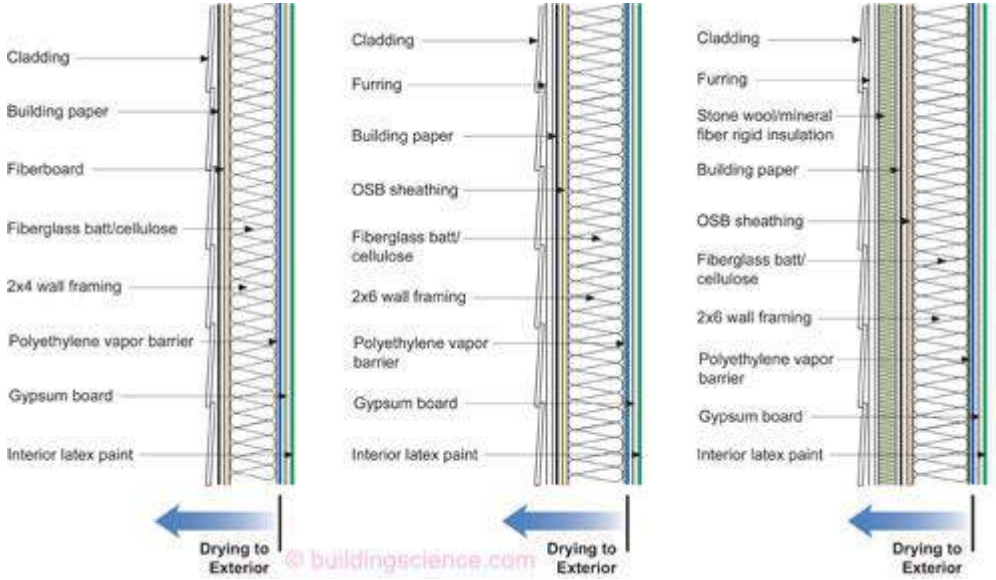
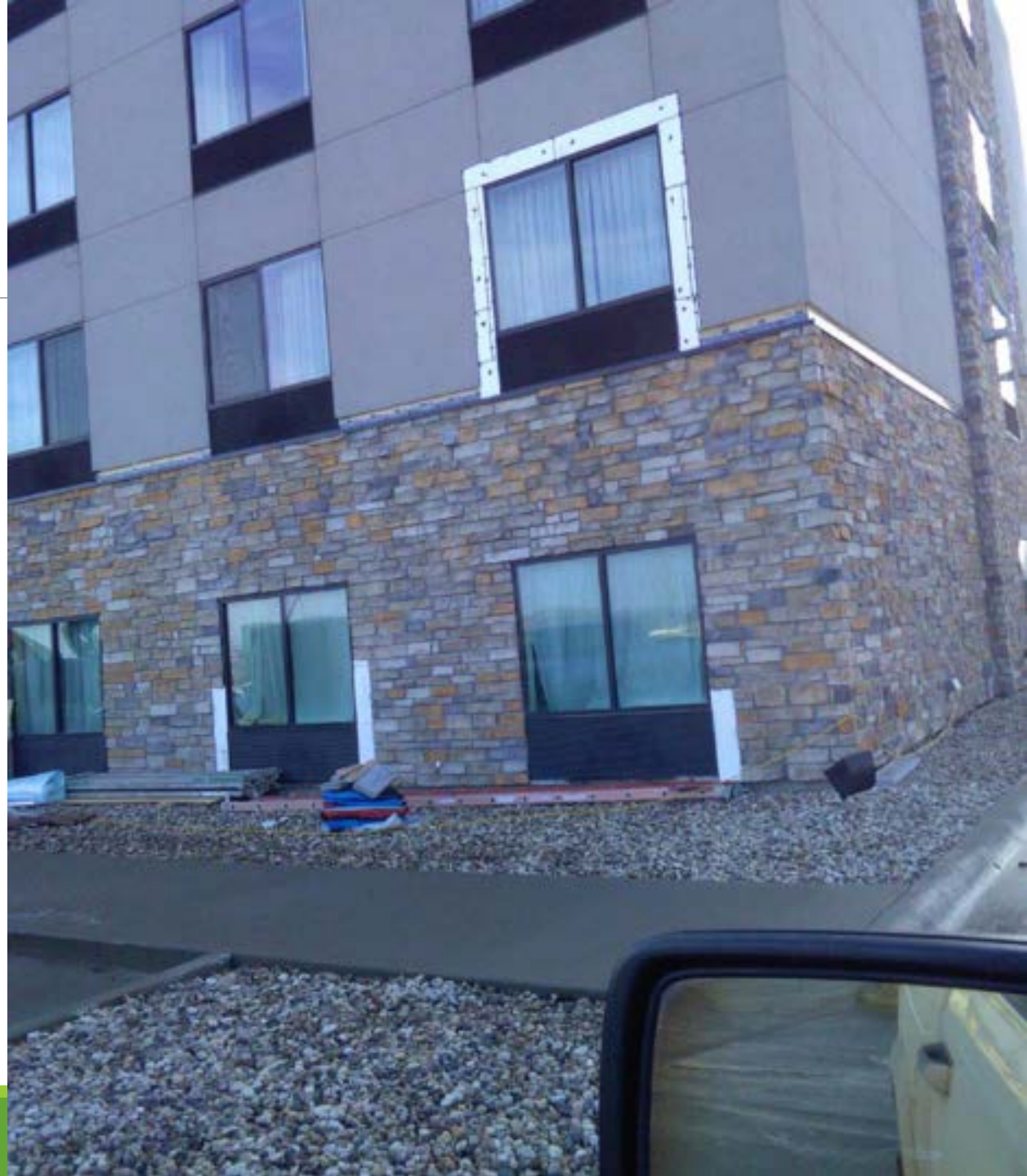


