In accordance with the Department of Labor and Industry's statute 326.0981, Subd. 11,

"This educational offering is recognized by the Minnesota Department of Labor and Industry as satisfying **1.5 hours** of credit toward **Building Officials and Residential Contractors code /1 hour energy** continuing education requirements."

For additional continuing education approvals, please see your credit tracking card.

Building to ZERH/Lessons Learned & FORTIFIED Build

Brian J. Wimmer

Lou Behrens

Retired Electrical Engineer & Project Manager

Building to Meet ZERH w/Multiple Layers of Foamboard: Lessons Learned

1. How we've built to meet ZERH
2. What we've learned and what will we adopt or change
3. Moving to remodel on tax forfeited properties to make ZERH
4. What are our costs to meet ZERH?
5. The two most important controls in constructing our energy-efficient homes starting with the simplest techniques
6. What is "Fortified Build?
7. The three levels of Fortified Build
8. Benefits & Cost

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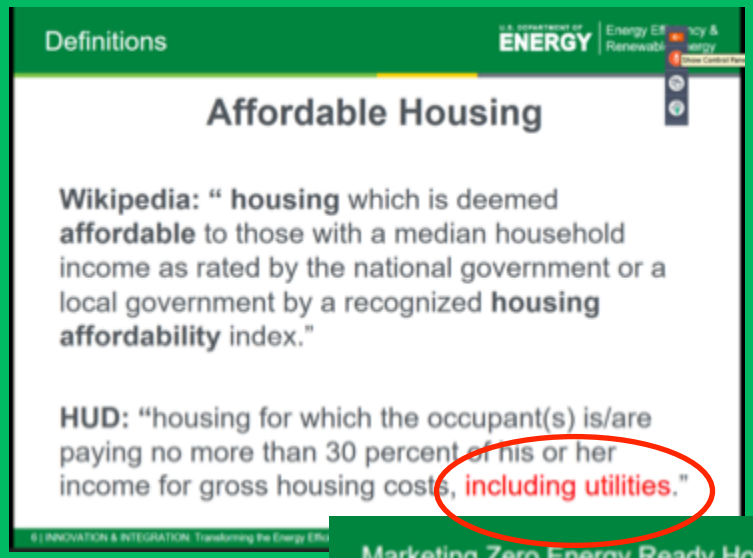
ZERH: Affordable?



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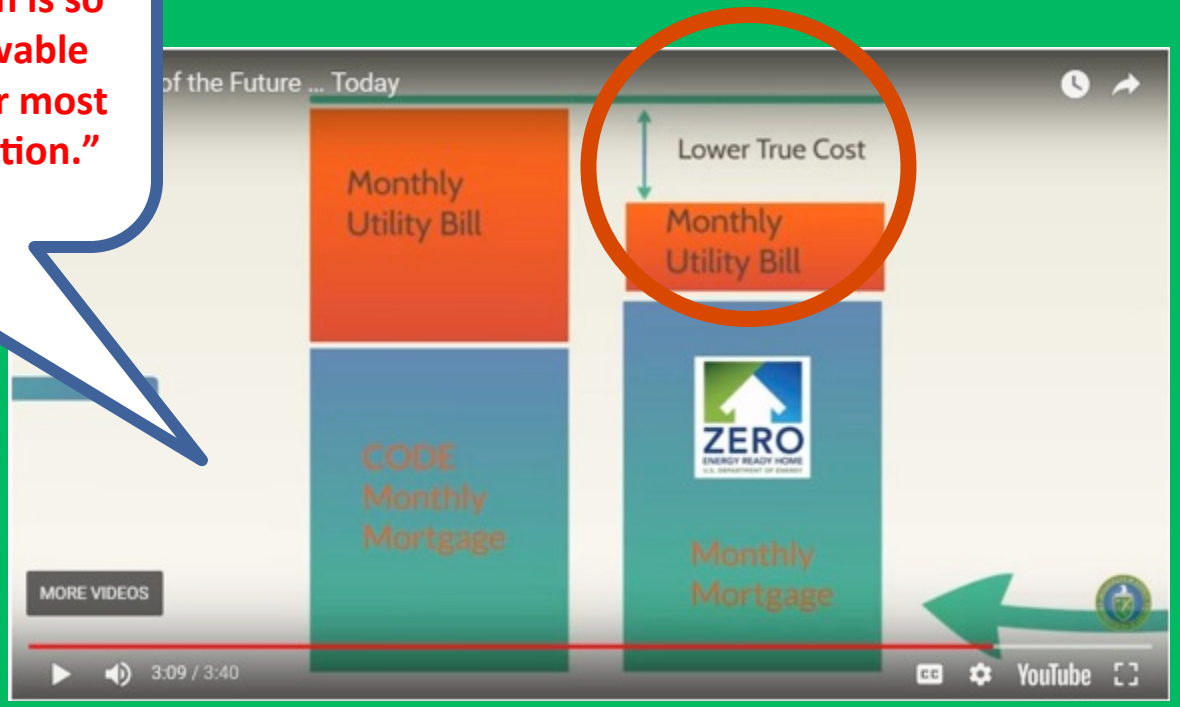
ZERH: What is it?

"A DOE Zero Energy Ready Home is a high performance home which is so energy efficient, that a renewable energy system can offset all or most of its annual energy consumption."



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DOE ZERH Requirements

DOE Zero Energy Ready Home
National Program Requirements (Rev. 06)
April 20, 2017

DOE Zero Energy Ready Home Performance Path

While all mandatory requirements for labeled homes in Exhibit 1 shall be met, the performance path provides flexibility to select a custom combination of measures that meet the performance level of the DOE Zero Energy Ready Home HERS Target Home (Exhibit 2). Modeling is required, but measures can be optimized for each particular home or builder. Follow the steps below to use the performance path with RESNET-accredited Home Energy Rating Software programs:

1. The HERS Index of the DOE Zero Energy Ready Home Target Home is determined. The DOE Zero Energy Ready Home Target Home is identical to the home that will be built, except that it is configured with the energy efficiency features of the DOE Zero Energy Ready Home Target Home as defined in Exhibits 1 and 2. Note, any state energy code requirements that exceed those specified on Exhibit 2 take precedence for purposes of determining the DOE Zero Energy Ready Home Target Home[8]. The HERS Index of the Target Home is automatically calculated in accordance with the RESNET Mortgage Industry National Home Energy Rating Standards.
2. A size modification factor is next calculated using the following equation:

$$\textbf{Size Modification Factor} = [CFA_{\text{Benchmark Home}} / CFA_{\text{Home To Be Built}}]^{0.25}, \textbf{ but not to exceed 1.0}$$

Where:

$CFA_{\text{Benchmark Home}}$ = Conditioned Floor Area of the Benchmark Home, using Exhibit 3
$CFA_{\text{Home to be Built}}$ = Conditioned Floor Area of the Home to be Built

Since the Size Modification Factor cannot exceed 1.0, it only modifies the HERS Index score for homes larger than the CFA of the Benchmark Home.

