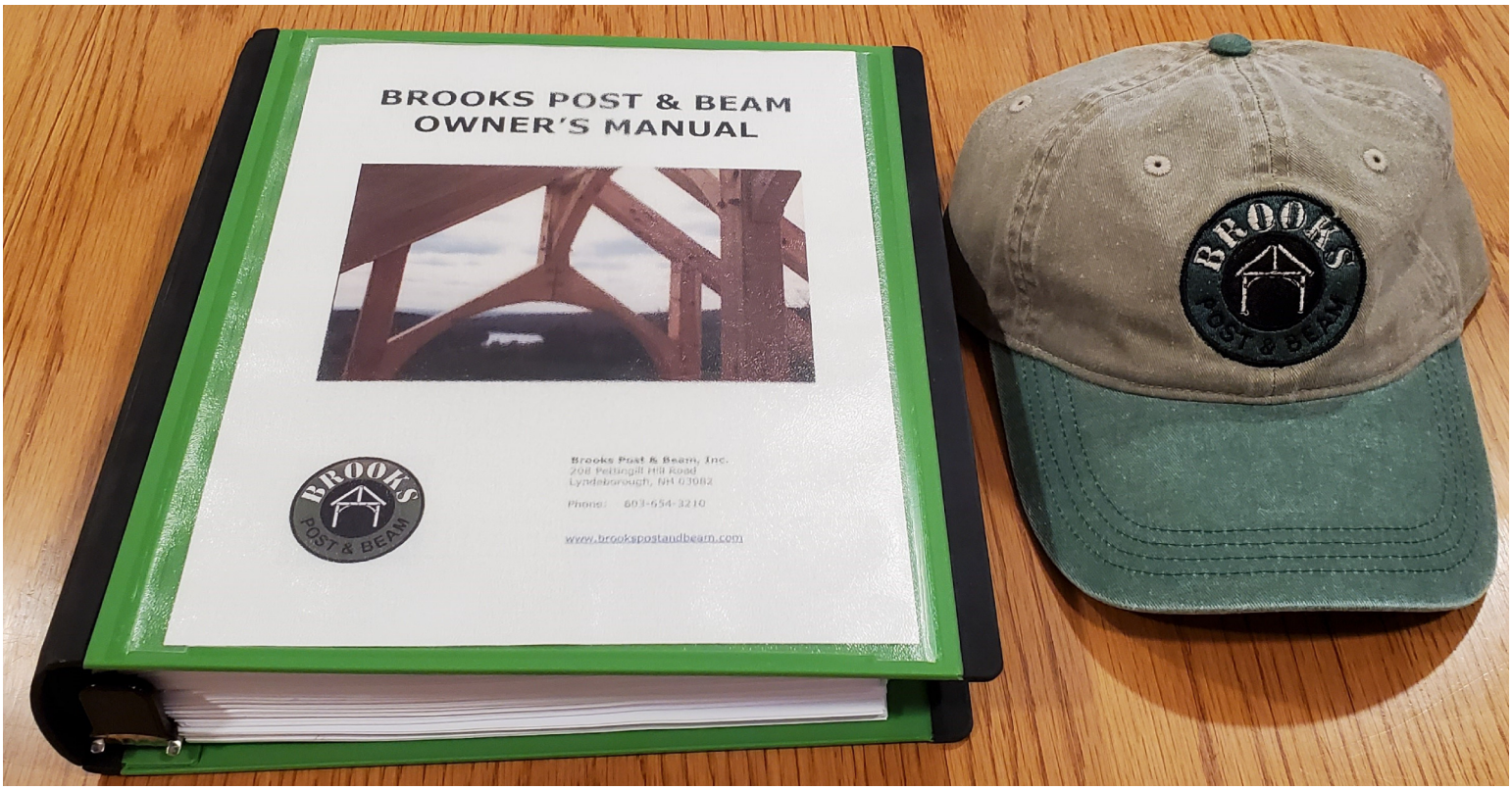
BROOKS POST & BEAM OWNER'S MANUAL

Brooks Post & Beam, Inc.
208 Pettingill Hill Road
Lyndeborough, NH 03082

Phone: 603-654-3210

www.brookspostandbeam.com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INTRODUCTION TO OUR COMPANY
by PAUL FREEMAN
June 20, 2018

Its been almost 11 years since I wrote a cover letter for our Owner's Manual. During that time we have updated much of the content, written a Kit Construction Manual and formalized our kit program, complete with standard plans, pricing, and options. While the four of us have simultaneously, designed and built another 130 homes, barns and additions!.

Recently I wrote to a prospective customer about what sets us apart from other timber framing companies. There are the obvious, and thankfully fairly consistent values that we and many of our colleagues share; conscientiousness, honesty, skill and experience. But that's just a baseline, something all contractors should provide. Following are a few of the unique characteristics that set us apart:

We "draw-bore" our frames - Draw boring eliminates the need to pull the frame together with multiple straps and come-alongs. The timbers are pulled tightly toward plumb and square with much less effort while increasing the stiffness of the frame
We erect many of our frames ourselves - The same craftsmen that cut your frame also erect multiple frames a year, providing immediate feedback on the quality of our shop work and the ease of the frame raising. Whether we erect the frame or you assemble one of our kits, you can be assured we are going through the same thing you are.
We maintain a large timber inventory - We carry thousands of board feet of timber instead of just ordering what we need for your frame. This gives us the ability to quickly replace a piece that might be flawed, damaged, or on rare occasions: cut wrong! We replace flawed pieces quickly with our onsite inventory avoiding the temptation to "make do" or delay progress waiting for a new timber from the sawmill.
We have over four decades of experience - We have been improving our product for almost 50 years now. For example the use of spline joinery is common today and our SIP panel wire chase detail is now employed by multiple panel manufacturers across the country. There are "copycats" out there that duplicated our process years ago, but we have not stopped improving our tooling and methods, their frame may look like ours, but you'll find it much more difficult to assemble. Perhaps most importantly, we treat our craftsmen well and turnover is rare, our framers use their average of 25 years experience each to produce high quality frames quickly, providing you the best "bang for the buck"!
We are your guides to the realization of your dream! Our design services, online video tutorials, building guide, Owner's Manual and willingness to answer all your questions helps you make your way through the thousands of little decisions you need to make to turn your dream plan into reality while staying on budget.

Please use this Owner's Manual to learn about timber frame construction. I think you will also learn to appreciate how our unique combination of value, experience and innovation continue to quietly lead the industry in affordable timber frame construction..

Paul A. Freeman, President
Brooks Post & Beam, Inc. Lyndebrough, NH 03082

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INTRODUCTION TO OUR COMPANY
by PAUL FREEMAN
August 27, 2007

Thank you for your interest in one of our Post & Beam structures, I am looking forward to working with you. I would like to welcome you into the community of people that include our customers, friends, family, coworkers, vendors and trades people. We are privileged to be surrounded by so many fair and considerate people, and I believe the reason for our good fortune is that good people are drawn to eachother. Phil Brooks has been building Post & Beam homes for over 40 years now and throughout his career as timber framer, educator, and philanthropist he has consistently treated people with respect and encouragement and built a network of committed clients, friends, and professionals all across the country.

Phil and I met not long after he had built the first ever automated timber cutting machine in the country, and most likely on the planet! My background at the time was as an architectural and timber frame designer, and I had recently developed a timber frame design software program with my good friend Ed Levin, an internationally renowned timber frame designer. Over the next few years Phil and I developed the software we still use today that takes advanatage of the power of computer modeling and ties it into our timber cutting machine for full automation from the "drawing board" to the shop floor. The efficiency of our design to shop process is the second biggest reason for the success of our company, and when used in conjunction with Phil's unique and efficient timber frame joinery system has given us the ability to provide extremely strong joinery with a minimal of material and labor costs, thereby passing on to our customers considerable cost savings for a very high level of quality.

From time to time I look around myself and am struck with my good fortune to have been given the opportunity to take the reins of this remarkable company that has been quietly leading our industry forward over the last 3 decades. I am indebted to my parents, Robert and Ivy Freeman, Ed Levin, and Phil Brooks for providing me with the opportunities and experiences that have brought me to this place. And now I also have people like you to thank for recognizing our ability to help you fulfill your vision of your new home, barn, or business structure. Welcome to our community. We are well met!

Paul A. Freeman
Brooks Post & Beam, Inc.
Lyndebrough, NH 03082

p.s. Over time we have been improving our products and methods for construction of Post & Beam homes with Stress-Skin Panels. There have been some recent changes in recommended construction methods and we strongly advise you to carefully review Foard Panel's enclosed "Guide to Enclosing Your Timber Frame Home", especially with respect to their new recommendations for roofing and siding application.

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GENERAL INFORMATION

1.0.0. OWNER'S MANUAL

Building a new home is not a job to be undertaken lightly. To help guide you through the many decisions with which you will be faced, we have written our Owner's Manual. Whether you plan to contract out the work, be your own general contractor, or do it all yourself, this manual will explain and specify details and various tasks from locating your house on the lot to the last finishing detail of trim or carpet.

Our hope is that this manual will help eliminate those unplanned items that can cause misunderstandings, changes, and cost overruns.

Having this kind of information available, will give you the confidence you need to be sure that your future home will live up to your present vision. Included are specification sheets, estimation forms, architectural details, and contract forms on the following subjects:

General Information
Earthwork
Concrete Foundation
Rough Carpentry
Timber Frame
Electrical
Plumbing and Water Supply
Heating, Ventilating and Air Conditioning
Drywall
Masonry
Finish Carpentry
Cabinets and Countertops
Wall and Floor Finishes
Appliances
Landscaping

1.1.0. ABOUT BROOKS POST & BEAM

Phil Brooks has been building timber frames since 1968. He began by disassembling old barn and house frames and reconstructing them. When the demand for buildings outgrew the supply of old frames, he began producing his own. His experience and research on old frames instilled a deep respect for the skills and training of colonial craftsmen. It also challenged us to find more cost effective, structurally sound and energy efficient ways to improve on this ancient craft.

Phil developed the first automated timber cutting machine, a brace tenon-er, and a unique timber framing system and details that incorporate the old style craftsmanship with improvements possible with modern tools. Phil also played a significant role in the development of stresskin panels and the growth of Winter Panel Corp. and later the creation and rapid success of Foard Panel in West Chesterfield, NH.

Paul Freeman started designing timber frame homes in 1983 at Timberpeg Design in Hartland, VT. After pioneering the use of CAD at Timberpeg Paul continued as an independent architectural and timber frame designer while providing AutoCAD support and training to architects, engineers, and manufacturers throughout Northern New England. During this time in partnership with Ed Levin he developed TimberCAD, an AutoCAD add-on specifically developed

1.2.0. WHAT IS POST AND BEAM?

Also known as Timber Framing, it is a method of building that uses large wooden timbers joined together with wood pegs. Colonial homes, churches, barns, and covered bridges were built this way. Our modern timber frames use the same structural techniques as the old world craftsmen and combine them with high-tech tools and energy efficient insulation.

From the Timber Framer's Guild: (https://www.tfguild.org/faq/basics)

POST AND BEAM. 1. Any structural system made up primarily of vertical and horizontal members. 2. Such a system in which floor and roof loads are carried by principal timbers butted together and fastened with structural hardware. 3. A structural system of heavy timbers connected by woodwork joints. See TIMBER FRAME.

TIMBER FRAME. A frame of large timbers connected by structural woodwork joints and supporting small timbers to which roof, walls, and floors are fastened. Sometimes called a *braced frame*. Cf. POST AND BEAM 2.