Photo Credit: Building Science Corporation



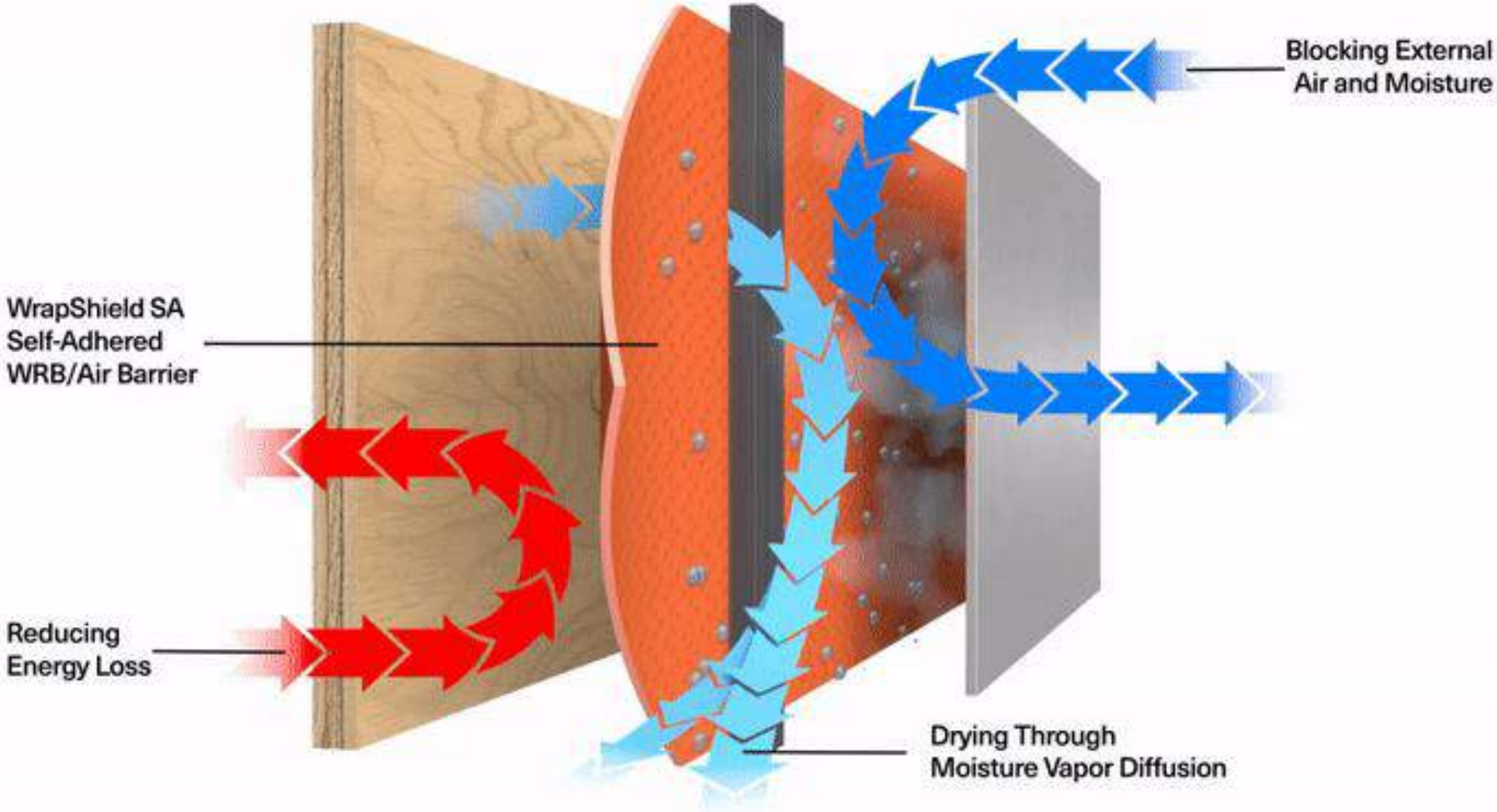
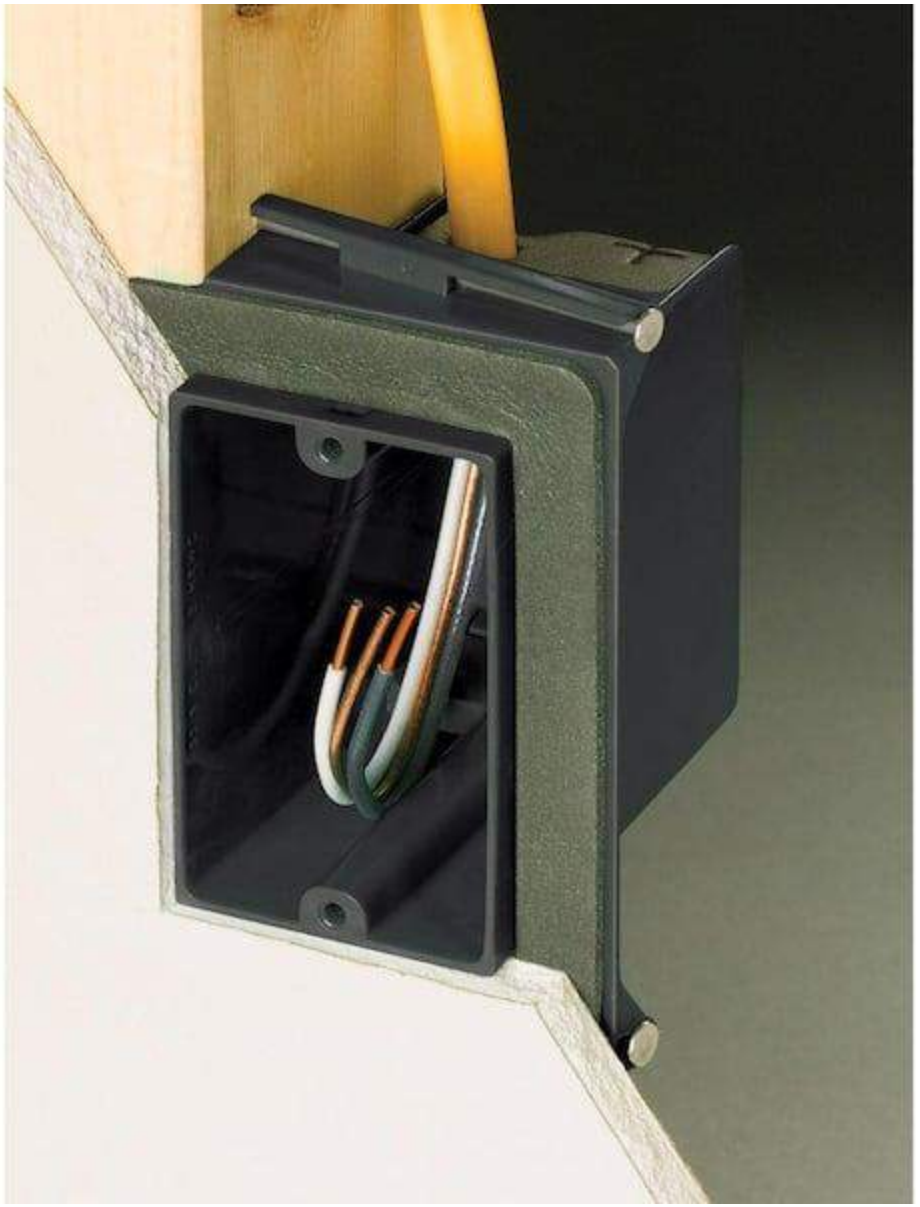

Blocking External
Air and Moisture
WrapShield SA
Self-Adhered
WRB/Air Barrier
Reducing
Energy Loss
Drying Through
Moisture Vapor Diffusion

Photo Credit: AeroBarrier West

Aerosolized Air Sealing

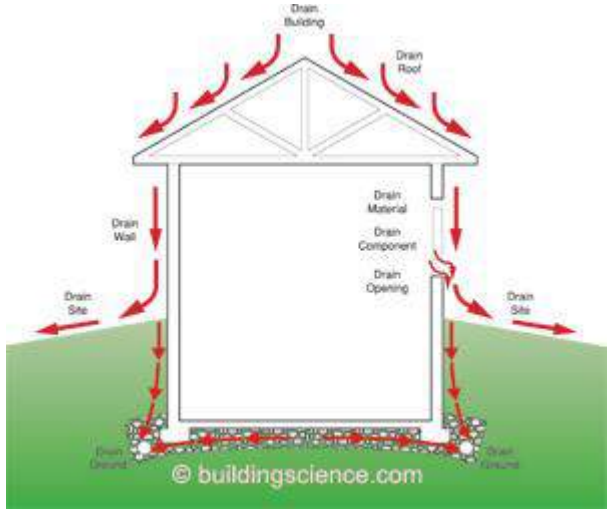
"The interior air sealant can seal all building envelope leaks of up to one-half inch in diameter. Using automated sprayers, AeroBarrier passes through gaps in the building envelope and accumulates on the edges of the openings. In less than three hours the sealant fills all the gaps. The sealant itself dries in about 30 minutes, allowing work to resume after a short break.

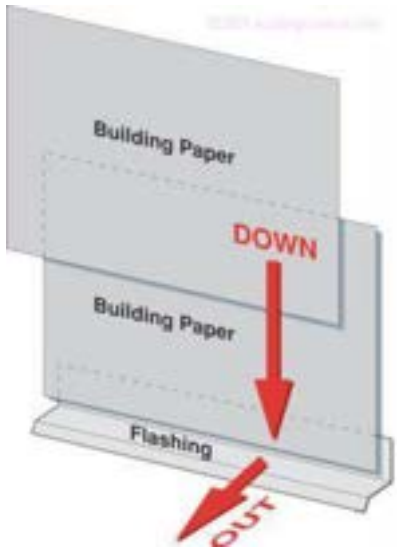
Meanwhile, the computer-controlled process allows builders to monitor act" - AeroBarrier