3. The HERS Index of the DOE Zero Energy Ready Home Target Home is calculated next[9]:

DOE Zero Energy Ready Home HERS Index Target =
HERS Index of DOE Zero Energy Ready Home Target Home x Size Modification Factor

4. Complete HERS software calculations for preferred set of energy measures and verify resulting HERS Index Score at or below DOE Zero Energy Ready Home Target Home HERS Index Score modified, as required, for house size.
5. Construct the home using measures that result in a HERS Index at or below the DOE Zero Energy Ready Home HERS Target, calculated above, and the mandatory requirements for all labeled homes, Exhibit 1.
6. Verify that all requirements have been met using an approved verifier.

All homes certified through the Performance Path shall be submitted to DOE by submitting the compliance verification report to zero@newportpartnersllc.com.

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DOE ZERH Requirements

DOE Zero Energy Ready Home
National Program Requirements (Rev. 06)
April 20, 2017

Exhibit 1: DOE Zero Energy Ready Home Mandatory Requirements for All Labeled Homes

Area of Improvement	Mandatory Requirements
1. ENERGY STAR for Homes Baseline	☐ Certified under ENERGY STAR Qualified Homes Program Version 3 or 3.1 [10, 11]
2. Envelope[12]	☐ Fenestration shall meet or exceed ENERGY STAR requirements. See End Note for specific U, SHGC values, and exceptions. [13] ☐ Ceiling, wall, floor, and slab insulation shall meet or exceed 2012 or 2015 IECC levels[14, 15]
3. Duct System	☐ Duct distribution systems located within the home's thermal and air barrier boundary or an optimized location to achieve comparable performance[16]
4. Water Efficiency	☐ Hot water delivery systems (distributed and central) shall meet efficient design requirements[17]
5. Lighting & Appliances[18]	☐ All installed refrigerators, dishwashers, and clothes washers are ENERGY STAR qualified. ☐ 80% of lighting fixtures are ENERGY STAR qualified or ENERGY STAR lamps (bulbs) in minimum 80% of sockets ☐ All installed bathroom ventilation and ceiling fans are ENERGY STAR qualified
6. Indoor Air Quality	☐ Certified under EPA Indoor airPLUS [11]
7. Renewable Ready	☐ Provisions of the DOE Zero Energy Ready Home PV-Ready Checklist are Completed [19]

Exhibit 2: DOE Zero Energy Ready Home Target Home [8, 20]

HVAC Equipment[21]			
	Hot Climates (2012 IECC Zones 1,2) [22]	**Mixed Climates** (2012 IECC Zones 3, 4 except Marine)	**Cold Climates** (2012 IECC Zones 4 Marine 5,6,7,8)
AFUE	80%	90%	94%
SEER	18	15	13

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DOE ZERH Requirements

DOE Zero Energy Ready Home
National Program Requirements (Rev. 06)
April 20, 2017

HSPF	8.2	9	10[23]
Geothermal Heat Pump	ENERGY STAR EER and COP Criteria		
ASHRAE 62.2 Whole-House Mechanical Ventilation System	1.4 cfm/W; no heat exchange	1.4 cfm/W; no heat exchange	1.2 cfm/W; heat exchange with 60% SRE

Insulation and Infiltration

- Insulation levels shall meet the 2012 IECC and achieve Grade 1 installation, per RESNET standards.
- Infiltration – Detached Dwellings[24] (ACH50): 3 in CZ's 1-2 | 2.5 in CZ's 3-4 | 2 in CZ's 5-7 | 1.5 in CZ 8
- Infiltration – Attached Dwellings (ACH50): 3 (all Climate Zones)

Windows[25, ,26, 27]

	Hot Climates (2012 IECC Zones 1,2,)	Mixed Climates (2012 IECC Zones 3, 4 except Marine)	Cold Climates (2012 IECC Zones 4 Marine 5,6,7,8)
SHGC	0.25	0.25	any
U-Value	0.4	0.3	0.27

Homes qualifying through the Prescriptive Path with a total window-to-floor area greater than 15% shall have adjusted U-values or SHGCs.[28]

Water Heater

ENERGY STAR levels for the system Energy Factor, as follows:
- Gas/propane systems of ≤ 55 gallons, EF = 0.67
- Gas/propane systems of > 55 gallons, EF = 0.77
- Electric systems, EF = 2.0

For heating oil water heaters use EF = 0.60

Thermostat[29]

- Programmable thermostat (except for zones with radiant heat)

Lighting & Appliances

- For purposes of calculating the DOE Zero Energy Ready Home Target Home HERS Index, homes shall be modeled with an ENERGY STAR dishwasher, ENERGY STAR refrigerator, ENERGY STAR ceiling fans, and ENERGY STAR lamps (bulbs) in 80% of sockets or 80% of lighting fixtures are ENERGY STAR Qualified.