1.2.1. HOW DOES THIS DIFFER FROM CONVENTIONAL CONSTRUCTION?

In standard construction, framing and insulation are combined in the outer walls and roof. While this works structurally, it creates many problems with insulation. Since about 30% of the wall and roof area is used for framing, making them air tight, eliminating heat loss through the framing and preventing moisture from condensing inside these spaces is difficult and expensive.

In our Post and Beam homes we separate the framing and insulation. The frame becomes the skeleton of the building and can be given a rustic, formal or furniture-like finish. Stresskin panels are then installed as the energy-efficient skin that encloses this structure. These panels consist of an interior surface of fire-rated blueboard, a core of rigid XPS or EPS foam and an exterior sheathing of ½" oriented strand board. They provide excellent thermal, infiltration and vapor protection. Exterior and interior finishes can be applied to these panels using conventional methods of carpentry. Electrical and plumbing runs are also provided.

Interior partitions in Post & Beam structures are not structural elements of the building; therefore the building is more easily adapted to changing needs over time. This is a good thing since a well constructed timber frame building can be expected to last for centuries, in comparison most "stick framed" construction's lifetime is measured in decades. It is not lost on us that each one of our frames could be a testament to our company for generations to come.

1.3.0. HOW MUCH DOES IT COST?

Timber framing has a reputation for being an expensive way to build. While this may be true for many other companies, we have developed methods in our building system that allows us to be very competitive:

- Traditional timber framing requires 8 inch or larger members, not for strength, but to accommodate the joinery. Our joinery requires only 6 inch members. This can represent a 40% savings in material and allow the frame to be a less massive and dominant feature of the building. The strength of a beam is achieved mostly from its depth, not its width.

- The use of computers in design and in our automated cutting machines allows just a few highly skilled craftsmen to be extremely productive in our shop and at your site.

1.4.0 INFORMATION NEEDED FOR PLANS

1.4.1 EARTHWORK

- Septic and site plans to include the following:
    - Location of house, outbuildings, pools etc. with elevations to top of walls.
    - Driveway route with culvert locations
    - Utility locations with trench route to house
    - Well
    - Underground fuel tanks
    - Electric, phone, cable TV
    - Burial site for stumps and rocks
    - Site for brush or chips, logs, and cordwood
    - Concrete truck ramps if needed
    - Location of trench to drain foundation hole
    - Drainage

1.4.2. CONCRETE

- Foundation insulation inside or outside
- Bulkhead
- Windows
- Walkout

1.4.3. TIMBER FRAME and PANELS

- Wood species
- Type of finish on timbers
- Floor framing
- Solid 2x8 planks or hollow stick frame
- Brace type and location
- Wire runs under panels or flooring
- Panel specifications

1.4.4. ROUGH CARPENTRY

- Window and exterior doors
- Roof trim details
- Shingle type
- Siding type

3.0.0 EARTHWORK NOTES

3.0.1 CLEARING TREES FROM SITE

Time spent visualizing your finished site is critical to successful landscaping. Mature trees take a lifetime to replace. It is better to leave and clearly mark any trees in question and cut them later if need be. Clearing trees from the site of the driveway, foundation, septic leach field, and any other area to be open, can be done several different ways. The easiest is to hire a land clearing contractor who can harvest and chip whole trees. Depending on the quality and quantity of your trees, this can be an economical approach. You should at least get an estimate.

Land clearing contractors will bring in large equipment that can shear off an entire tree and drag it to a machine that will chip the whole thing and blow it into a trailer truck. The chips are sold as fuel to energy plants or as pulp. Larger trees are saved and sold for lumber or cordwood. This method is quick and leaves your lot clear of slash wood and brush. It requires a large landing area for the trucks and chipper to set up. The skidders that haul the trees should not operate in wet conditions and should use the future driveway route to drag trees if possible. Protect any saved trees from being scraped and damaged by material being hauled by the skidders. Don't be too concerned about the cleared area being torn up by the skidder because stumps will be pulled out by heavy equipment and smoothed over afterward. The yarding area is usually the biggest problem to locate because it must be accessible to the trailer trucks. Discuss the options with all bidding contractors.

Clearing with a chain saw is slower. Brush and slash must be burned or buried. You can rent a chipper or haul it away on or off site, but it is something you can do yourself to save money and is the best option for a small lot.

Always be sure to check with town officials concerning permits that may be required to cut trees, install driveways, and burn brush.

3.0.2 STUMP AND ROCK REMOVAL

Pulling stumps is usually best accomplished with an excavator, which is a large backhoe on tracks. Once the stumps and rocks are pulled, they can be buried in holes or trenches. A dozer can then fill in the holes and smooth everything over. Stumps should be buried downhill of the well and above the water table. Some towns require permits to bury stumps. Hauling stumps off site can be expensive. Grinding stumps with specialized equipment is another option that might be less expensive than hauling.

3.0.3 TOPSOIL

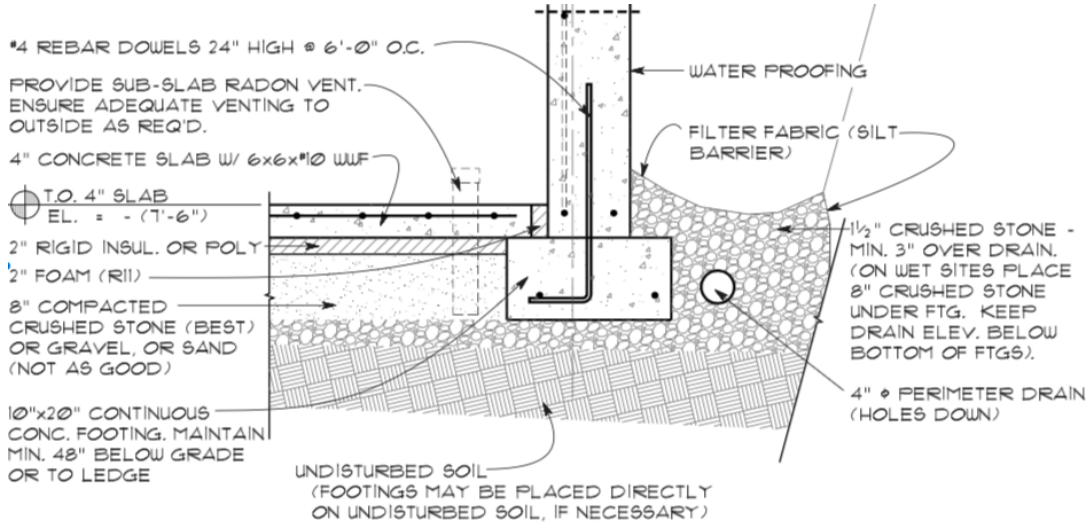
Before digging the cellar hole or starting the driveway and leach bed, any topsoil should be scraped off and saved in piles to be spread out later. Screen out roots and rocks with a mechanized screener before spreading loam on finished grade.

3.0.4 DRIVEWAY

A smooth and maintenance free driveway depends on water drainage. Water that is not quickly drained away from the base and surface of a driveway or road will cause it to soften up and become full of ruts and potholes. Freeze and thaw cycles will compound these problems. This is true no matter what finish surface is used.

3.2.4 PLACE AND LEVEL "UNDER SLAB MATERIAL"

The bottom of cellar hole should be filled with a well compacted layer of gravel, or much better, crushed stone to the top of the footing (8-10 inches). Rigid insulation or a 6mil or thicker layer of polyethylene sheet should be placed over this layer of gravel to prevent moisture and radon from migrating into the living space. **The edges of this material should *not* be folded up the wall** allowing rain water to run off during construction.



C1 – Standard Foundation Wall Section – Lower Portion

3.2.5 TRENCHING & UNDERGROUND UTILITIES

The trench, from foundation to well, should be at least 4 feet deep and the water line should be surrounded by a minimum of 6 inches of stone-free material. The hole where the pipe penetrates foundation should be sealed; urethane foam sealer works fine.

If using gas (especially if for cooking, hot water, and heat) it might be worth your while to purchase your own underground storage tank. You will have better price negotiating power if you are not contracted with a supplier that owns your tank. Talk to us and to your suppliers about your options and costs. Of course many owners are attracted by the lower upfront cost of renting your tank, but chances are you will end up paying for the tank many times over.

Trenching for underground utilities should be done to specifications of local offices. Check with your local power, telephone, gas, and water and sewage companies.

3.2.6 BLASTING

Any blasting should be done by registered and insured companies. Disposal of large chunks of stone should be considered as part of the cost of blasting.

3.2.7 FINAL GRADING AND SPREADING OF LOAM

Elevations on the site plan should be checked to determine if additional material will need to be trucked in. Loam should be screened and spread 4 inches deep and raked with "York" type rake to level. Hand raking can also be done on smaller lots.

3.3.0. EARTHWORK SPECIFICATIONS

Job Name _____ Contractor Name_____

Owner _____ Name _____

Address _____ Address _____

_____ _____

Site Address _____ Phone# _____

_____ Insurance Agency _____

Work phone # _____ Worker's Comp policy # _____

Home or Cell# _____ Liability policy # _____

3.3.1. CUT TREES AS INDICATED

3.3.2. DISPOSE OF BRUSH

- Permit may be required to burn.

3.3.3. STACK LOGS AND CORDWOOD AS INDICATED

3.3.4. DISPOSE OF STUMPS & LARGE ROCKS

- Permit may be required to bury stumps

3.3.5. REMOVE AND STORE TOPSOIL

3.3.6. CONSTRUCT DRIVEWAY

- Permit usually required
- Length _____
- Width _____
- Material Specs
    - Base of bank run gravel _____ thick (compacted)
    - Culverts—number _____ diameter _____length _____
    - Finish of crushed gravel _____ thick (compacted)
    - Hot top asphalt _____ thick

4.0.0. FOUNDATIONS and CONCRETE NOTES

4.0.1. FOOTINGS

We recommend 10” poured concrete foundation walls on 10”x20” concrete footings. Soils with poor load bearing characteristics will require steel reinforcing rods. Footings should always be poured on undisturbed or well compacted soil that is free of frost and that will be backfilled with at least 4 feet of fill. 3000 psi concrete is recommended for footings and walls. The top of the footing should have either a 2x2 groove or 18 inch pieces of #4 rebar vertically every 3 feet in order to pin the wall to the footing.

4.0.2. WALLS

Poured in place 8 inch concrete walls are adequate for most residential construction provided that a straight run without any intersections or corners does not exceed 30 feet. Longer walls should be poured 10 inches thick or reinforced with steel. 10 inch walls are always better. Residential loads will easily be carried by this type of wall and it is extremely unlikely that any problems will occur from the weight of the structure.