TESSCO

Water Control layer





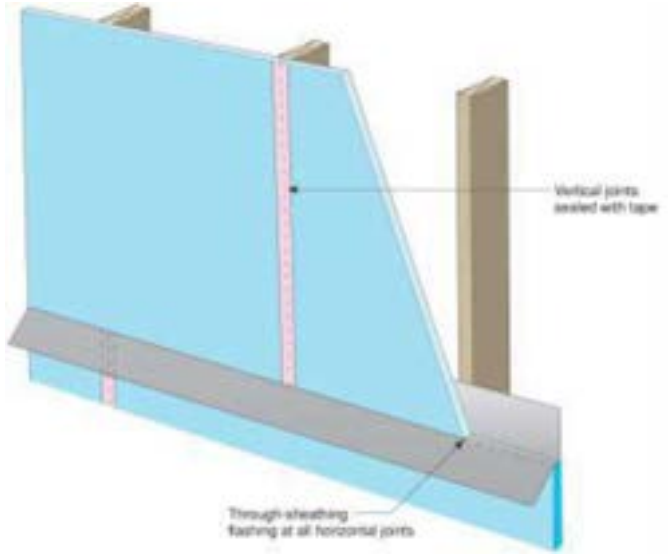
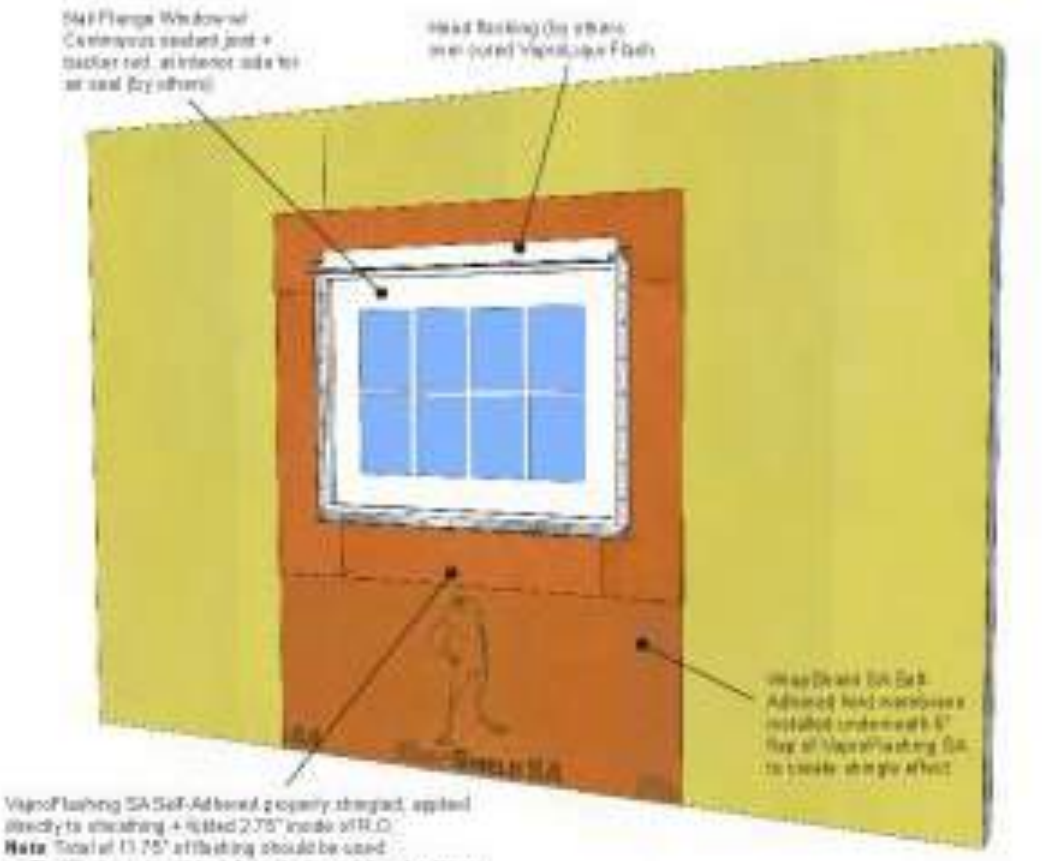


Photo Credit: Building Science Corporation

VAPROSHIELD®
Breathable Membrane Systems for Roofs & Walls

Step 7: Nail Flange Window RO Flashing System



VaproFlashing SA Self-Adhered properly shingled, applied directly to sheathing + folded 2.75" inside of R.O.
Note Total of 11.75" of flashing should be used
- 9" of flashing should be left on the face of the sheathing
- Remove release film from flashing and adhere bottom 6" to field membrane

VAPROLIQUI-FLASH™

Step 7: Install metal head flashing (by others) over cured VaproLiqui-Flash and install field membrane - shingled underneath window flashing

PRODUCT DESCRIPTION

VaproLiqui-Flash is a liquid applied, vapor permeable, waterproof, air barrier flashing system component for window and door rough openings. VaproLiquiFlash is designed to work with VaproFlashing and VaproShield field membranes as a complete system.

DISCLAIMER

DRAWN BY: AR DATE: 06.22.16

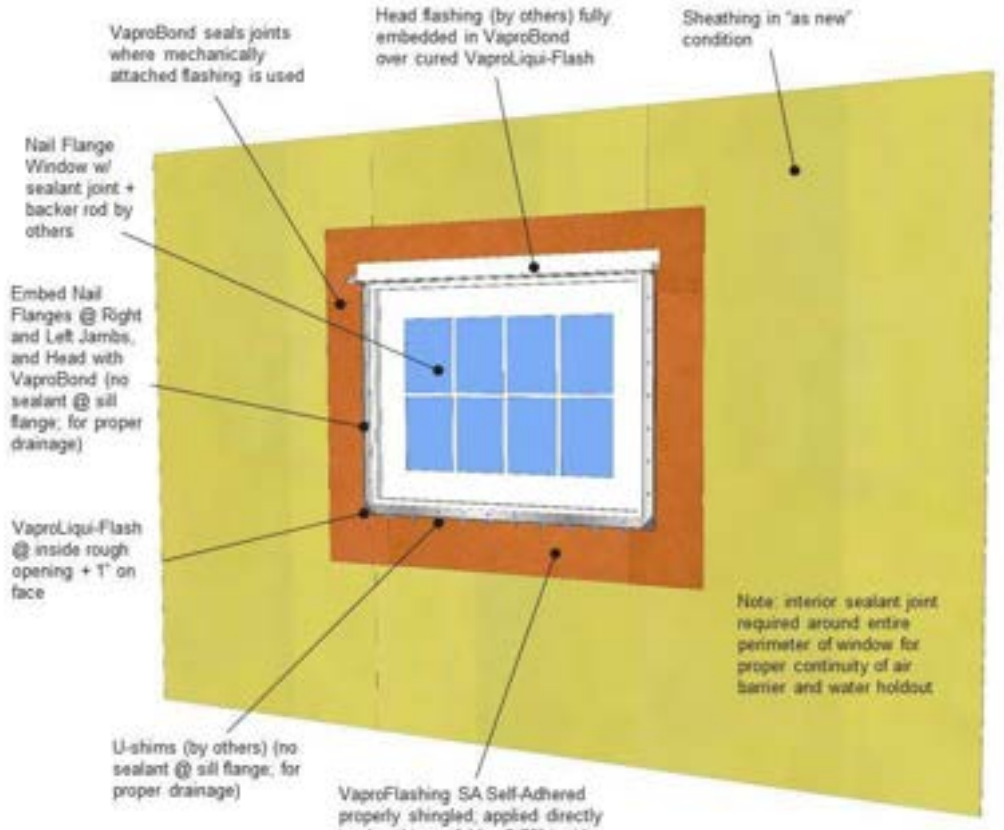
REF: 1358

Always check www.VaproShield.com for the latest details and installation instructions

VaproShield LLC | 915 26th Ave. N.W. Suite C5 | Gig Harbor, WA 98335 | Toll Free: 1.866.731.7663 | www.VaproShield.com | © VaproShield
VaproShield Canada | 101-1001 West Broadway Suite 545 | Vancouver, B.C. V6H 4E4, Canada | Toll Free: 1.866.871.8283 | www.VaproShield.ca

VAPROSHIELD®
Breathable Membrane Systems for Roofs & Walls

Rough Opening Flashing: Nail Flange Window



VAPROLIQUI-FLASH™

PRODUCT DESCRIPTION

VaproLiqui-Flash is a liquid applied, vapor permeable, waterproof, air barrier flashing system component for window and door rough openings. VaproLiquiFlash is designed to work with VaproFlashing and VaproShield field membranes as a complete system.

DISCLAIMER

Detail sketch is generic, representing suggested best practices for VaproShield materials, and does not represent a specific job site condition and therefore may not be applicable to certain projects. Detail sketch is designed for use as a reference and must be approved by the designer/ consultant of record for each project prior to installation by the subcontractor. Changes and approvals of VaproShield details are the sole responsibility of the designer/consultant of record. VaproShield is not the designer of record for building enclosure details and takes no responsibility for the accuracy or interpretation of actual project site conditions.

DRAWN BY: AR DATE: 06.23.16

REF: 103

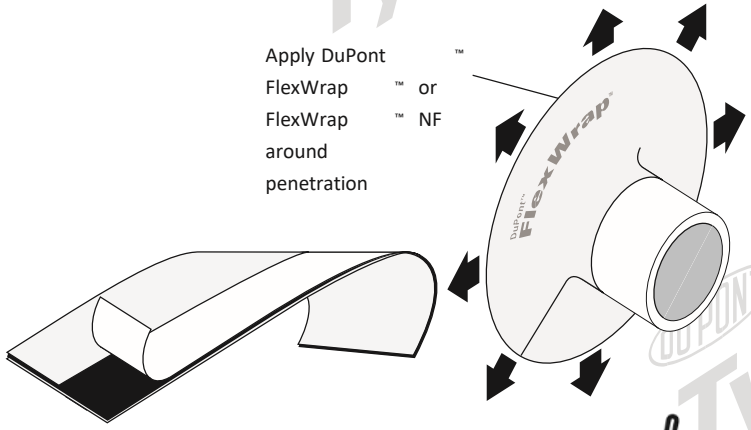
Always check www.VaproShield.com for the latest details and installation instructions