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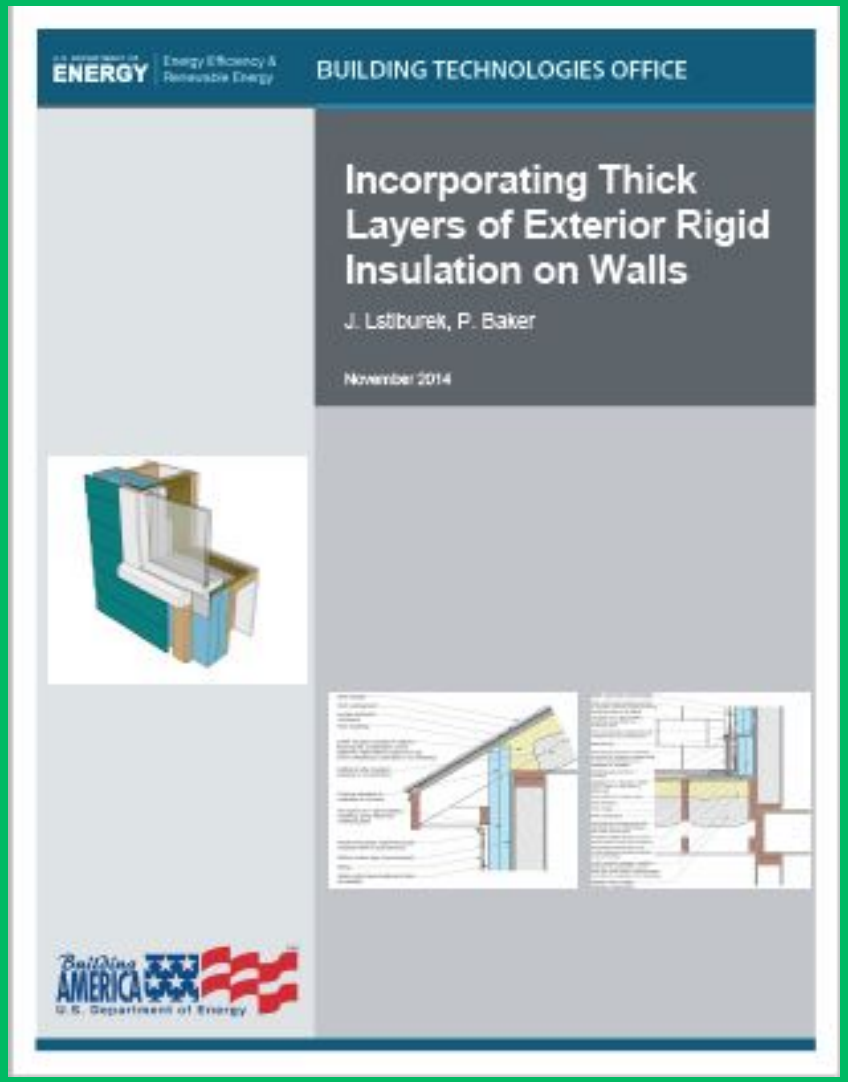
Rigid Foam: choosing a method



Two methods

- Water control layer in front of rigid insulation
- Water control layer behind rigid insulation
- We chose behind rigid insulation.
- *Water control layer must be continuous and uninterrupted!*

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Rigid Foam Concept

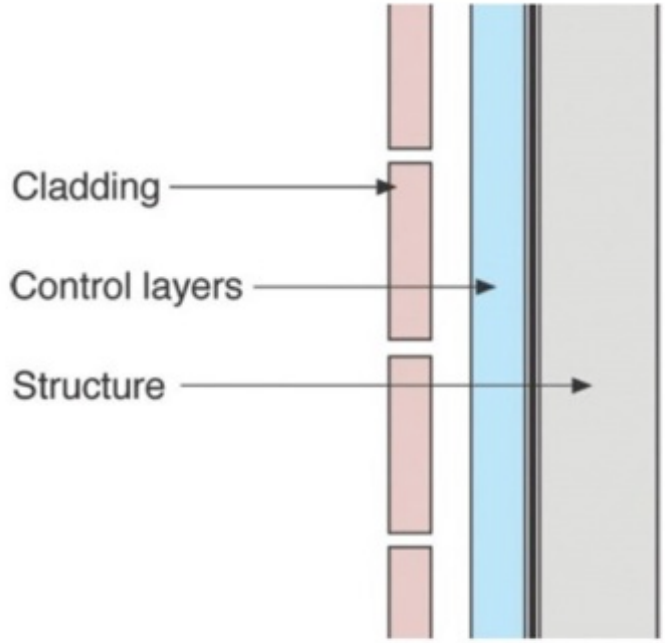

Figure 1. Optimum configuration of control layers

Thermal control layer outside the structure.

- Protecting the structure
- OSB sheathing never reaches dew point
- Dry to the inside – Class III vapor retarder

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What worked well? What didn't?

What worked well?

- Aligning upper and lower wall studs
- Long screws
- Drill press/pre-drilling and countersinking
- Battery impact drivers
- First layer of XPS
- Vinyl window/door jamb extensions
- Learning curve was reasonable/better than expected

What didn't work well?

- Long screws missing stud/poking through
- Extending bottom cord of roof truss to top cord
- Roof intersection with house wall
- Upper wall stud non-alignment with gable end
- Diverter flashing(?)
- Window top drip cap(?)

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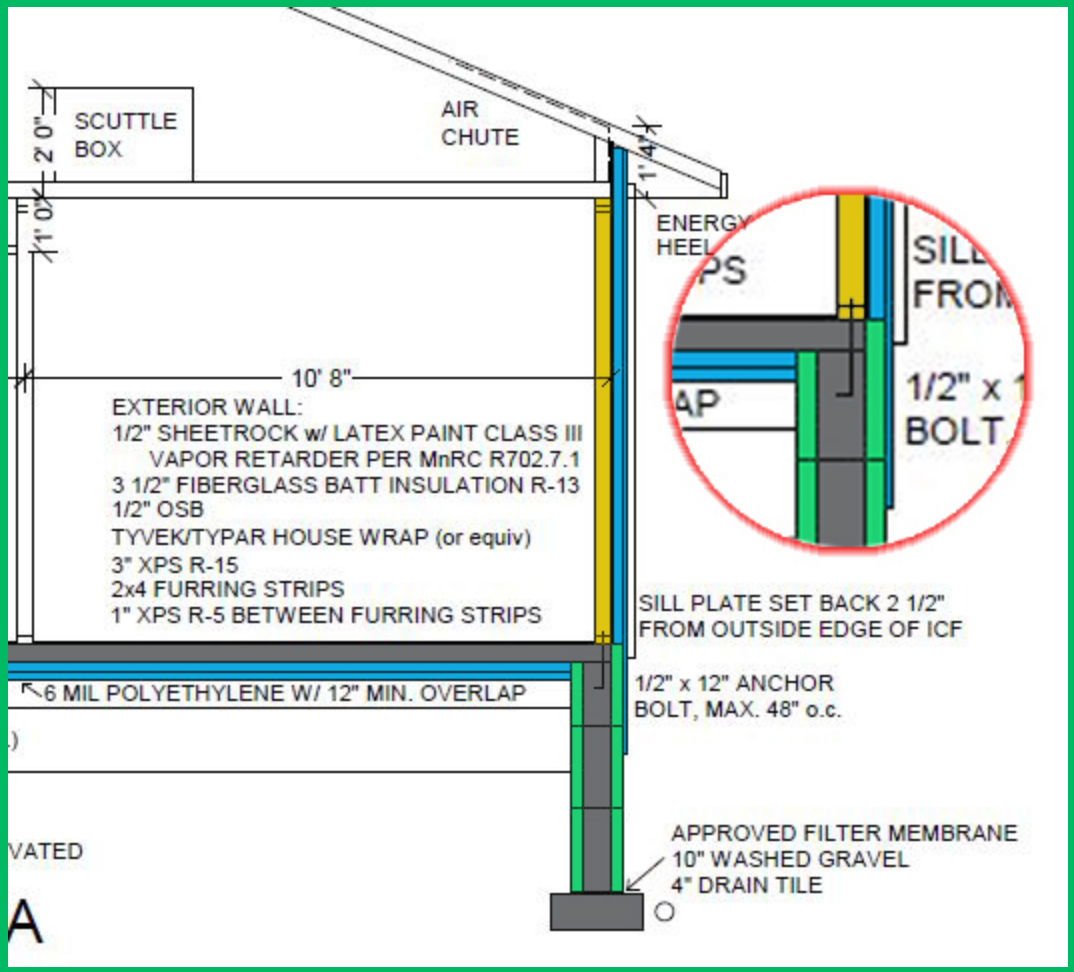
Starting with ICF foundation design