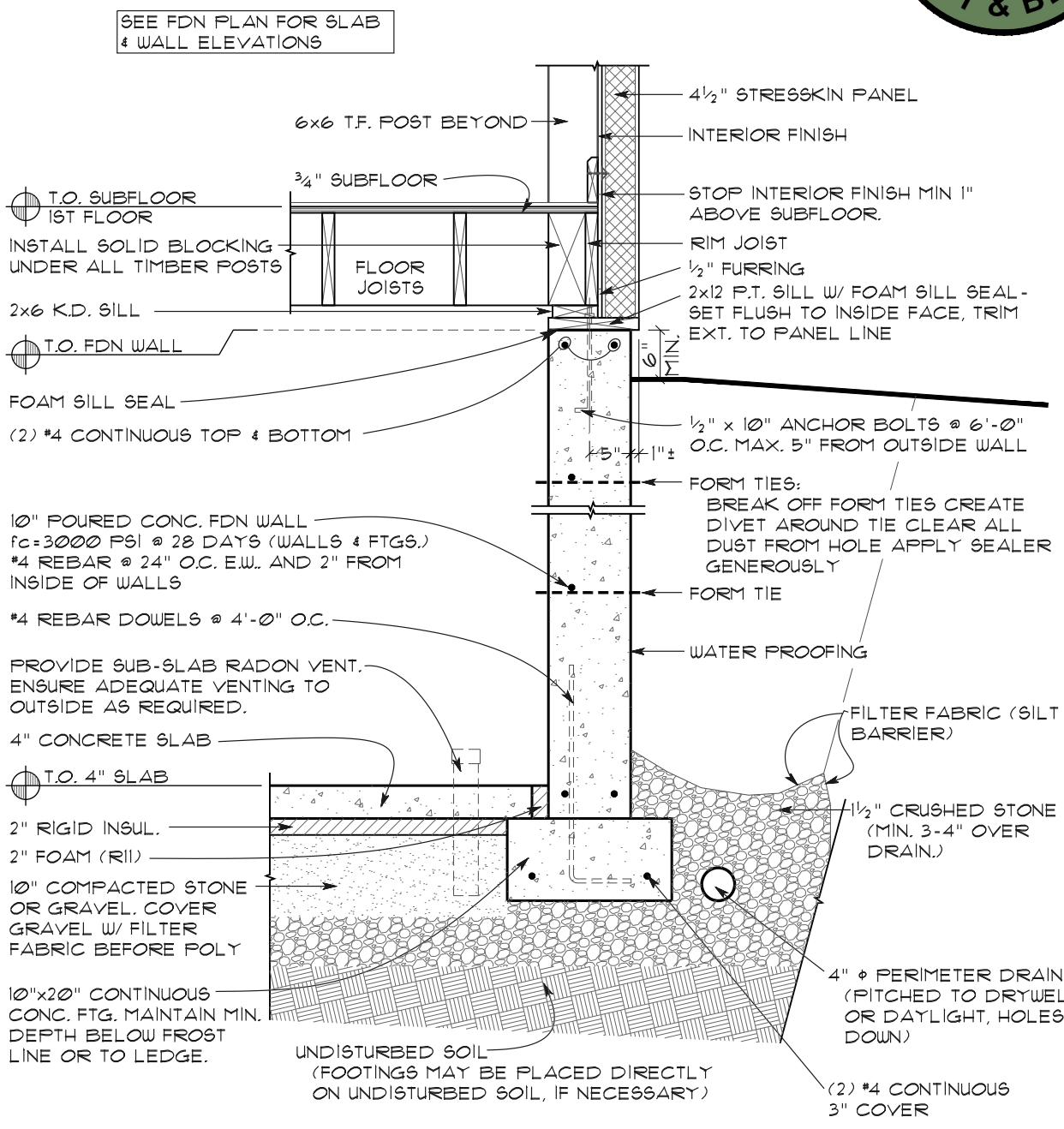
Concrete is very strong when resisting the compressive or "squeezing together" forces, but surprisingly weak when subjected to tension or "stretching" forces. There are only two common ways in which a poured concrete wall will fail. The most likely failure is the wall will crack or break from the weight of the soil, rocks, and heavy earth moving equipment pushing against the outside of the wall when it is backfilled. The other most likely failure will be from the effects of poorly drained soil freezing and expanding which forces the walls in or the footings up.

In order for the wall to break under these conditions, the surface opposite the pressure must stretch and become longer as the wall bends. The best way to resist this stretching or tension is with steel reinforcing rods. These rods are designed to work under tension and are therefore most effective when placed toward the inside and top of the walls. The importance of keeping all footings below the frost line and providing drainage for backfill material cannot be over emphasized.

Eight foot forms will usually allow a level wall to be poured 7'-10" (seven feet ten inches) high. The slab will be poured on top of the footings and is generally 4” thick, so your typical finished concrete wall is 7’-6” (seven feet six inches) high. Some contractors have forms taller then eight feet but typically they demand a premium as they are not common. Stacking forms is another option for a taller basement however this can also lead to significant additional expense. Plumb, level, and square walls accurate to ¼" are a must for precut houses. Careful attention should be paid to the location and projection of anchor bolts, the location and size of beam pockets, and foundation windows.

4.0.3. FOUNDATION WINDOWS

Vinyl frames with insulating glass are recommended. Windows should be located away from load bearing posts. To allow the finished grade to expose as little of the foundation as possible, keep windows near the top of the wall. Window wells can help make it possible to achieve this end. If window wells are installed, crushed stone should be used as backfill under the wells and should extend all the way to the foundation drains to assure that water will quickly drain from them. A pressure treated plywood box can be installed under the window wells before the foundation is backfilled, to make the job easier. Walls with large window areas should be framed like the rest of the building for reasons of esthetics and energy conservation. Egress window wells (legal by



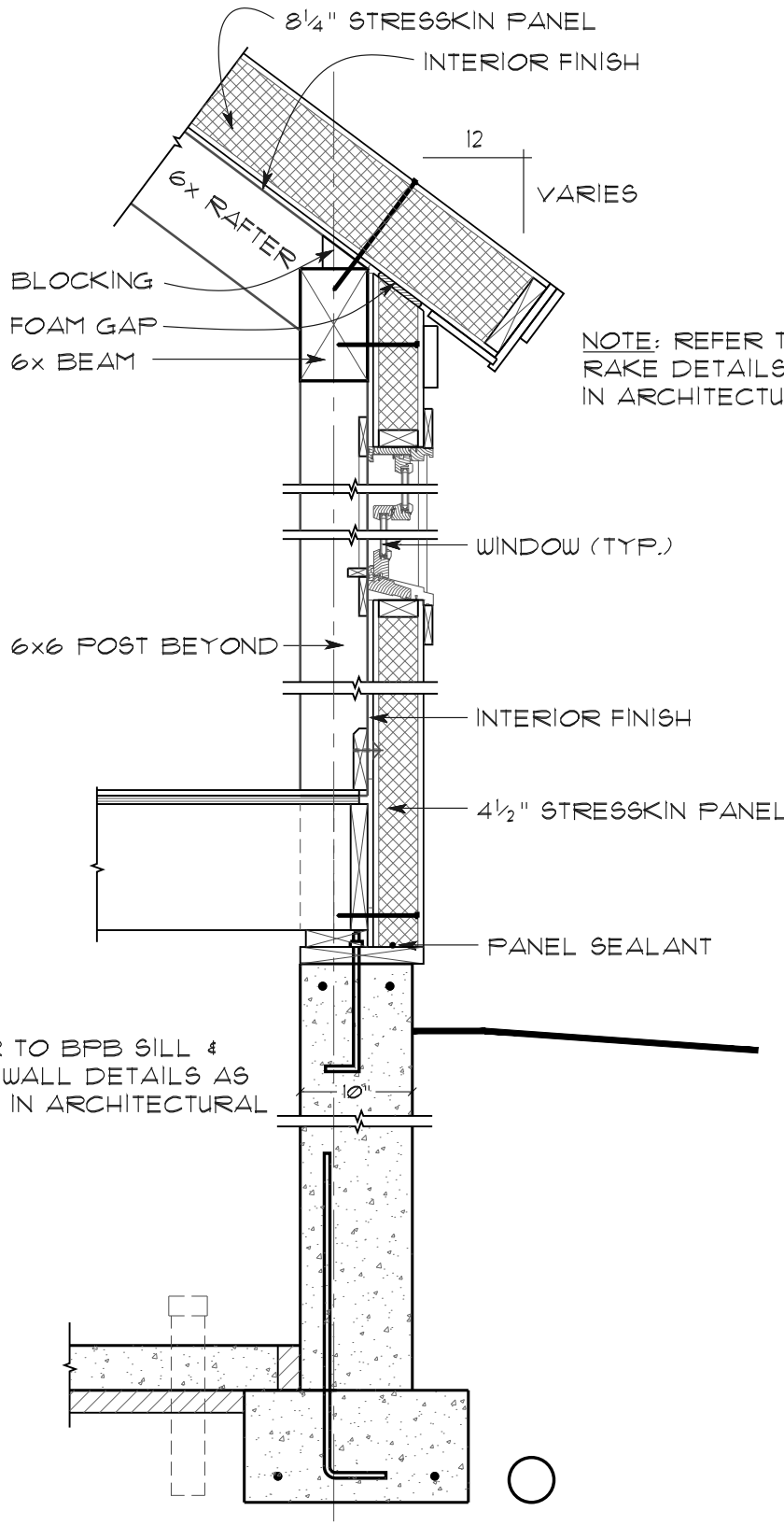
C1

TYPICAL FOUNDATION WALL SECTION

NOT TO SCALE

02/01/19 LBJ

NOTE:
THE DECK MUST BE SQUARE, CORNER TO CORNER WITHIN ¼". DECK MUST BE LEVEL AT POST LOCATIONS WITHIN ⅛". EDGES MUST BE STRAIGHT WITHIN ¼".



NOTE: REFER TO BPB EAVE/ RAKE DETAILS AS CALLED OUT IN ARCHITECTURAL PLANS

NOTE: REFER TO BPB SILL & FOUNDATION WALL DETAILS AS CALLED OUT IN ARCHITECTURAL PLANS

S1

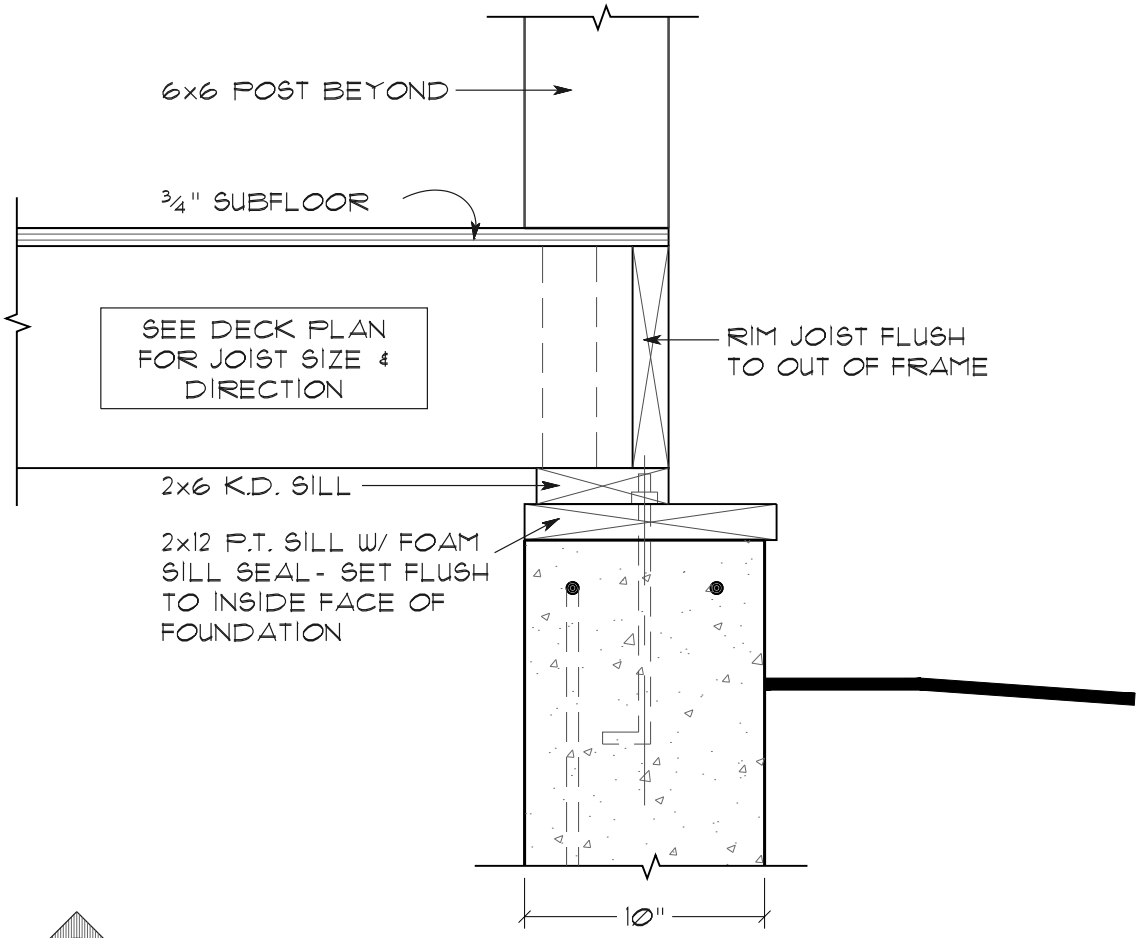
STANDARD WALL SECTION

w/ SQUARE FASCIA

SCALE: ¾" = 1'-0"