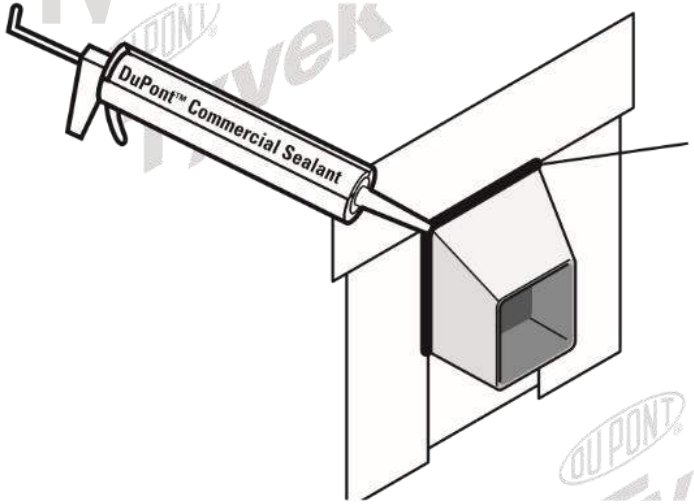
VaproShield LLC | 915 26th Ave. N.W. Suite C5 | Gig Harbor, WA 98335 | Toll Free: 1.866.731.7663 | www.VaproShield.com | © VaproShield
VaproShield Canada | 101-1001 West Broadway Suite 545 | Vancouver, B.C. V6H 4E4, Canada | Toll Free: 1.866.871.8283 | www.VaproShield.ca


SHIELD SA

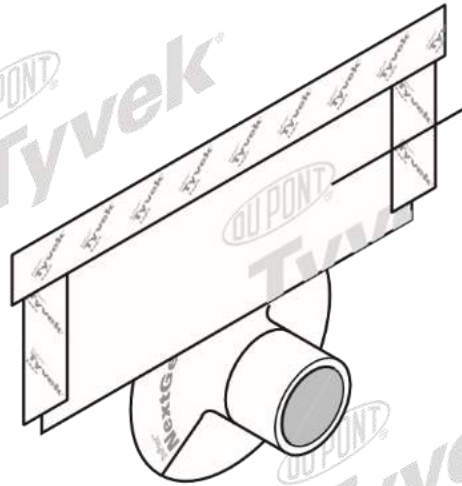

Pella
ROCKWOOL
COMFORTBOARD 80
ROCKWOOL


COMME
DUPONT





Seal around penetration using DuPont Commecial Sealant or DuPont approved sealant



Tape a piece of DuPont™ Tyvek® over the top of the DuPont™ FlexWrap™

Cobbled?


QUICKFLASH
NO CAULKING UTILITY FLASHING PANEL
FITS LOW VOLTAGE ROUNDED WIRE,* COAXIAL CABLE AND
¼" TO ¾" SIZED PIPES
PART # E-LV
P-25
Warning!
Manufacturer will not warranty any panel that has
had the seal altered, been installed incorrectly
and/or mounted on a non-specified size.
* Refer to the Quickflash electrical cross reference guide
Scan for install guides or visit
www.QuickflashProducts.com
TECHNICAL ASSISTANCE CONTACT QUICKFLASH AT 1-800-983-6888
Made in the USA


DUPONT
Tyvek
COMMERCIAL WRAP
DUPONT


Tyvek
HomeWrap
DUPONT
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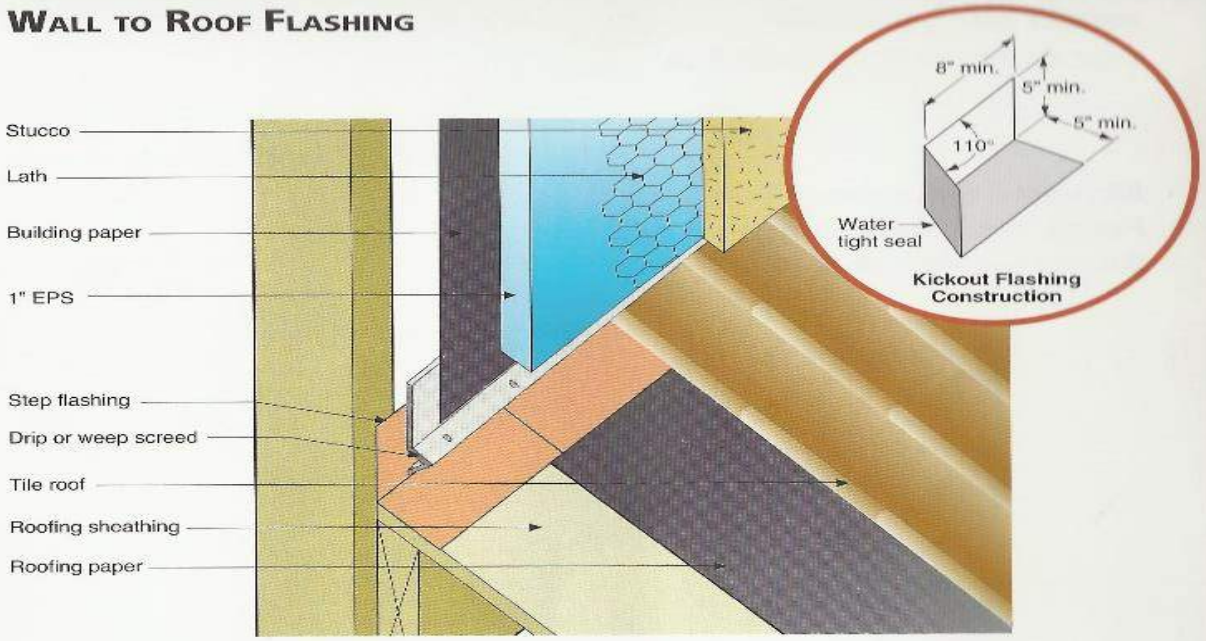
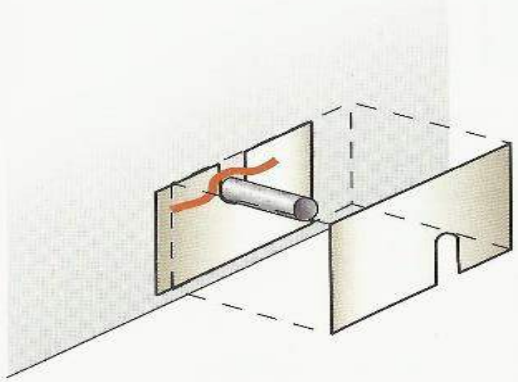
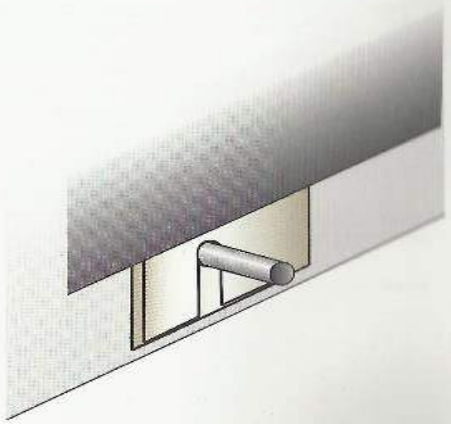
Wall to Roof Flashing