Foam board/ICF

- 3” foam board over framed wall (2” x 4”)
- 1” foam board over ICF foundation wall, extending down 2’

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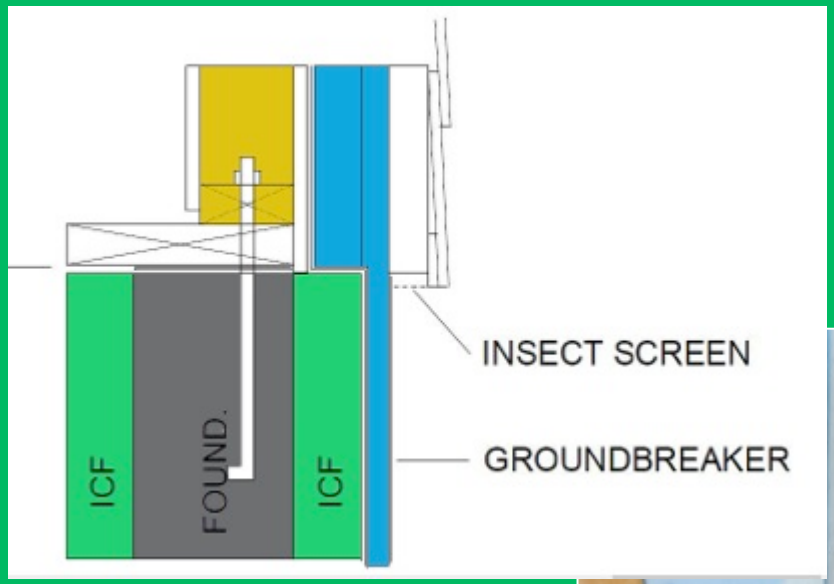
Foam board detail at foundation



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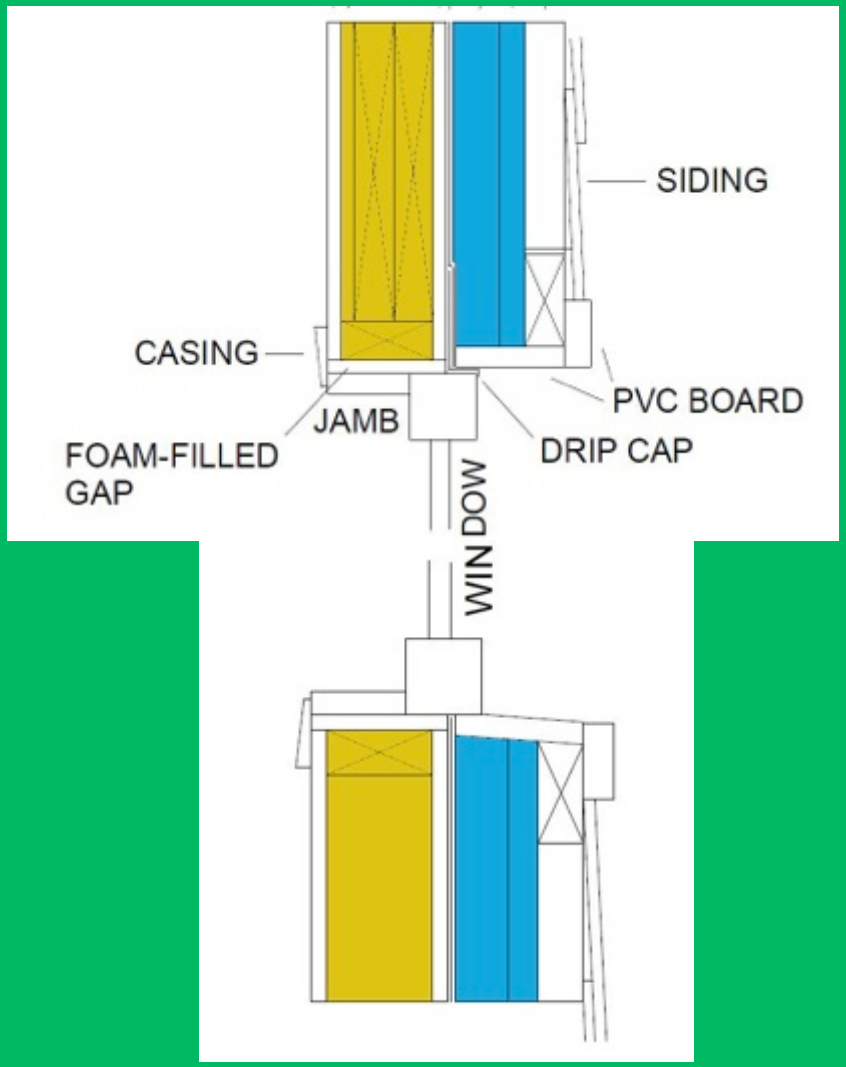
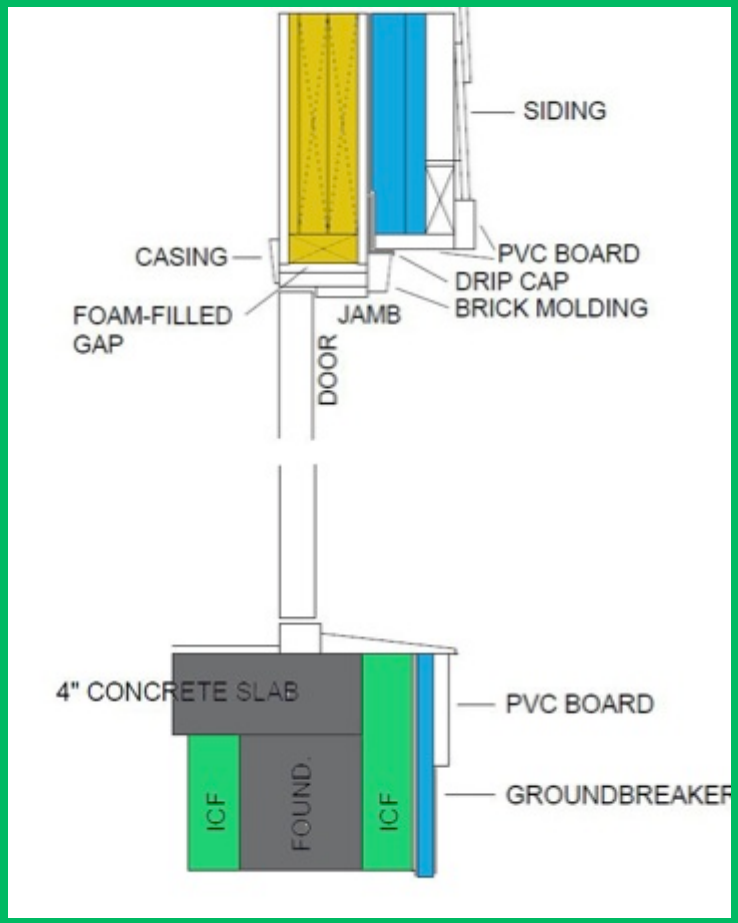
Foam board detail doors & windows