12/27/18 LBJ

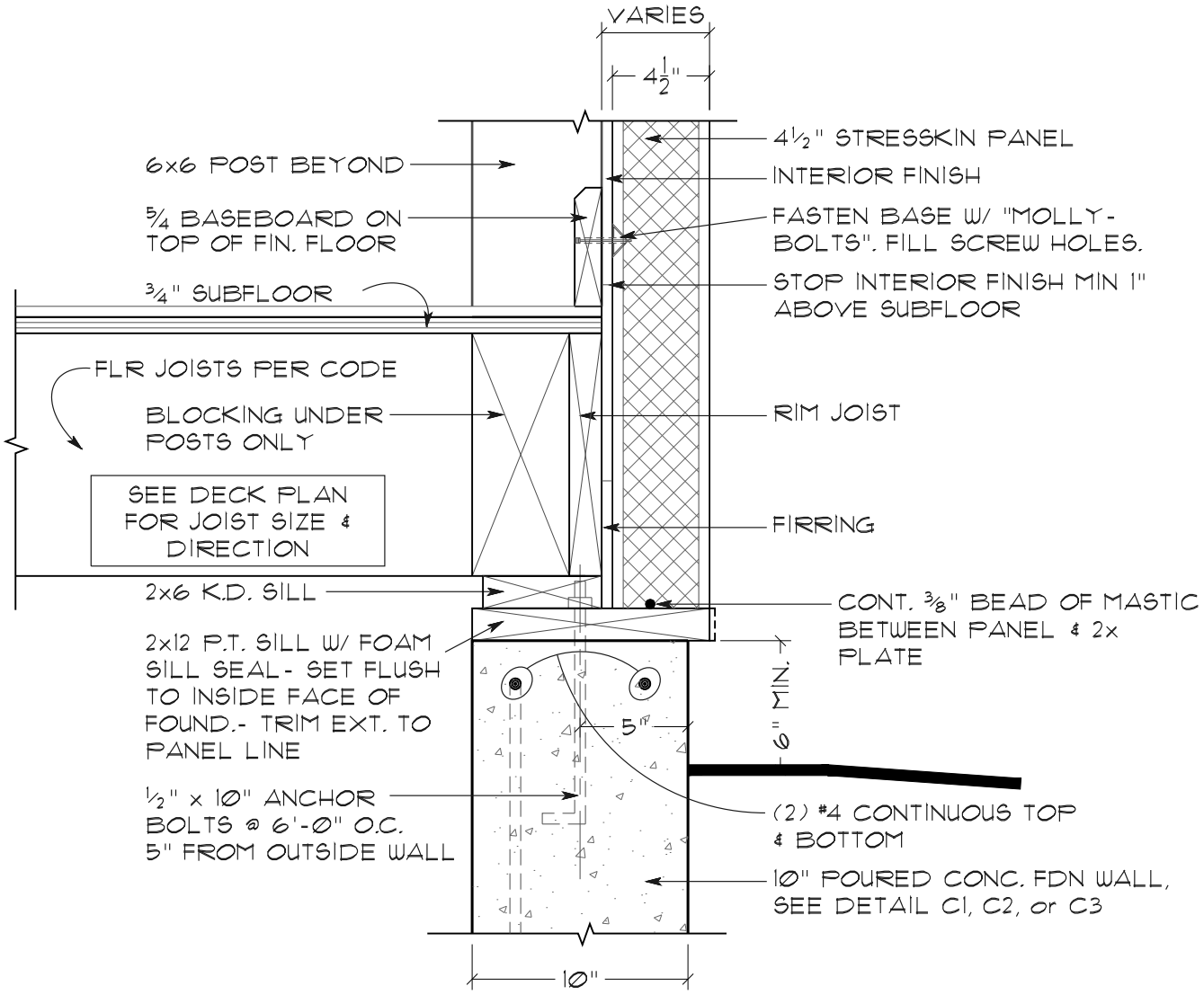
NOTE: THE DECK MUST BE SQUARE, CORNER TO CORNER WITHN ¼". DECK MUST BE LEVEL AT POST LOCATIONS WITHIN ⅛"±. SIDES MUST BE STRAIGHT WITHIN ⅛"±.



S6

SILL @ T.F. ON CONC. WALL

SCALE: 1½" = 1'-0" 09/17/19 LBJ



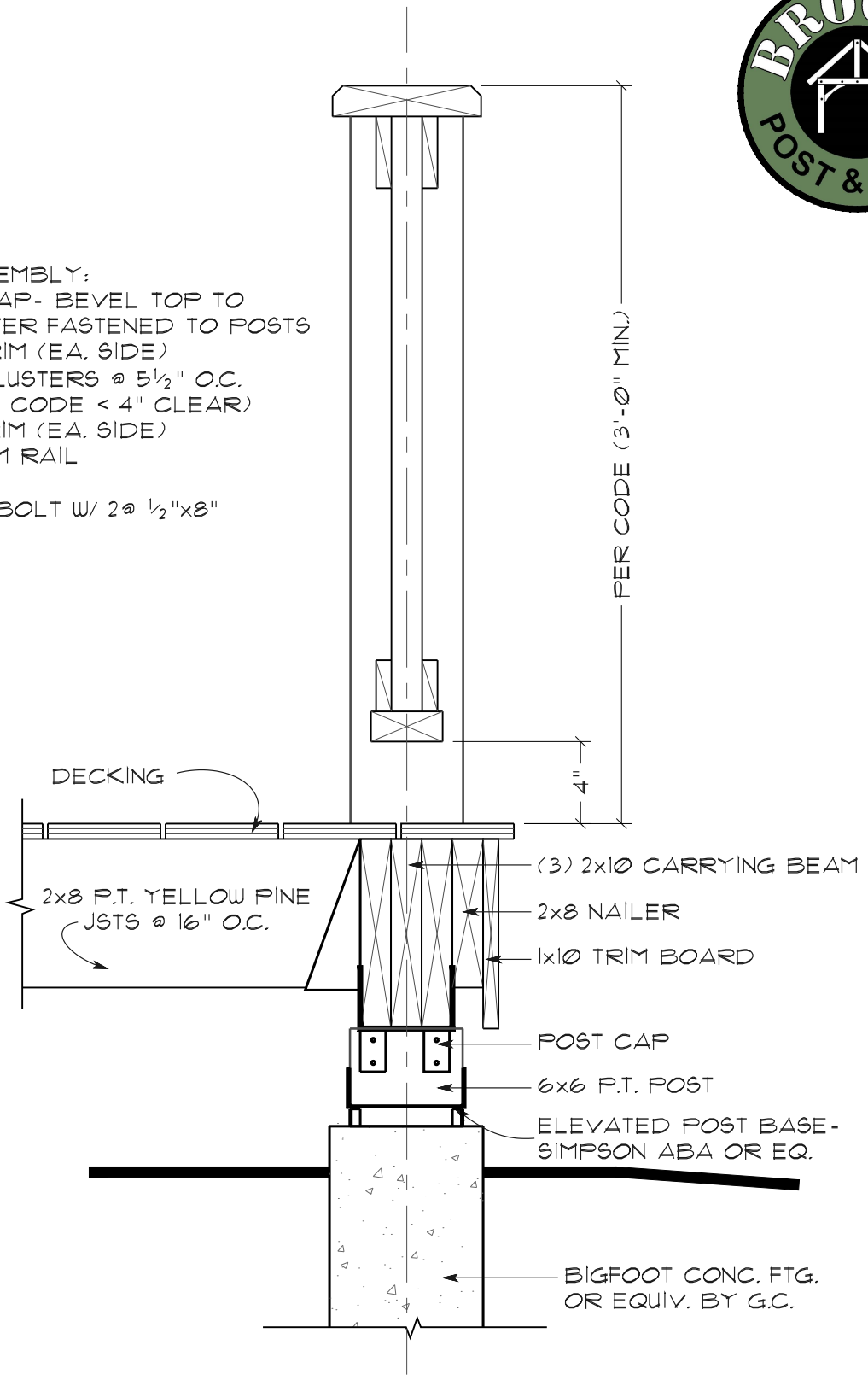
C4

SILL DETAIL

SCALE: 1½" = 1'-0" 07/11/19 LBJ

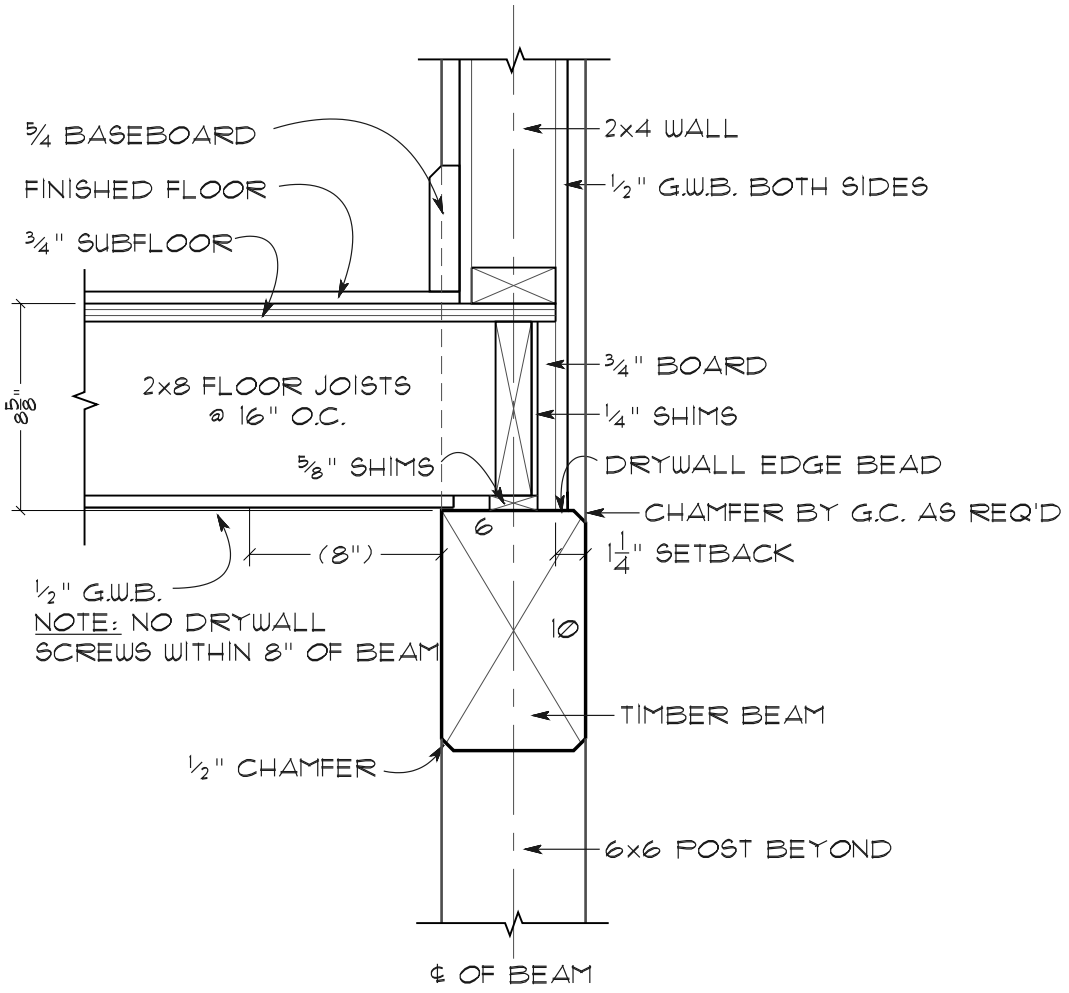
NOTE:
THE DECK MUST BE SQUARE, CORNER TO CORNER WITHIN ¼".
DECK MUST BE LEVEL AT POST LOCATIONS WITHIN ⅛".
EDGES MUST BE STRAIGHT WITHIN ¼".