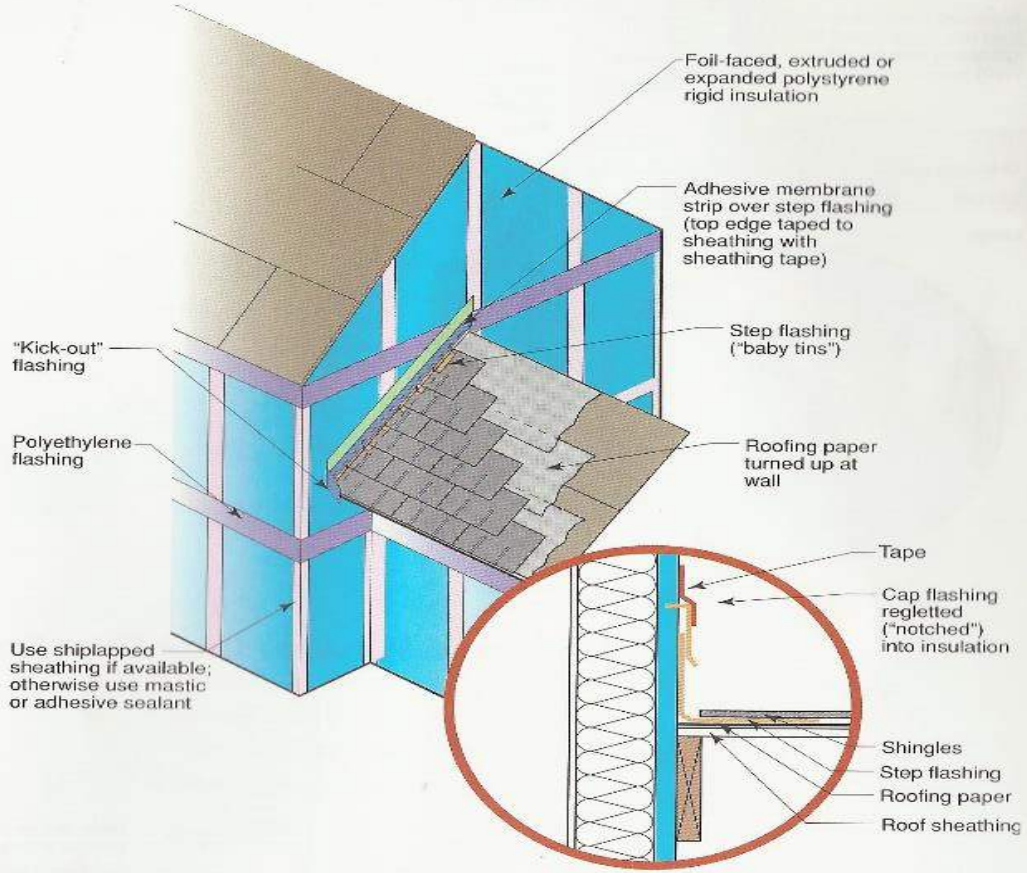


Flashing Penetrations





Wall to Roof Flashing with Foam Sheathing



Alternate Flashing Detail

Proper Window Installation

ASTM E 2112 Standard Practice for Installation of Exterior Windows, Doors, and Skylights

Sloped sub-sill or beveled siding filler

Flexible pan and up the sides

Overlaps and drip cap

Caulk and seal corners

Double check your rough openings against actual unit dimensions.


DOW
DUPONT
Tyvek
COMMERCIALWRAP
JENSEN
JENSEN


DUPONT
Tyvek
meWrap
WWW.TYVEK.COM


LP
APA
LP
APA

Attics

- Penetrations –from “has to breathe” to airtight
- Air from soffits – “vented” from bathroom?
- Kitchen exhausts – yes - no
- R-value – all 6 sides?
- Stomped on, wind blown
- Access – sealed & fire rated

Causes of Attic Frost

- Bath fans with zero ductwork
- Range hood fans to attic
- Bath or range fans ducted to a vented soffi
- Poor air sealing around penetrations and party walls
- Poor baffle installs allowing attic insulation to cavitate


IC/non-IC
PS 1


Schaeffer's
SPECIALIZED
LUBRICANTS
API SM/CF
CID-A-A-52039BB
ENERGY CONSERVING
SAE 10W-30

Heating and Cooling Common Types

- Ground Source Heat Pump
- Air Source Heat Pump
- Electric Resistance
- Natural Gas Forced Air Furnace
- Natural Gas Boiler

Domestic Hot Water Heating

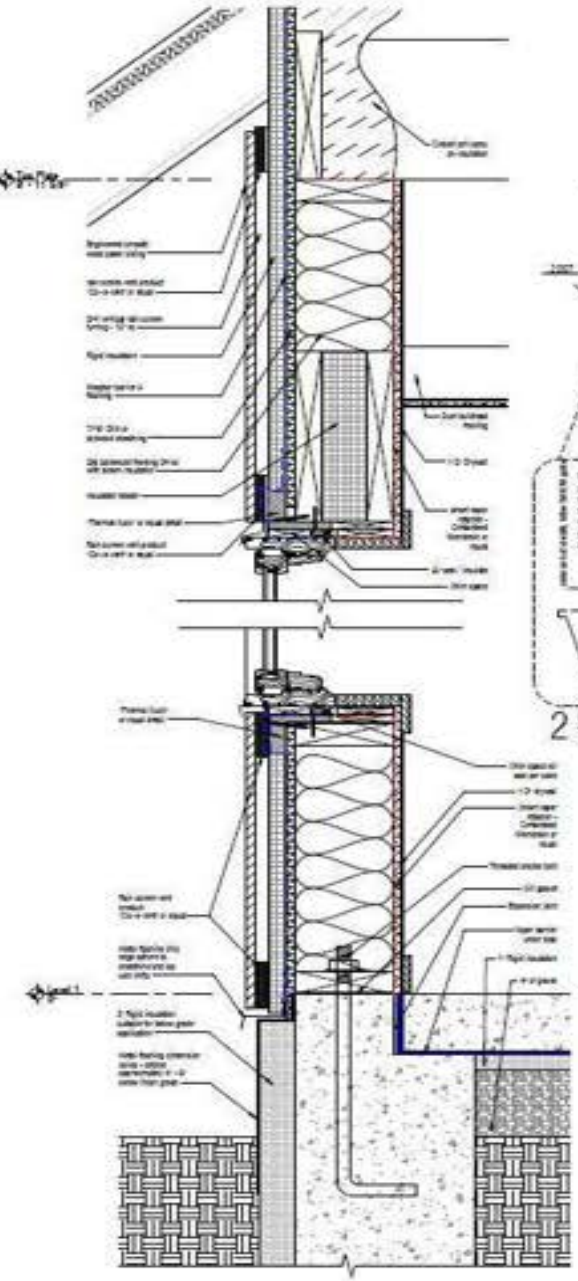
- Efficient Pipe Layout
  - Central Location of Hot Water Heater
- Insulated Hot Water Piping (R-3)
- High Efficiency
  - Natural Gas
  - Electric Resistance
  - Heat Pump

Ventilation and Indoor Air Quality

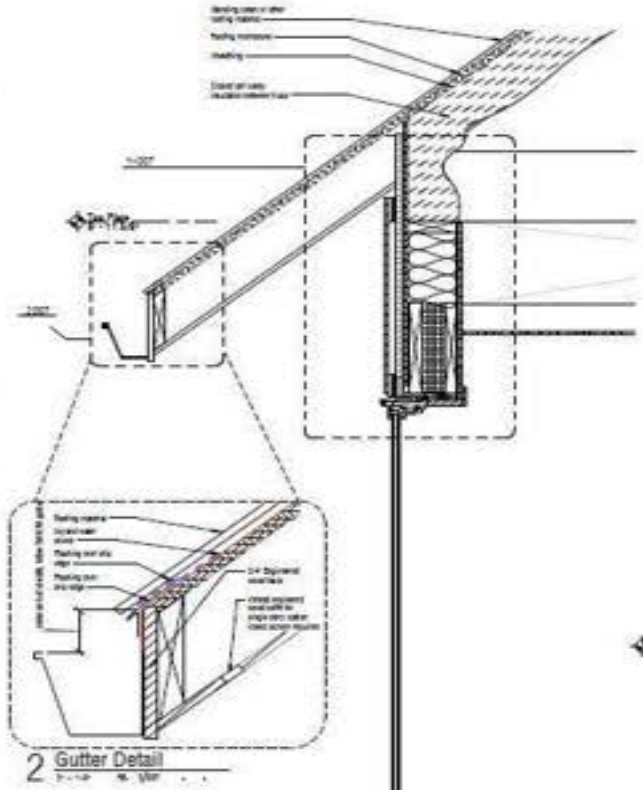
- Balanced Ventilation System (ERV/HRV)
  - Dedicated or Integrated System
- Local Mechanical Exhaust
  - Kitchen Vented to the Exterior
  - Bath Fans Vented to Exterior and Energy Star Rated
- Humidity Control
- Low VOC Materials

Now

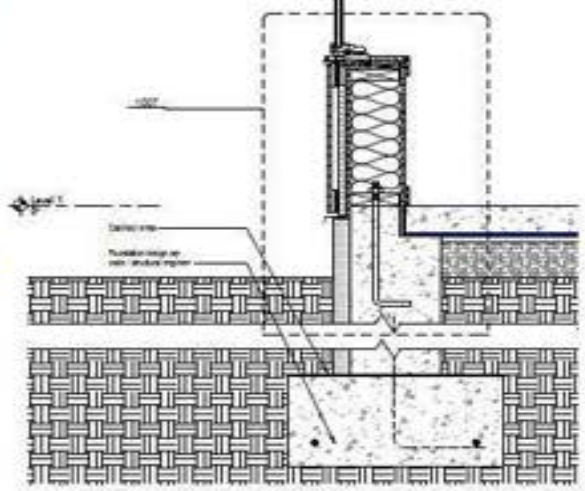
- Continuous exterior insulation
- Robust WRB
- “Smart Vapor Retarders” or Warm Surface Walls
- Heat Pump Usage
- Resilient design for extreme weather conditions
- Universal design – aging in place
- Iowa Green Streets Criteria