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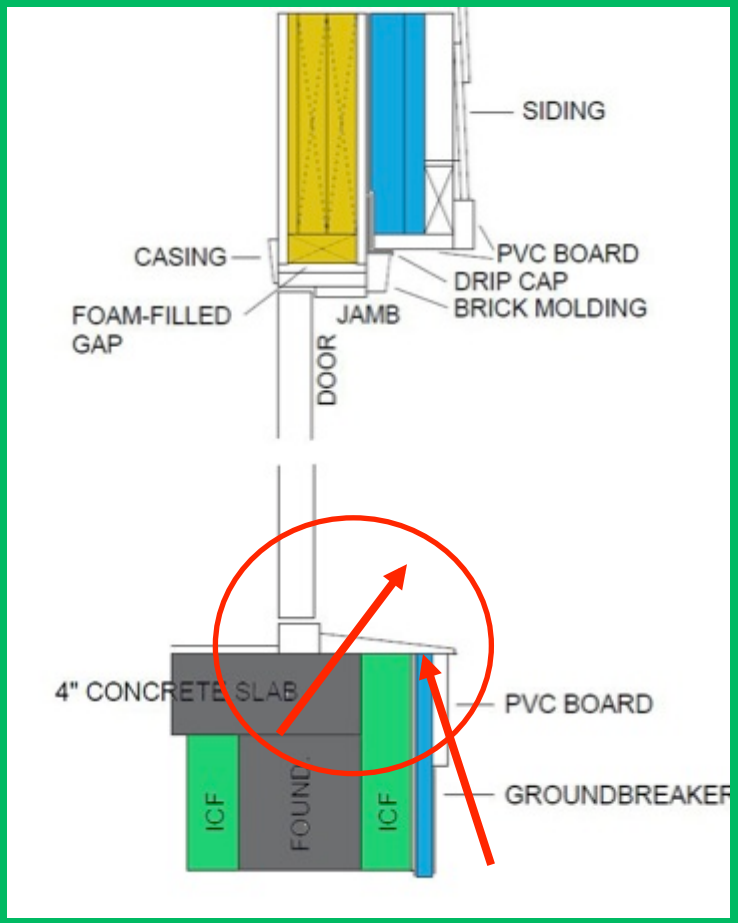
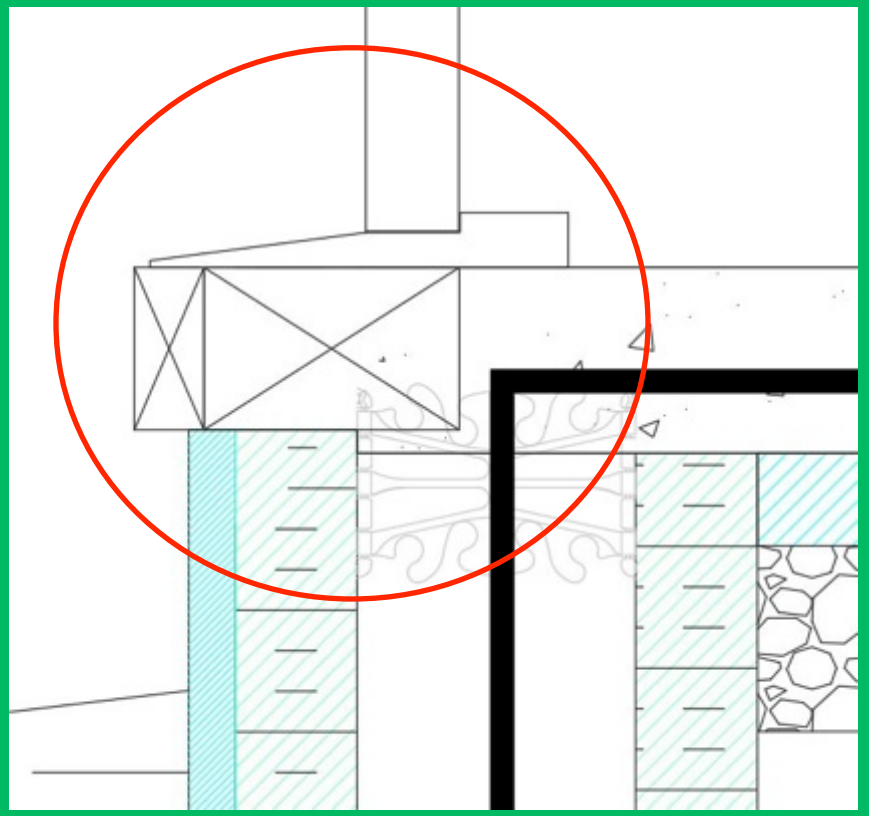
Foam board detail doors & windows