RAILING ASSEMBLY:
- 2x8 RAIL CAP- BEVEL TOP TO SHED WATER FASTENED TO POSTS
- 1x4 SIDE TRIM (EA. SIDE)
- 1½" SQ. BALUSTERS @ 5½" O.C. (MAINTAIN CODE < 4" CLEAR)
- 1x3 SIDE TRIM (EA. SIDE)
- 2x4 BOTTOM RAIL
- 6x6 POST
- THROUGH- BOLT W/ 2@ ½"x8"



D3 EXTERIOR DECK RAIL SECTION

SCALE: 1½" = 1'-0" 06/16/18



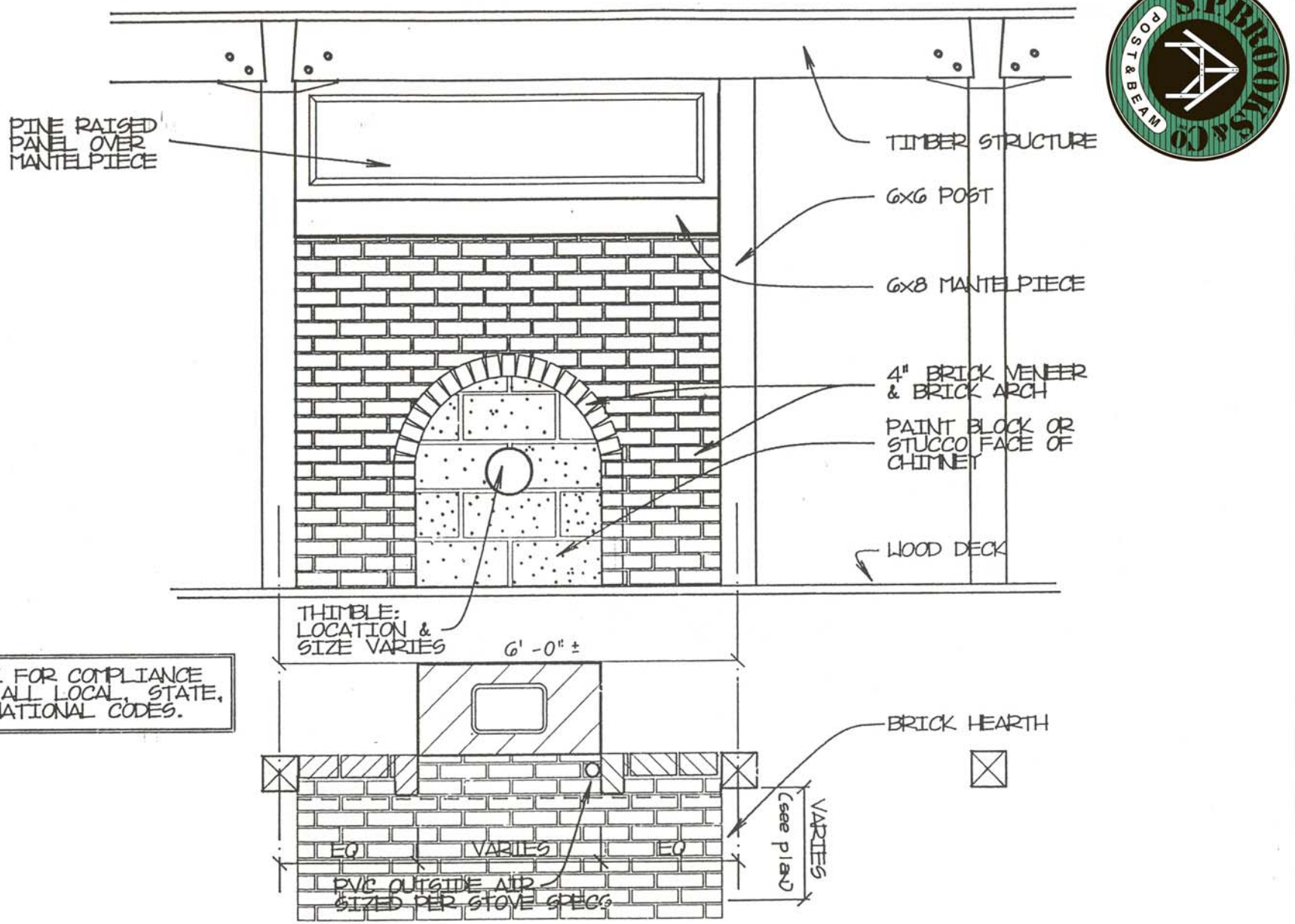
F2

2x8 HOLLOW FLOOR SECTION

PARTITION ADJACENT TO FLOOR OPENING

SCALE: 1½" = 1'-0"

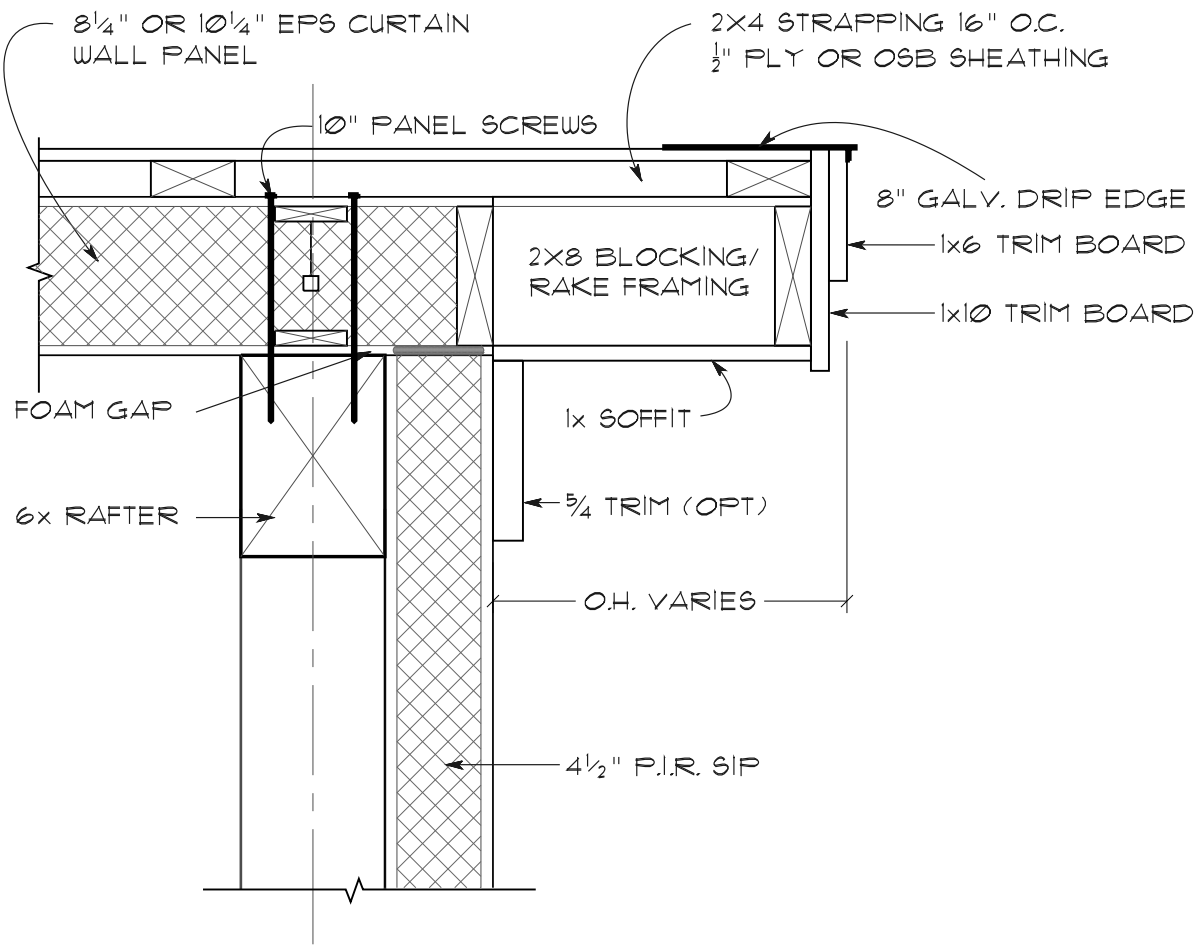
06/17/18



WOODSTOVE CHIMNEY DETAIL

scale: ½" = 1' -0"

M
S1



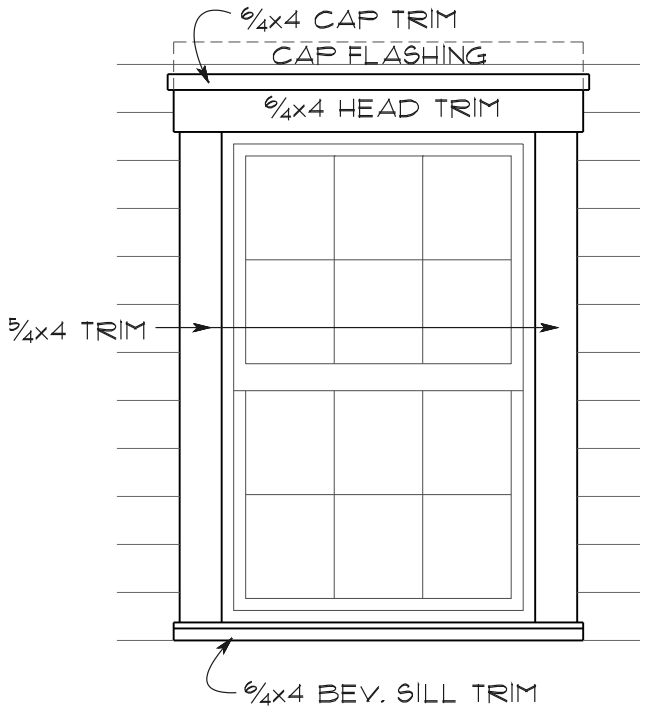
R6

RAKE DETAIL – COLD ROOF, PLUMB FASCIA

SCALE: 1½" = 1'-0"

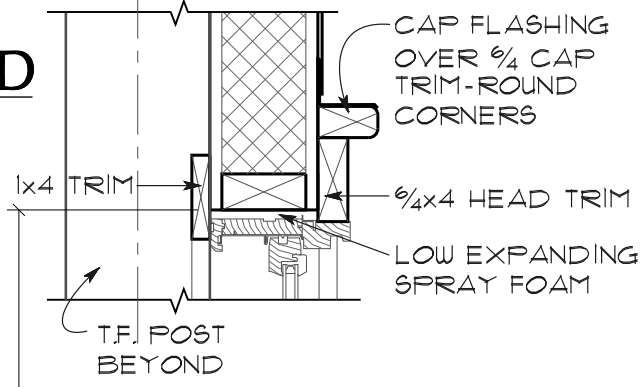
11/12/18 LBJ

INTERIOR TRIM:
OWNER'S OPTION.