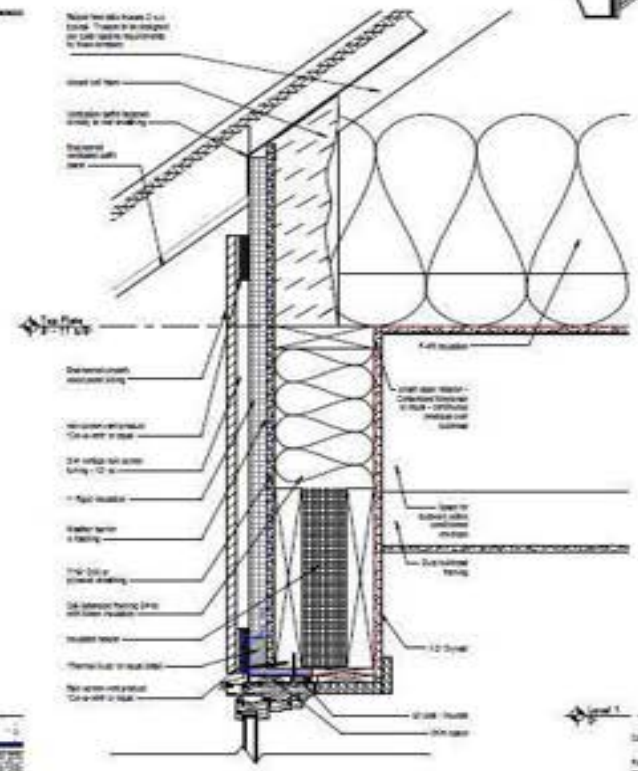
1 Detail Section - Foundation and Sill



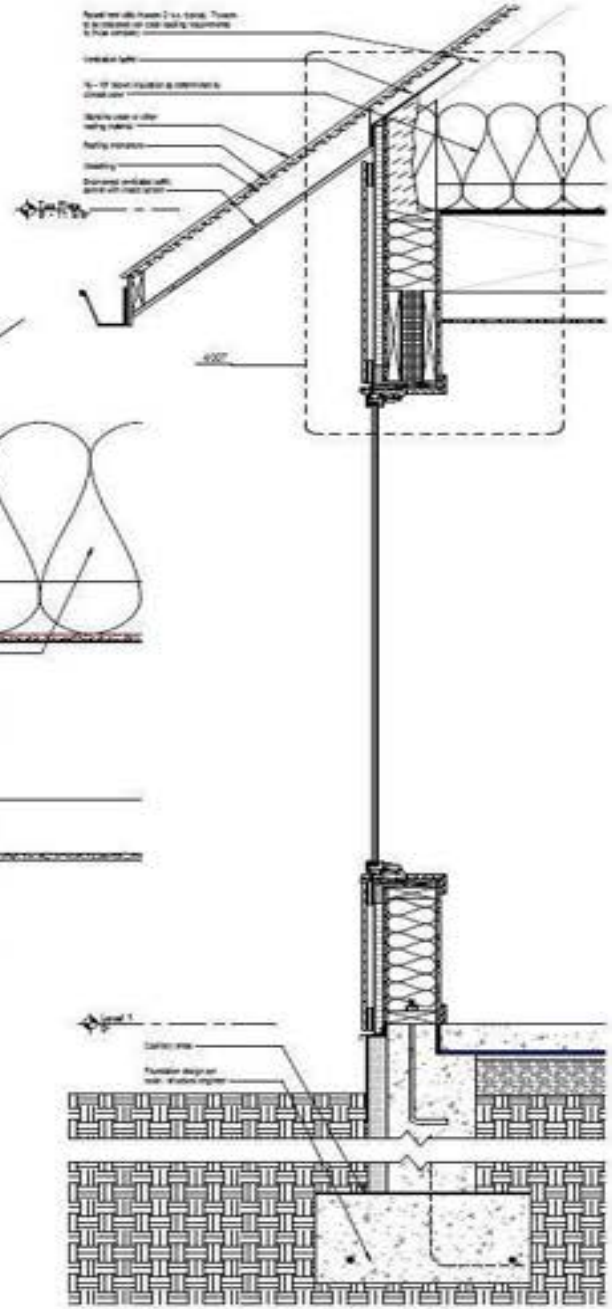
2 Gutter Detail



3 Exterior Wall - 2 Story Option



4 Vented Attic Detail



5 Exterior Wall - 1 Story Option

bnim

Schematic Design Documents

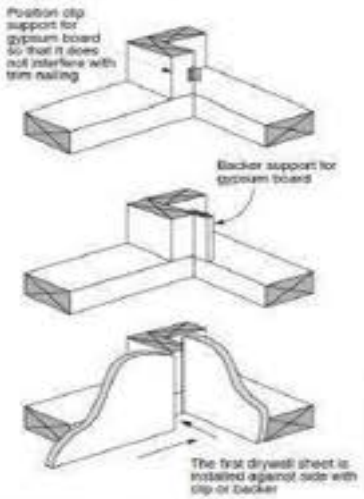
Iowa - High Performance Prototype Home

Project No: 20023.00

Details

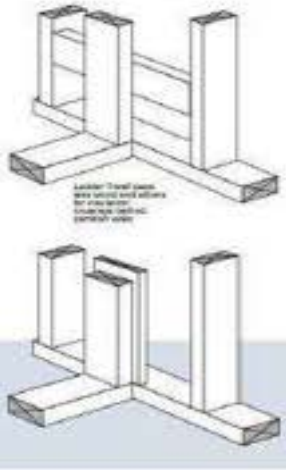
007

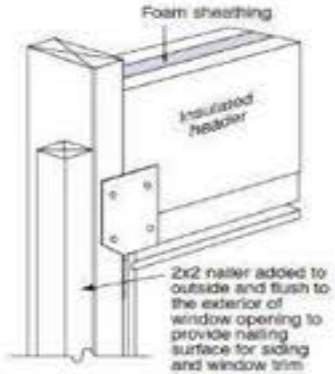
INSIDE "TWO-STUD" CORNERS

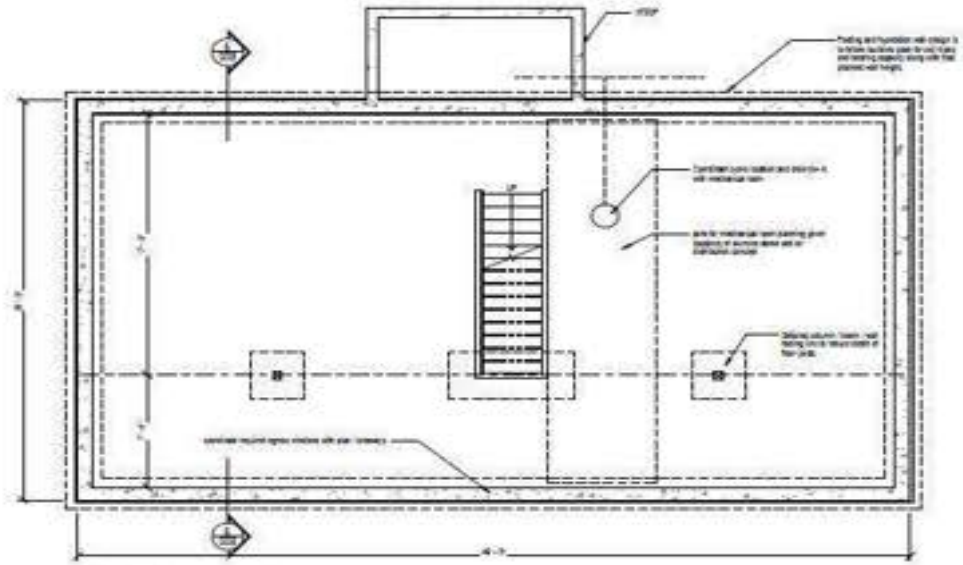


EXTERIOR WALL ALTERNATIVES

The use of ladder blocking or a full-length 1x6 or 2x6 blocking allows for increased insulation in the outer wall



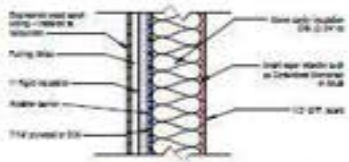




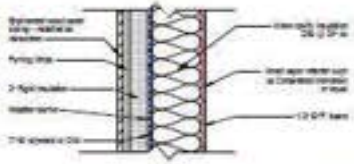
5 Optional Basement

Advanced Framing Details - Example

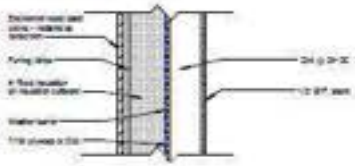
Details can be found on www.buildingamerica.com and DOE Building America Website