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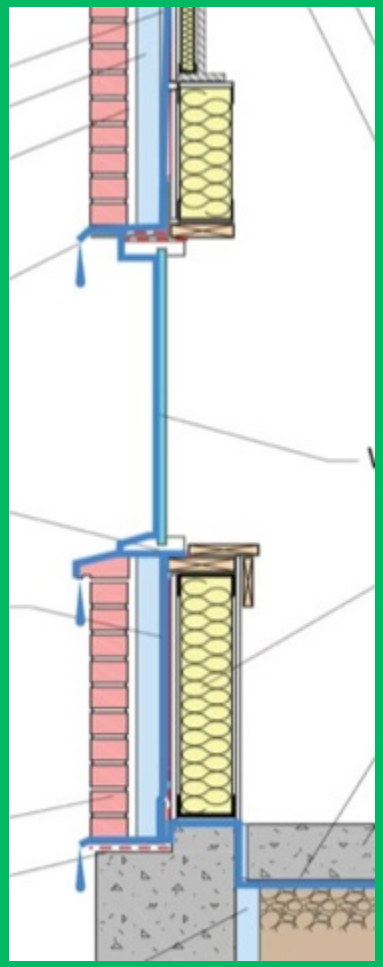
Foundation to framing

Continuous Water Control Layer

- Plans vs. real construction methods
- *Water control layer must be continuous and uninterrupted!*



S

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Foundation to framing

- Continuous Water Control Layer
- Bug Screen/air flow
- Bringing 1” foam board down over ICF foundation

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Building the layers of rigid foam

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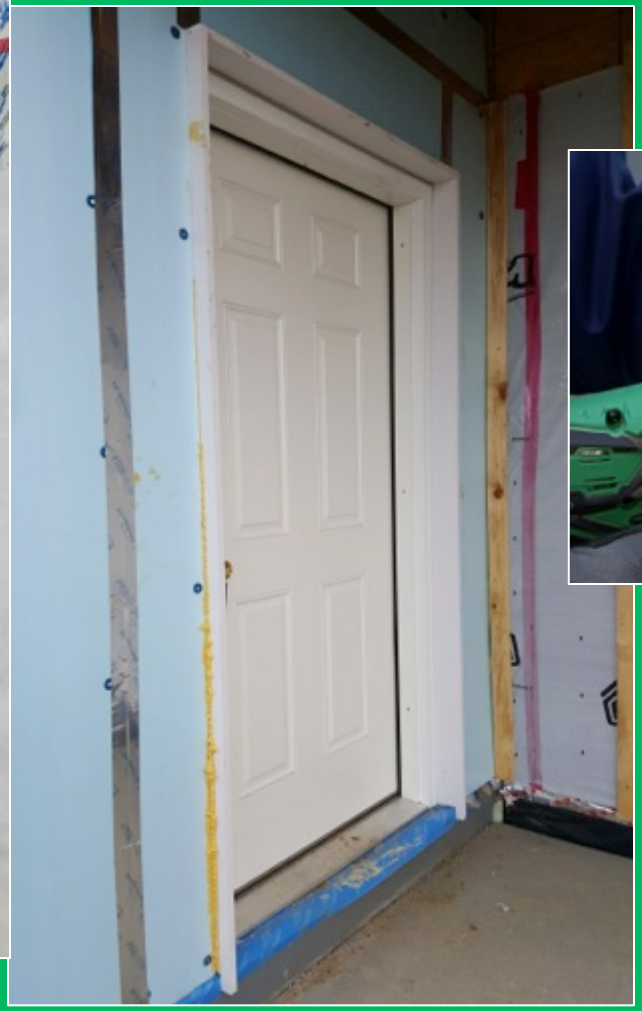
Window/door bucks and furring strips



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Window/door bucks and furring strips

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Maintaining Air Flow

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Evolution of Technique

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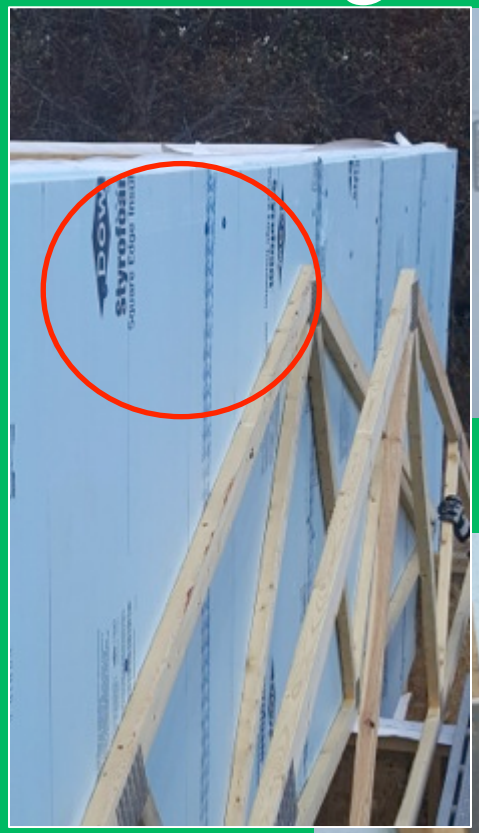
Garage/House, Penetrations, Soffit



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Windows: air/water control layers

***Air Control**

**The two most important controls in constructing our energy-efficient homes starting with the simplest techniques.*

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Thermal control layers

*The two most important controls in constructing our energy-efficient homes starting with the simplest techniques.