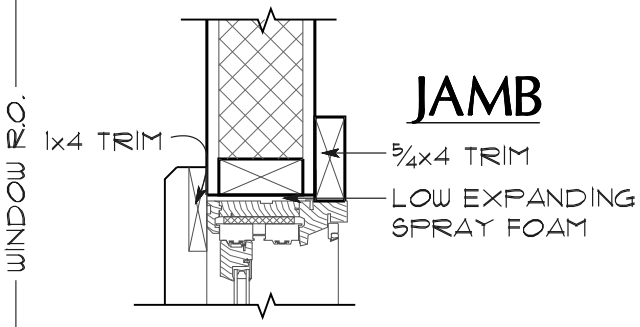


NOTE:
DOUBLE HUNG WINDOW SHOWN. OTHER WINDOW TYPES SIMILAR. WINDOW SIZES VARY (SEE DRAWINGS).

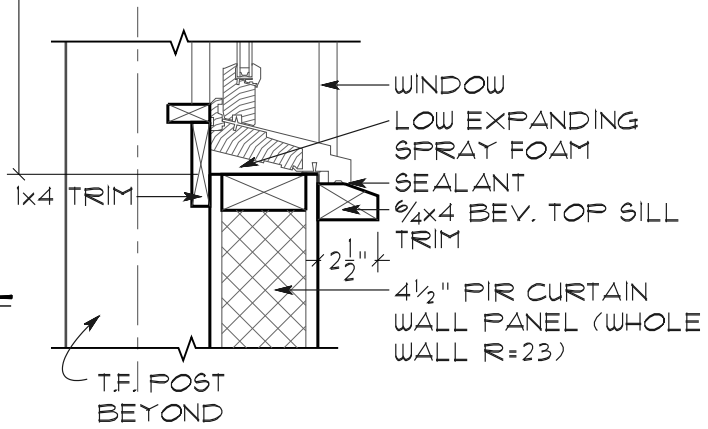
HEAD



JAMB



SILL



W3

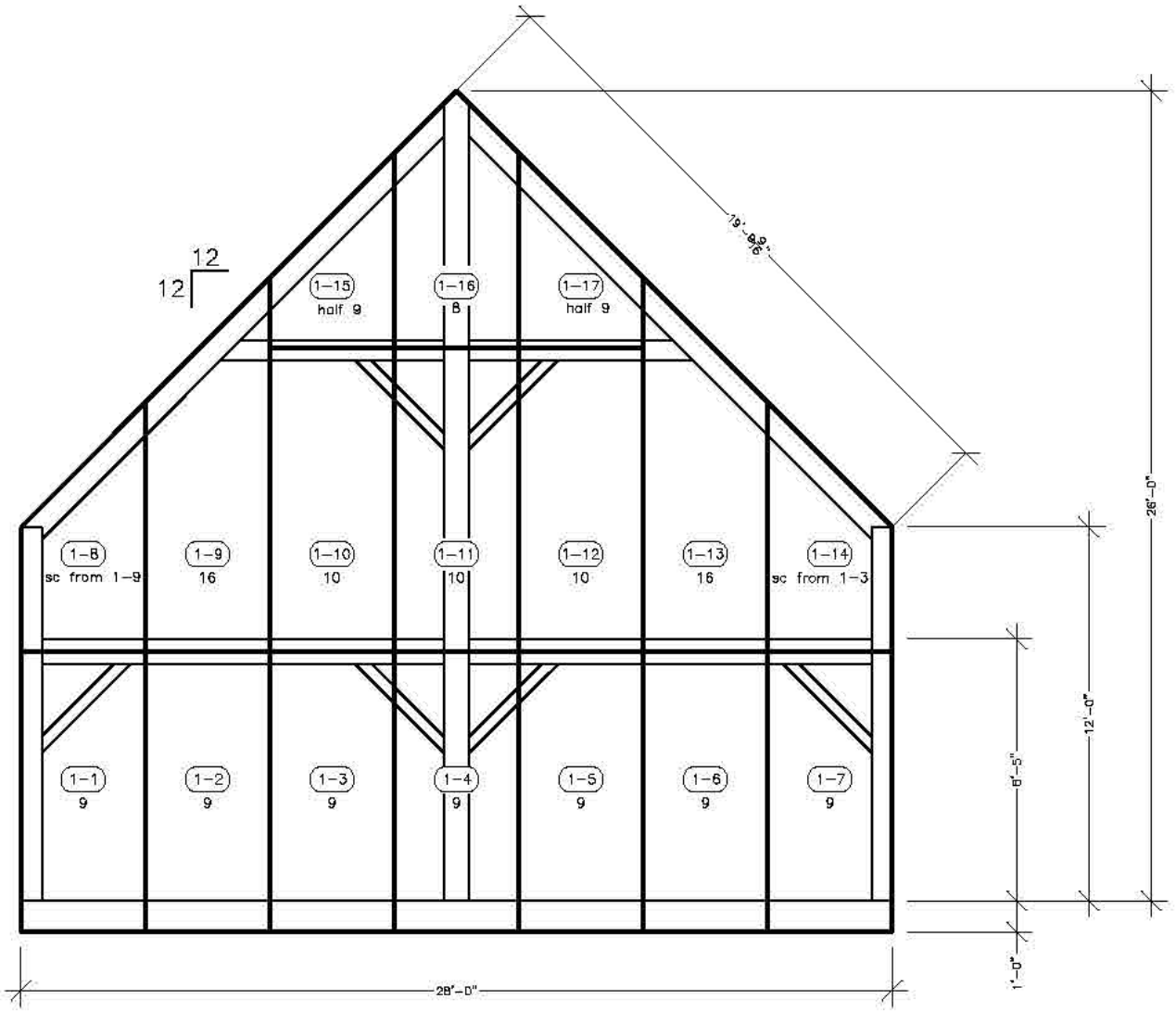
EXTERIOR WINDOW DETAILS

CLASSIC 5/4 TRIM W/ 6/4 SILL & HEAD CAP

SCALE: 1½" = 1'-0" 11/13/17 LBJ

Foard PANEL

STRUCTURAL INSULATED PANELS



Wall Panel Layout – Surface 1

6.5" SIP EPS

GUIDEBOOK

A guide to enclosing your Timber Frame with SIPs

TABLE OF CONTENTS

We encourage contractors and homeowners to use this book as a guide to designing for SIPs, however final construction details may be project specific and will be found on your Foard Panel shop drawings.

Introduction to Foard Panel

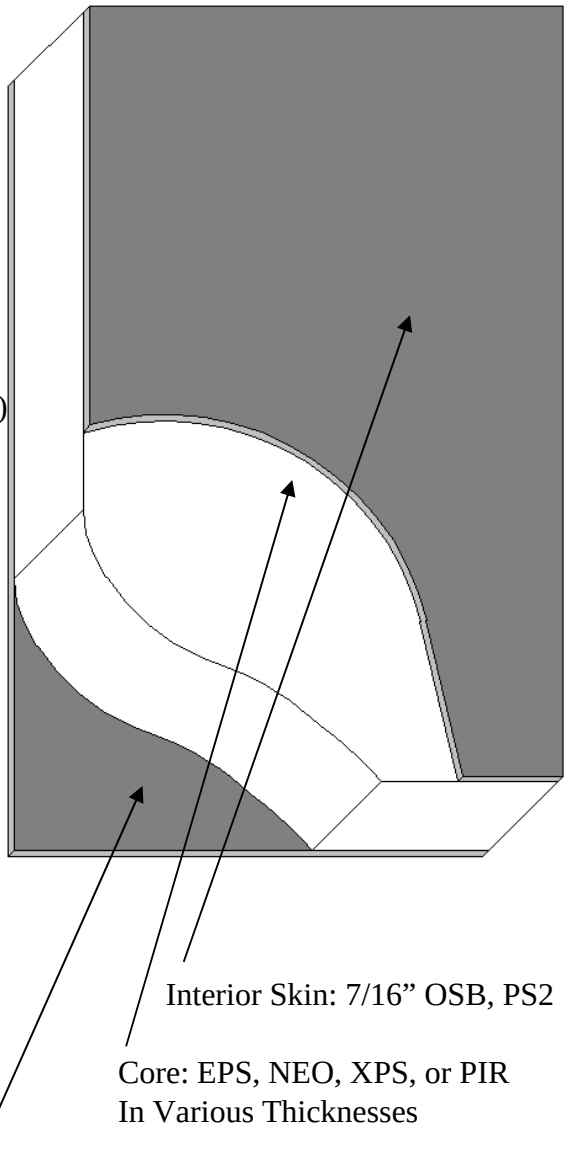
Foard Panel Products

Specialized Panel Details

Best Practice Recommendations

Structural Insulated Panel

Structural Insulated Panels (SIPs) are an energy efficient alternative to conventional framing, insulation, sheathing and other building systems. They are load-capable insulated panels used as walls, roofs, and floors in residential, commercial and institutional buildings. SIPs provide the exterior sheathing, insulation, and structure in one unit.



Interior and Exterior Skin:

7/16" thick HUD-PS2-grade Oriented Strand Board (OSB)

Core Materials:

EPS: Expanded Polystyrene, 1.0 lb/cuft, 1 in. is R-3.8
XPS: Extruded Polystyrene, 1.6 lb/cuft, 1 in. is R-5.0
NEO: Neopor Polystyrene, 1.15 lb/cuft, 1 in. is R-4.7
PIR: Polyisocyanurate foam, 2.0 lb/cuft, 1 in. is R-5.7

Features:

- Reduces Heating and Cooling Costs
- Fast Installation Reduces Labor Costs
- Uses Renewable Wood
- Recycled / Recyclable Foam Insulation

Availability:

- 3.0 through 17.0 inches thick
- 4ft by 6, 7, 8, 9, 10, 12, 14, 16, 18, 20, 22, & 24ft
- 8ft by 8, 10, 12, 14, 16, 18, 20 & 24ft
- Optional pre-cut services
- Optional embedded nailers
- Optional custom skins
- Optional wire chases
- Optional Code Listing NTA FRD-031609-25 (EPS and NEO Only)

Manufacturing & Quality Control:

Foard Panel manufacturing meets ICC-ES AC-10. Independent review and approval of procedures and plant operations by registered, third party, ISO Guide 65/17065:2012 accredited inspection agency.

20 Year Limited Warranty:

Foard Panel Inc. warrants to the buyer that Foard Panels will not delaminate in normal use as the result of a defect in materials or manufacturing for 20 years from the date of purchase. See full warranty for details.