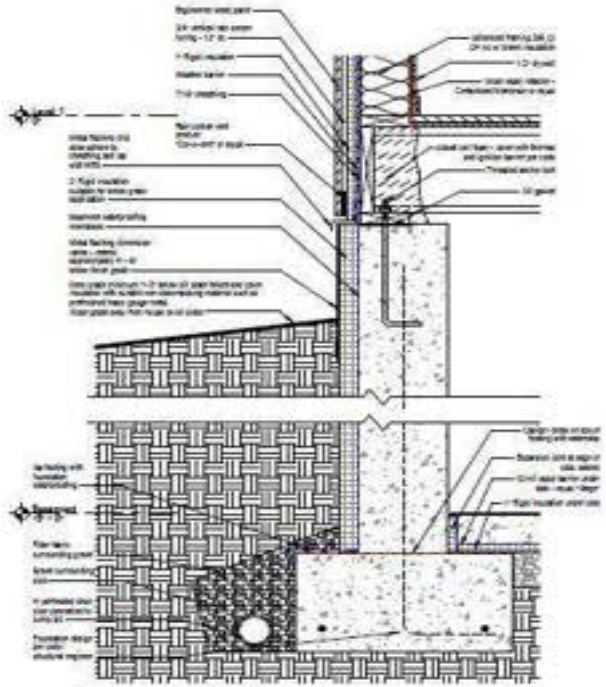
1 Wall Type A - Home Plans as drawn



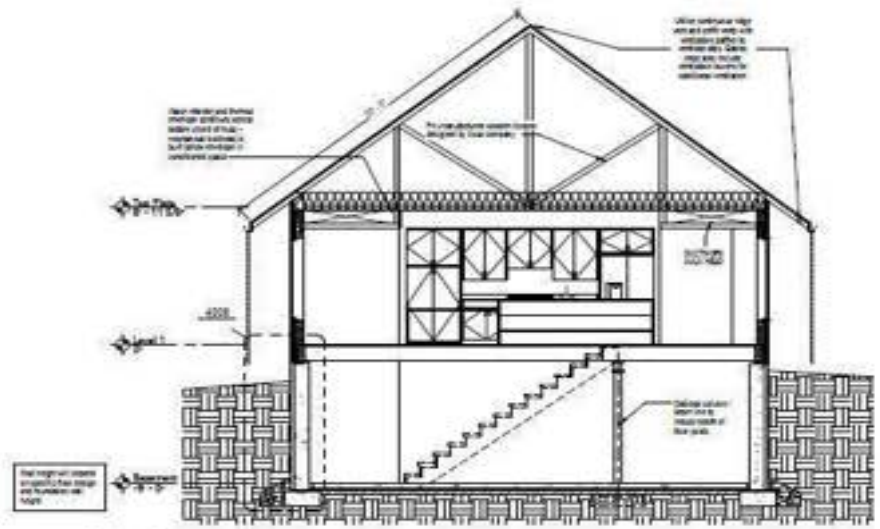
2 Wall Type B - High Performance Option



3 Wall Type C - High Performance Option



4 Basement Wall Detail



6 Section Basement

bnim

Schematic Design Documents

Iowa - High Performance Prototype Home

Iowa Energy Office

Iowa Economic Development Authority

Project No: 03013.00

Basement and Wall Options

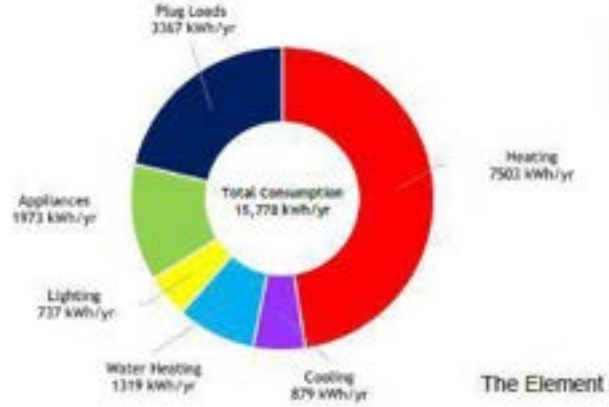
008

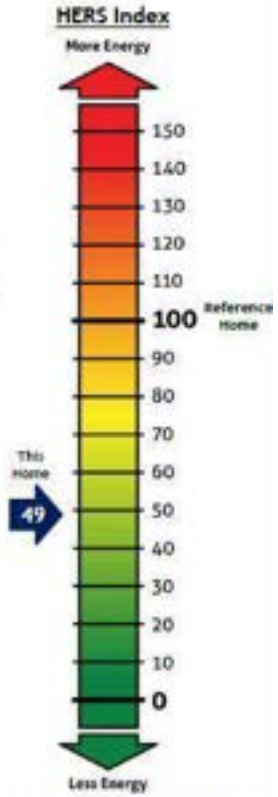
Prototype Option 3B (Modified Envelope & Systems)

Model Information:

- 2 Story, Finished Basement
- Des Moines, IA (Climate Zone 5)
- 4 Bedroom, 3 Bathroom
- Gross Floor Area = 2943 SF
- DOE Net Zero Ready Home
  - Total Building Leakage = 2 ACH50
  - Window U-Factor = 0.30, 0.40 SHGC
  - Increased South Facing Fenestration
  - R-20 Cont. Insulation, 4" Rigid Foam
  - Vaulted Ceiling, R-33.5 CCSP
  - Basement Foundation
    - R-15 CI Foundation Walls, 8'
    - R-5 Under Slab
  - Energy Star Mechanicals and Appliances
    - Air Source Heat Pump (9 HSPF, 16 SEER)
      - Ductwork in Conditioned Space
      - Duct Leakage at Code Maximum Threshold
    - Balanced Ventilation w/ Recovery (SRE 64%)
    - 2.0 EF Heat Pump Water Heater, DHW Insulated R-3
    - Energy Star Appliances
    - 100% LED Lighting Fixtures
    - WaterSense Labeled Fixtures

Annual Energy Consumption:





Detail Driven

Healthy

Comfortable

Energy efficient

Durable / Ready for extreme weather events

Ease of replication

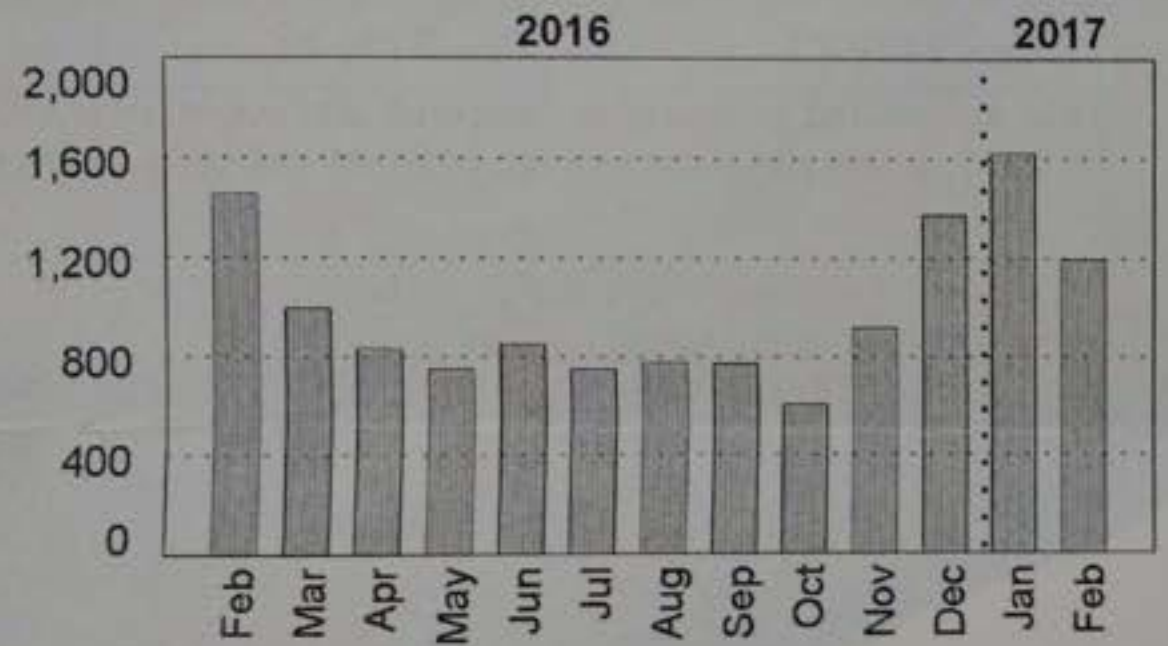
Directions – Why not follow them?


QUESTIONS?