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Fasteners

Pre-drilling &

Countersinking

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Preparing for Siding

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Exterior

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Roof to Wall Detail

Thick layers,

Diverter flashing

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HRV/Rim Cavity

HRV/Rim joists

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Interior

Central returns

Pass-through

Ceiling Sealing

Electrical boxes

Top wall plates

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Results

Final Testing and Completion Report (SV3)

Site Walk Date: 2016-11-22

Building Code	MN Code
File Number	#58692
Site Walk Date	2016-11-22

Home
2290 Cedar Park Ct SE

Rochester, MN 55904

Builder
Habitat for Humanity - Rochester Area
1530 Greenview Drive SW
Suite 107
Rochester, MN 55902

Model
Production
Type: Single-family detached
Size: 1985 ft²

ENERGY STAR Requirements — NO

Checklists Completed	Checklists Signed	Meets Testing Standards
No	No	Yes

HERS Index — 42

HERS/NET Ratings provide a relative energy use index called the HERS Index, which represents the home's energy usage as a percentage of the energy usage of the "American Standard Building."

Beats 2006 IECC standard by 68.11%

0
TBC Failures need correcting

3
Issues could use improvement

0
Exceptional building practices identified

Insulation Features

Worst Insulation Grade	III/NR
Rim	Grade: III
Ceiling Flat	R = 50.0 (Grade III/NR)
Vaulted Ceiling	n/a
Above Grade Walls	R = 26.0 (Grade III)
Foundation Walls	R = 23.0 (Grade I)
Framed Floors	n/a
Slab	R = 23.0 Edge, 23.0 Under (Grade III/NR)
Duct	Uninsulated
Window	U = 0.270, SHGC = 0.290

Blower Door Test Results

Tested CFM50	322
CFM50 / ft² surface area	0.07
CFM50 / ft² floor area	0.16
ACH50	1.09

Ventilation Flow Test Results

Target Flow (CFM)	Unknown
Actual Flow (CFM)	0
Rated Flow (CFM)	0.0
Duct Leakage to Outside	15

	Heat	Cooling	Hot Water	Ventilation	Thermostat
Efficiency	96.1 (AFUE)	(SEER)	0.66		
Brand / Make	Daikin	Not Installed	Bradford White	Venmar	Pro1
Model	DM96VEB4028NAB	N/A	RG1PV40S6N	Venmar	Pro1
Size	38.0 BTU	BTU	40 Gal		

Fuel Summary

Property
2290 Cedar Park Ct SE
Rochester, MN 55904

Weather: Rochester, MN
15-XRG-459-11
15-XRG-459-11 2290 Cedar Park Ct SE Rochester MN 55904 REM
Fnl 112816 BV.blg

Organization
XRG Concepts, LLC
507-258-6500
Brandon Vagt

Builder
Habitat for Humanity - Roch

HERS
Confirmed
11/22/16
Rating No:15-XRG-459-11
Rater ID:8188958

Annual Energy Cost	$/yr
Natural gas	361
Electric	616

Annual End-Use Cost	$/yr
Heating	203
Cooling	0
Water Heating	172
Lights & Appliances	602
Photovoltaics	-0
Service Charge	323
Total	1300

Annual End-Use Consumption	
Heating (Therms)	255
Heating (kWh)	146
Water Heating (Therms)	232
Lights & Appliances (kWh)	5757
Total (Therms)	487
Total (kWh)	5903

Annual Energy Demands	kW
Heating	0.1
Cooling	0.0
Water Heating (Winter Peak)	0.0
Water Heating (Summer Peak)	0.0
Lights & Appliances (Winter Peak)	0.5
Lights & Appliances (Summer Peak)	1.1
Total Winter Peak	0.5
Total Summer Peak	1.1

Utility Rates	
Electricity	RPU 2016 07/18/16**
Natural Gas	MERC 2016 3/23/16**

Results

Final Testing and Completion Report (SV3)

Site Walk Date: 2016-12-27

Building Code	MN Code
File Number	#66534
Site Walk Date	2016-12-27

Home
701 Blanch St

Mantorville, MN 55955

Builder
Habitat for Humanity - Rochester Area
1530 Greenview Drive SW
Suite 107
Rochester, MN 55902

Model
Production
Type: Single-family detached
Size: 1982 ft²

ENERGY STAR Requirements — NO

Checklists Completed	Checklists Signed	Meets Testing Standards
No	No	Yes

HERS Index — 45

RESNET Ratings provide a relative energy use index called the HERS Index, which represents the home's energy usage as a percentage of the energy usage of the "American Standard Building."

Beats 2006 IECC standard by 70.10%

0
TBC Failures need correcting

4
Issues could use improvement

0
Exceptional building practices identified

Insulation Features

Worst Insulation Grade	III/NR
Rim	Grade: 1
Ceiling Flat	R = 50.0 (Grade III/NR)
Vaulted Ceiling	n/a
Above Grade Walls	R = 28.0 (Grade I)
Foundation Walls	R = 23.0 (Grade I)
Framed Floors	n/a
Slab	R = 23.0 Edge, 23.0 Under (Grade III/NR)
Duct	Uninsulated
Window	U = 0.220, SHGC = 0.270

Blower Door Test Results

Tested CFM50	330
CFM50 / ft² surface area	0.07
CFM50 / ft² floor area	0.36
ACH50	1.05

Ventilation Flow Test Results

Target Flow (CFM)	Unknown
Actual Flow (CFM)	0
Rated Flow (CFM)	0.0
Duct Leakage to Outside	235

	Heat	Cooling	Hot Water	Ventilation	Thermostat
Efficiency	96.1 (AFUE)	(SEER)	0.64		
Brand / Make	Daikin	Not Installed	Bradford White	Venmar	Pro1
Model	DM96VB1402BNAB	N/A	RG1PV40S6N	Venmar	Pro1
Size	38.0 BTU	BTU	40 Gal		

Fuel Summary

Property
701 Blanch St
Mantorville, MN 55955

Weather: Rochester, MN
16-XRG-437-09
16-XRG-437-09 701 Blanch St Mantorville MN 55955 REM Fnl 122716 BV.blg

Organization
XRG Concepts, LLC
507-258-6500
Brandon Vagt

Builder
Habitat for Humanity - Roch

HERS
Confirmed
12/27/16
Rating No: 16-XRG-437-09
Rater ID: 8188958

Annual Energy Cost	$/yr
Natural gas	349
Electric	587

Annual End-Use Cost	$/yr
Heating	171
Cooling	0
Water Heating	190
Lights & Appliances	575
Photovoltaics	-0
Service Charge	154
Total	1090

Annual End-Use Consumption	
Heating (Therms)	215
Heating (kWh)	146
Water Heating (Therms)	256
Lights & Appliances (kWh)	6773
Total (Therms)	471
Total (kWh)	6919