Foard PANEL

STRUCTURAL INSULATED PANELS

Foard Panel Inc.
www.foardpanel.com
1-800-644-8885
53 Stow Drive • PO Box 185
West Chesterfield, NH 03466

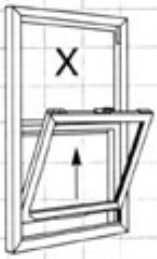
Windows

Window Operating Types

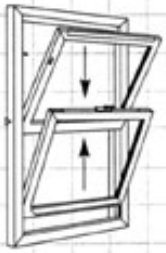
An important consideration is how the windows operate, because some operating types have lower air leakage rates than others, which will improve your home's energy efficiency. Traditional operating types include:

- **Awning**. Hinged at the top and open outward. Because the sash closes by pressing against the frame, they generally have lower air leakage rates than sliding windows. Often used where wall space is limited like baths, stairways, and entry halls. Also used in combination with fixed windows to create large glass areas with some ventilation.
- **Casement.** Hinged at the sides. Like awning windows, they generally have lower air leakage rates than sliding windows because the sash closes by pressing against the frame. Can be equipped with operating hardware that allows for full width opening, and often used as egress windows.
- **Single- and double-hung.** Probably the most common type of window. Both sashes slide vertically in a double-hung window. Only the bottom sash slides upward in a single-hung window. Most new single and double hung windows have tilt-out features that allow for easy cleaning. These sliding windows generally have slightly higher air leakage rates than hinged windows like casements or awnings.
- **Fixed.** Fixed panes that don't open. When installed properly they're airtight but are not suitable in places where window ventilation and egress is desired.
- **Hopper**. Hinged at the bottom and open inward. Like both awning and casement, they generally have lower air leakage rates because the sash closes by pressing against the frame.
- **Single- and double-sliding**. Both sashes slide horizontally in a double-sliding window. Only one sash slides in a single-sliding window. Like single- and double-hung windows, they generally have higher air leakage rates than projecting or hinged windows.

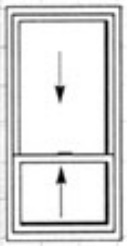
Window Styles



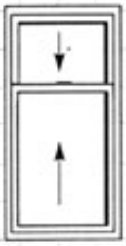
Single Hung



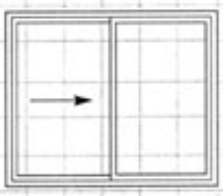
Double Hung



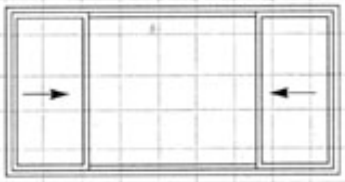
Oriel



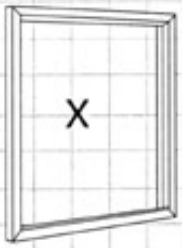
Cottage



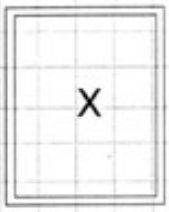
2 Panel Slider



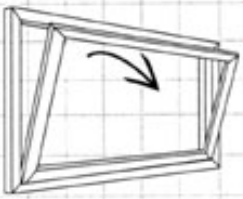
3 Panel Slider
(Available 1/4-1/2-1/4 Shown
or 1/3-1/3-1/3 configuration)



Picture Window



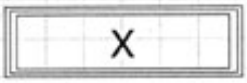
Deadlites
Sash Only



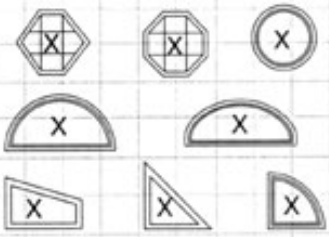
Hopper

Casement

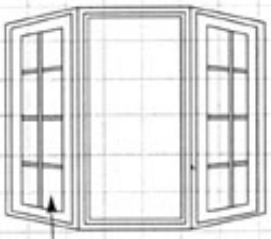
Awning



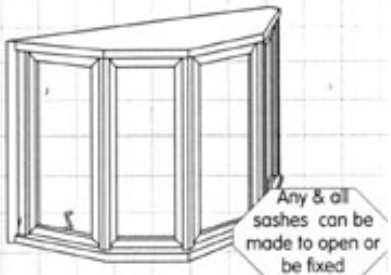
Transoms



Architectural Shapes



(Optional Opening) Bay



Bow

→ Opening Shows Direction X Non Opening

2.1 U-Factor

A principal energy concern about windows is their ability to control heat loss. Heat flows from warmer to cooler bodies, thus from the inside face of a window to the outside in winter, reversing direction in summer (see Figure 3). Overall heat flow from the warmer to the cooler side of a window unit is a complex interaction of all three basic heat transfer mechanisms—conduction, convection, and long-wave radiation. A window assembly's capacity to resist this heat transfer is referred to as its U-factor (U-value). It is expressed in units of Btu/h·ft^2·°F (U.S.) or W/m^2·°K (European metric). Essentially, the lower the window's U-factor, the greater its resistance to heat flow and the better its insulating properties.

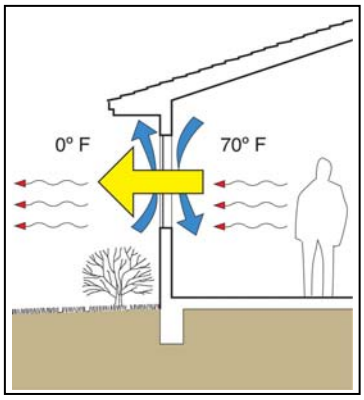


Figure 3. Heat loss through a window by conduction, convection, and radiation

NFRC's U-factor rating method is for the whole window, including glazing, frame, and spacers. Center-of-glass U-factor is also sometimes referenced, and describes the performance of the glazing alone without the effects of the frame. For most energy-efficient windows, the whole window U-factor is higher (worse in performance) than the center-of-glass U-factor.

The U-factor is used to express the insulation value of windows; R-value is used for insulation in most other parts of the building envelope (walls, floors, roofs). To compare R-value and U-factor, divide 1 by the U-factor number; e.g., a 0.25 U-factor equals a 1/0.25 = 4 R-value.

Low U-factors are most important in heating-dominated climates, although they are also beneficial in cooling-dominated climates. ENERGY STAR provides recommended U-factors for all U.S. climates.

2.2 Solar Heat Gain Coefficient

The origin of solar heat gain is the direct and diffuse radiation coming from the sun and the sky (or reflected from the ground and other surfaces). Some radiation is directly transmitted through the glazing to the building interior, and some may be absorbed in the glazing and indirectly admitted to the inside (see Figure 4). Some radiation absorbed by the frame will also contribute to overall window solar heat gain factor. Essentially, the lower the window's SHGC, the less solar heat it transmits.

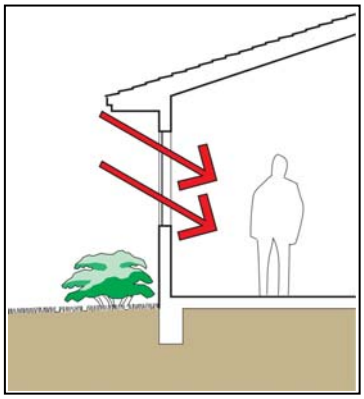


Figure 4. Solar gain through a window

SHGC is expressed as a dimensionless number from 0 to 1. A high coefficient signifies high heat gain; a low coefficient means low heat gain.

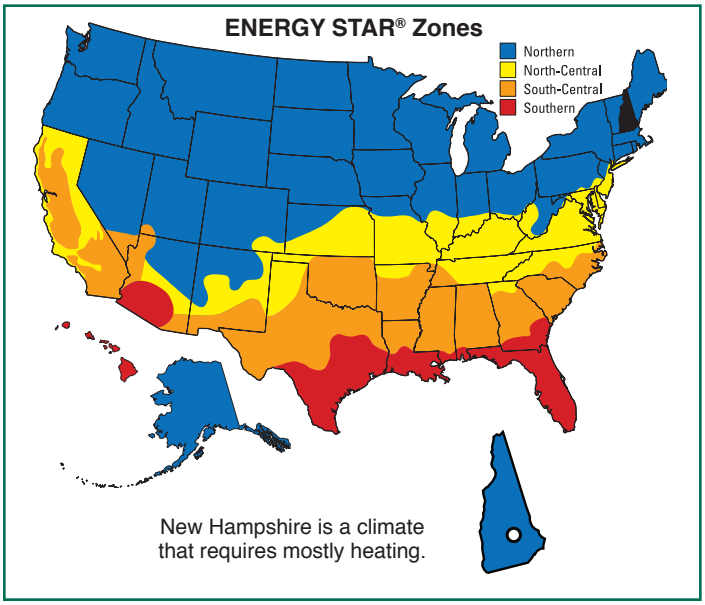
The glazing type, number of panes, and any glass coatings influence solar heat gain. Solar heat gain of glazing ranges from above 80% for uncoated clear glass to less than 20% for highly reflective coatings on tinted glass. A typical double-pane insulating glass unit (IGU) has an SHGC of around 0.70. This value decreases somewhat by adding a tint and can be decreased substantially by adding a low-solar-gain low-e coating.

Go to www.efficientwindows.org to find guidelines for your State.

Efficient Windows™ Collaborative

Selecting Energy Efficient New Windows in New Hampshire

www.efficientwindows.org January 2016



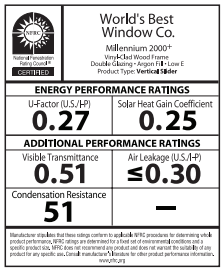
U-factor	SHGC	Air Leakage
Windows: U ≤ 0.27 **Windows: U = 0.28** **Windows: U = 0.29** **Windows: U = 0.30** **Skylights: U ≤ 0.50**	**Windows: Any** **Windows: SHGC ≥ 0.32** **Windows: SHGC ≥ 0.37** **Windows: SHGC ≥ 0.42** **Skylights: Any**	**Windows: AL ≤ 0.30** **Skylights: AL ≤ 0.30**
For superior energy performance, select windows with a U-factor of 0.25 or less. If air conditioning is not a concern, look for a higher Solar Heat Gain Coefficient (SHGC) of 0.35–0.60 so winter solar heat can help offset the heating energy need. If cooling is a significant concern and no shading is available, select windows with a SHGC less than 0.32.		
U-factor	**SHGC**	**Air Leakage**
Windows: U ≤ 0.30 **Skylights: U ≤ 0.53**	**Windows: SHGC ≤ 0.40** **Skylights: SHGC ≤ 0.35**	**Windows: AL ≤ 0.30** **Skylights: AL ≤ 0.30**
The larger your heating bill, the more important a low U-factor becomes. For superior energy performance, select windows with a U-factor of 0.25 or less. A low SHGC value reduces summer cooling demand, but also reduces free winter solar heat gain. If you have significant air conditioning costs or summer overheating issues, look for SHGC values of 0.25 or less.		
U-factor	**SHGC**	**Air Leakage**
Windows: U ≤ 0.30 **Skylights: U ≤ 0.53**	**Windows: SHGC ≤ 0.25** **Skylights: SHGC ≤ 0.28**	**Windows: AL ≤ 0.30** **Skylights: AL ≤ 0.30**
A low U-factor is useful during cold days when heating is needed and is also helpful during hot days when it is important to keep the heat out. Windows with low SHGC values help reduce summer cooling demand. If you have significant air conditioning costs or summer overheating issues, look for SHGC values of 0.25 or less.		
U-factor	**SHGC**	**Air Leakage**
Windows: U ≤ 0.40 **Skylights: U ≤ 0.60**	**Windows: SHGC ≤ 0.25** **Skylights: SHGC ≤ 0.28**	**Windows: AL ≤ 0.30** **Skylights: AL ≤ 0.30**
A low SHGC is the important window property in warm to hot climates. For superior energy performance, select windows with a SHGC of 0.25 or less. A low U-factor is useful during cold days when heating is needed and is also helpful during hot days when it is important to keep the heat out.		