Extra Slides Below

020 Davenport IA 52808-8020
mericanenergy.com

RIC USAGE (kWh) COMPARISON



Month	Days	Usage	Avg Use/Day	Avg Cost/Day	Avg Temp
02/17	29	1,198	41.31	$3.33	34
01/17	33	1,626	49.27	$3.49	24
12/16	30	1,375	45.83	$3.42	22
11/16	33	919	27.85	$2.43	47
10/16	29	610	21.03	$1.93	56
09/16	32	776	24.25	$2.78	68
08/16	29	779	26.86	$3.07	72
07/16	30	754	25.13	$2.89	72
06/16	32	851	26.59	$3.02	72
05/16	29	755	26.03	$2.29	57
04/16	28	837	29.89	$2.60	49
03/16	29	997	34.38	$2.91	42
02/16	33	1,461	44.27	$3.14	27


R-10
R-10
R-10

ENERGY STAR® CERTIFIED NEW HOME

Builder Name: **Corn Belt Builders & Realty**
Permit Date/Number:
Home Address: **101 Arrowhead Ridge Rd**
Denver, IA 50622

Rating Company: **The Element Group**
Rater Identification Number: **8354577**
Rating Date: **02/12/14**
Version: **3.0**

Standard Features of an ENERGY STAR Certified New Home

Your ENERGY STAR certified new home has been designed, constructed, and independently verified to meet rigorous requirements for energy efficiency set by the U.S. Environmental Protection Agency (EPA), including:

Thermal Enclosure System

A complete thermal enclosure system that includes comprehensive air sealing, quality-installed insulation and high-performing windows to deliver improved comfort and lower utility bills.

Air Infiltration Test: **Htg: 875 Clg: 875 CFM50**

Primary Insulation Levels:

Ceiling: R-46.0 **FndWall: R-22.2**
AGWall: R-28.0 **Floor: R-37.3** **Slab: R-15.0**

Primary Window Efficiency:
U-Value: 0.280, SHGC: 0.280

Water Management System

A comprehensive water management system to protect roofs, walls, and foundations.

Flashing, a drainage plane, and site grading to move water from the roof to the ground and then away from the home.

Water-resistant materials on below-grade walls and underneath slabs to reduce the potential for water entering into the home.

Management of moisture levels in building materials during construction.

Heating, Cooling, and Ventilation System

A high-efficiency heating, cooling system, and ventilation system that is designed and installed for optimal performance.

Total Duct Leakage:
326.00 CFM25.

Duct Leakage to Outdoors:
0.00 CFM25.

Primary Heating (System Type • Fuel Type • Efficiency):
Electric, Htg: 5.0 COP, Clg: 20.1 EER, w/DSH.

Primary Cooling (System Type • Fuel Type • Efficiency):
Electric, Htg: 5.0 COP, Clg: 20.1 EER, w/DSH.

Energy Efficient Lighting and Appliances

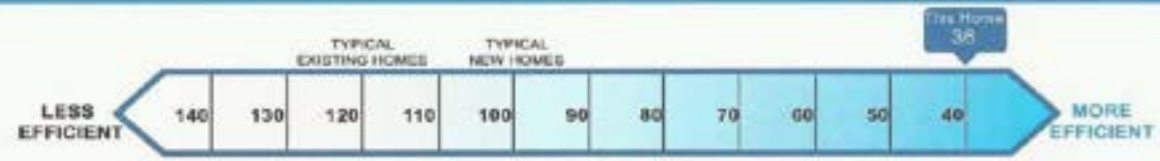
Energy efficient products to help reduce utility bills, while providing high-quality performance.

ENERGY STAR Qualified Lighting: **80%**

ENERGY STAR Qualified Appliances and Fans:

Refrigerators: 1 **Dishwashers: 1**
Ceiling Fans: 0 **Exhaust Fans: 0**

Primary Water Heater (System Type • Fuel Type • Efficiency):
Conventional, Electric, 0.94 EF, 50.0 Gal.



HERS® Index

This certificate provides a summary of the major energy efficiency and other construction features that contribute to this home earning the ENERGY STAR, including its Home Energy Rating System (HERS) score, as determined through independent inspection and verification performed by a trained professional. The Home Energy Rating System is a nationally-recognized index to measurement of the energy efficiency of homes.

Note that when a home contains multiple performance levels for a particular feature (e.g., window efficiency or insulation levels), the predominant value is shown. Also, homes may be certified to earn the ENERGY STAR using a sampling protocol, whereby one home is randomly selected from a set of homes for representative inspections and testing. In such cases, the features found in each home within the set are intended to meet or exceed the values presented on this certificate. The actual values for your home may differ, but offer equivalent or better performance.

This certificate was printed using REMRate – Residential Energy Analysis and Rating Software v14.4. © 1985-2013 Architectural Energy Corporation, Boulder, Colorado.

Learn more at www.energystarqualifiednewhomes.com

II. V.O.A.T. Wall

Energy Efficiency

Exceeds the energy code. Continuous insulation helps cancel the thermal bridging through the studs. Airtight.

Install Complexity

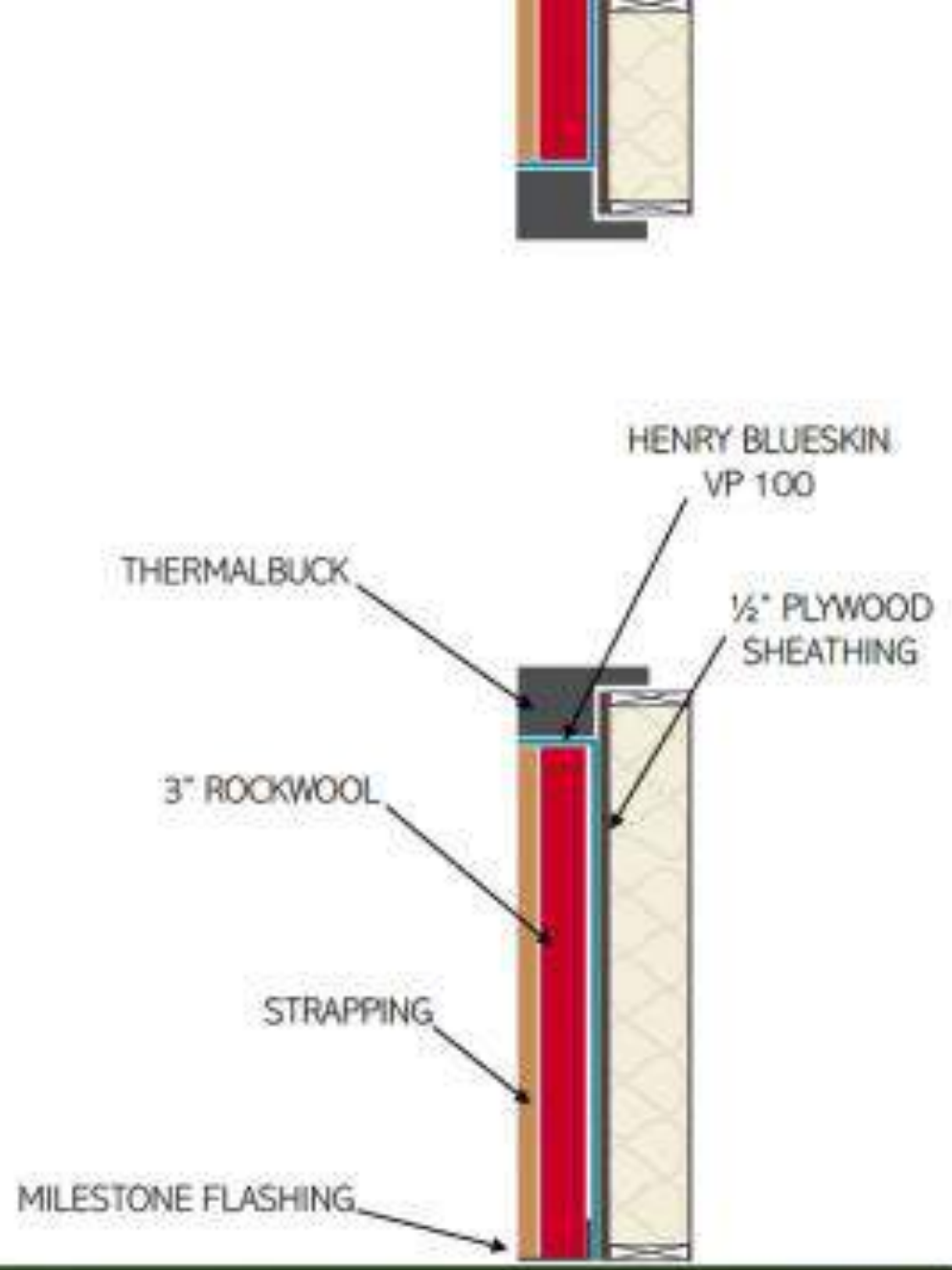
- Very complex - lots of components. All the newest building concepts combined into one idea.
- Six times around the house. Plywood, WRB, ThermalBuck,™ Exterior ROCKWOOL™ insulation (x2), and 5/8" strapping.

When

Best used with new construction and additions.

Moisture Management

Extremely effective.




CANADA STEAMSHIP LINES


JOHN DEERE
70
Power Steering
PLEASE
DO NOT TOUCH