Annual Energy Demands	kW
Heating	0.1
Cooling	0.0
Water Heating (Winter Peak)	0.0
Water Heating (Summer Peak)	0.0
Lights & Appliances (Winter Peak)	0.5
Lights & Appliances (Summer Peak)	1.3
Total Winter Peak	0.6
Total Summer Peak	1.3

Utility Rates

Electricity	'16 Xcel Elec UnGrnd**
Natural Gas	MERC 2016 3/23/16**

Monthly Cost Increase

Qty	Item	Per each	Total	Cost Diff.
250	2" x 3"	$2.05	$512.50	
1000	Screws	$0.50	$500	
65	1" Foamboard	$13.00	$845	
65	2" Foamboard	$26.00	$1,690.00	
			$3,547.50	
30 year loan	$200,00 Home	Monthly at 0% interest	$946.00	$0.00
	$203,574 Home	Monthly at 3.92% interest	$962.00	$16.00
	$207,095 Home	Doubled for labor at 3.92% interest	$979.00	$33.00

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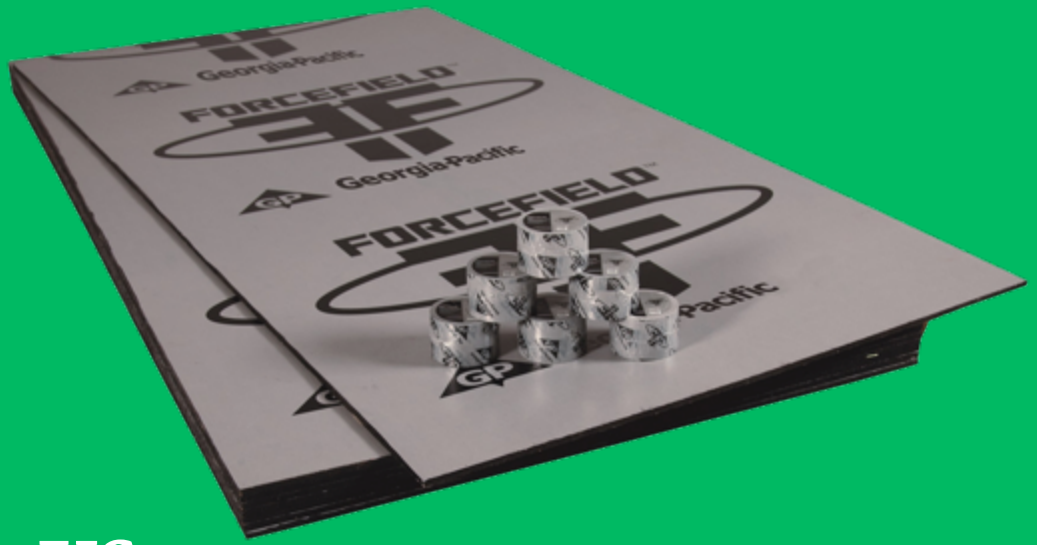
Alternative?



VS.

$17.00

Per
4’ x 8’

$23.25

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Source:

Building Science Corporation

buildingscience.com

BA-1406: Final Measure Guideline: Incorporating Thick Layers of Exterior Rigid Insulation on Walls

Joseph Lstiburek, Peter Baker - APRIL 15, 2015

http://buildingscience.com/documents/bareports/ba-1406-final-measure-guideline-incorporating-thick-layers-exterior-rigid-insulation/view

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What is FORTIFIED?

FORTIFIED Home™ is a set of engineering and building standards designed to help strengthen new and existing homes through system-specific building upgrades to minimum building code requirements that will reduce damage from specific natural hazards. The FORTIFIED Home program has three levels of designation—Bronze, Silver and Gold—that build upon each other, allowing you to choose the desired level of protection that best suits your budgets and resilience goals.

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What is FORTIFIED?

https://disastersafety.org/fortified/

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FORTIFIED

BRONZE:
Roof & Surroundings

SILVER:
Gables, Chimneys, &
Attached Structures

GOLD:
Garage Door &
Continuous Load Path

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Habitat for Humanity®

Why FORTIFIED

http://player.vimeo.com/video/237087513?autoplay=1

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FORTIFIED Build

Research Testing Background Information

- Stronger, more durable homes can be achieved through objective engineering solutions, which IBHS generates through rigorous research and testing.
- IBHS launched its FORTIFIED Home™—High Wind program last year during the National Tornado Summit to help homeowners located in inland areas build safer, stronger new homes, and retrofit or repair existing homes to make them more resistant to high winds.
- ***During the past five years, claims related to wind and hail damage on a national basis have accounted for almost 40 percent of all insured losses, averaging approximately $15 billion annually*** — and growing each year; just last year (2016), the top five most costly catastrophes for insurers were all high wind, hail storms and thunderstorms, according to ISO's Property Claims Service.
- Billion dollar wind storms are not unusual any more. On May 8 this year, Denver had its most expensive high wind and hail storm ever with estimated insured losses of $1.4 billion. ***Minnesota, Wisconsin, and Michigan had high wind and hail storms June 11, with insured losses likely to reach $1 billion.***
- The highest designation IBHS offers, FORTIFIED Home—High Wind Gold, recognizes (among other things) a sealed roof deck, porches, carports, and garage doors, as well as a strong continuous load path, which ties a home together from the roof to the foundation so that it can withstand the significant stress of high winds.

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Why? The Quick Visual Answer:

http://www.youtube.com/embed/2z18pilZ7DA?autoplay=1

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Advantage of Bronze Minimum: Deck Seal

http://www.youtube.com/embed/xS4kTWDeHOY?autoplay=1

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Roof

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Bronze - Surroundings

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Silver - Gables

Attached Structure (none)
Chimney (none)

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Gold - Continuous Load Path: Foundation

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Gold - Continuous Load Path: Openings for Windows/Doors

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Gold - Continuous Load Path: Openings for Windows/Doors

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Gold - Continuous Load Path: Wall to Plates & Roof Truss

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Gold - Continuous Load Path: Wall Plate to Plate & to Floor Truss

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Gold - Garage Door:
Higher Wind Load Rated

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Fortified Costs

Materials only

BRONZE: Added expense of shingles & “nailing” of Permafelt

SILVER: 2x4 bracing & minor strapping

GOLD: Anchors, strapping/clips, screws, & “special” nails

Questions?

Brian J. Wimmer

Lou Behrens

Thank You!

Rochester Area Habitat for Humanity®