1. Meet the Energy Code & Look for the ENERGY STAR®

Windows must comply with your local energy code. Windows that are ENERGY STAR certified often meet or exceed energy code requirements. To verify if specific window energy properties comply with the local code requirements, look for the NFRC label.

2. Look for Efficient Properties on the NFRC Label

The National Fenestration Rating Council (NFRC) label is needed for verification of energy code compliance. The NFRC label displays whole-window energy properties and appears on all fenestration products which are part of the ENERGY STAR program (www.nfrc.org).

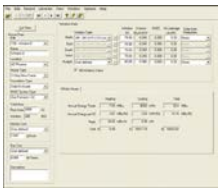


3. Compare Annual Energy Costs for a Typical House

Use computer simulations for a typical house to compare the annual energy performance of different window types. A comparison of the performance of a set of windows for this climate begins on Page 3 or use the Window Selection Tool on the EWC web site or the Window Selection Tool Mobile App (www.efficientwindows.org).

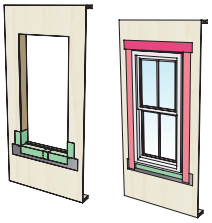
4. Customize Energy Use for a Specific House

A simulation program, such as RESFEN, lets you compare window options by calculating performance based on utility rates for your climate, house design, and window design options (windows.lbl.gov/software).

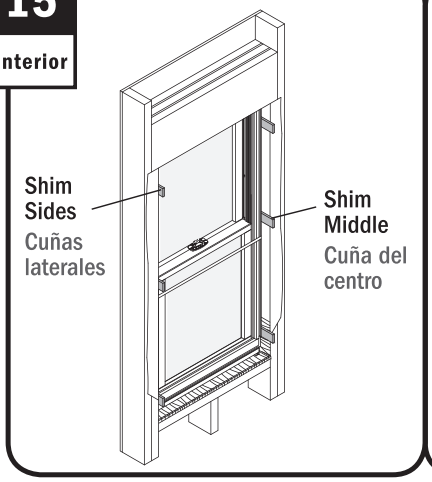


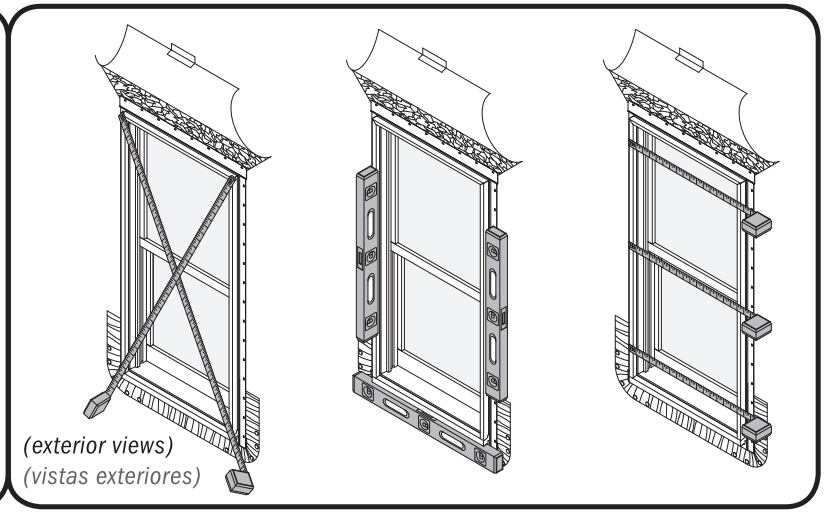
5. Ensure Proper Installation

Proper window and skylight installation is necessary for optimal performance, to avoid air and water leakage. Always follow manufacturers' installation guidelines and use trained professionals for window and skylight installation.



15
Interior

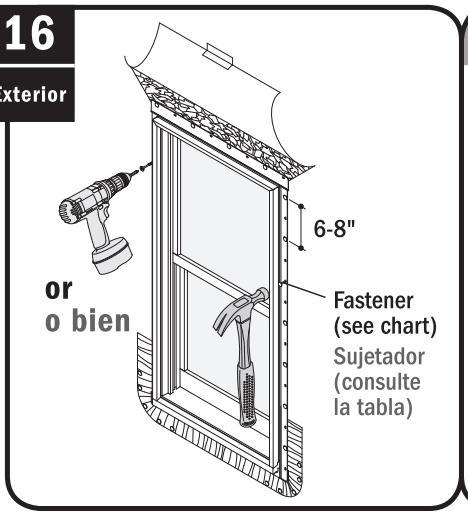




Shim sides. **Do not shim at top.**
Coloque cuñas en los laterales.
No coloque cuñas en la parte superior.

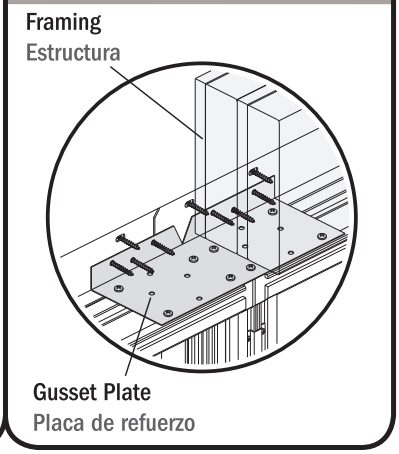
Check plumb, level, square. Adjust shims as needed until measurements are within 1/8".
Verifique la plomada, el nivel y la cuadratura. Ajuste las cuñas según sea necesario hasta que las medidas estén dentro de 1/8".

16
Exterior



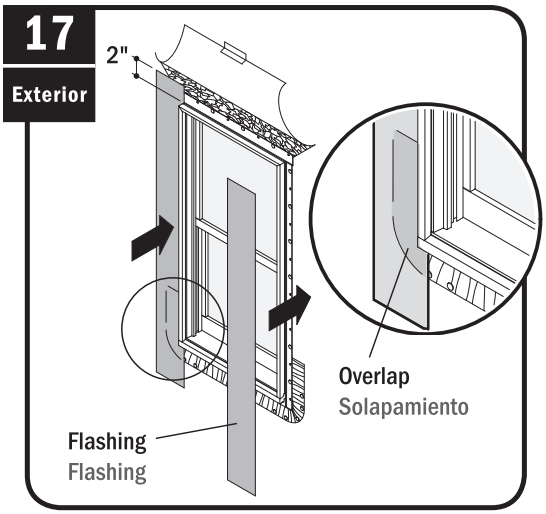
Fasten on all sides.
Sujete todos los lados.

Joined Units Only
Sólo unidades unidas



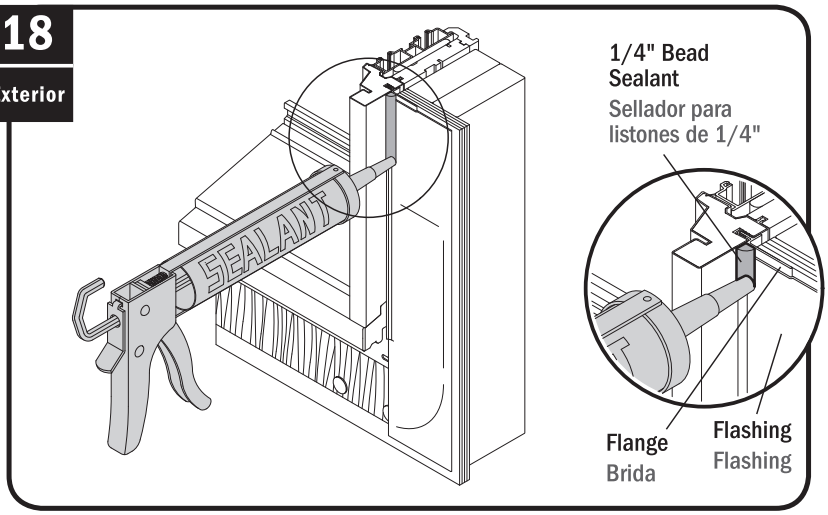
Fasten through gusset plates also.
Sujete también a través de las placas de refuerzo.

17
Exterior



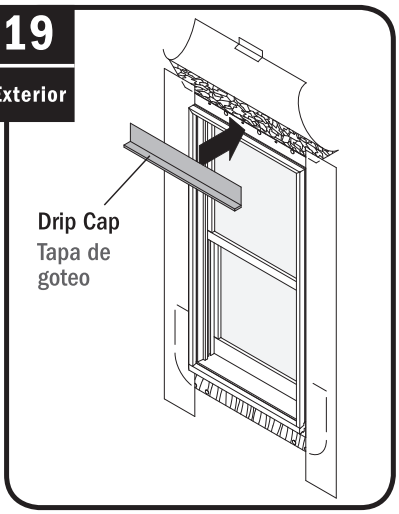
Apply flashing at sides, overlapping sill flashing.
Aplique flashing en los laterales, sobreponiéndolo sobre el flashing para riel.

18
Exterior



Seal **sides and top only**. Quickly go to next step.
Selle **únicamente los lados y la parte superior**. Pase rápidamente al siguiente paso.

19
Exterior



Place drip cap in sealant.
Coloque la tapa de goteo en sellador.

Heating and Cooling

A timber frame with foam core SIP or curtainwall panels creates a high performance, extremely energy-efficient building that will perform in an entirely different way than standard construction. It very important that anyone involved in designing an **HVAC** (Heating Ventilating & Air Conditioning) system for these buildings is aware of these differences. The following information is intended to help you understand the basic principles involved, and to give a brief overview of the different systems available to you.

Heat Flow

A brief explanation of heat physics will help you understand why heating and cooling a SIP enclosed building requires new thinking. The first principle is that heat always moves from hot to cold, not vice versa. It's easy to remember that heat moves "downhill" from higher temps to lower. There are 3 ways that heat can travel: *Conduction*, *Convection*, and *Radiation*.

Conduction-

This is the most familiar and predictable type of heat flow. Grab a hot frying pan, and you get burned because the pan's heat conducts into your skin. As an object becomes warmer, the molecules become more active, expanding and passing heat through the material. This flow of heat is always from higher temperature to lower temperature. Different materials conduct at different rates. Copper is a very good conductor of heat, while wood is a poor conductor. A poor conductor is known as an insulator.

Convection-

Convection is heat transferred by a moving fluid like air or water. We all learn that hot air rises- in fact heat moves in all directions, but hot air is less dense than cold air, and expands and rises. Denser cold air moves in from below to replace it, causing air currents or drafts.

Radiation-

Radiant heat travels through space from one object to another. The radiant waves do not heat the space in which they travel; they only heat (or lose heat to) the surfaces they strike. The sun is the most obvious example of this. Radiated heat from the sun strikes a white surface, and much it bounces or is reflected off while the surface remains cool. When it strikes a black or dark surface, it is absorbed and the surface warms or conducts the heat to a colder area. In this same manner, a window with a reflective coating will bounce radiated heat back into the room and not conduct as much heat outside, when compared to a window with no coating. This is how "Low-E" windows work. The inside face of the insulated glass is coated with a mostly transparent film which helps reflect indoor heat back into the room.

A Thermos jug resists **conducted** heat loss by eliminating the air between the inner and outer container (the vacuum seal). **Convected** heat loss is stopped by placing a cover on the jug, and **radiated** heat is reflected back by the shiny inner coating. To maintain a consistent indoor temperature, a building also must prevent temperature change by all 3 kinds of heat loss.

cool down or warm up, unlike other heating systems which can warm a room in a few minutes with a flick of the thermostat. A warm floor will stay warm, even if the sun shines through the south-facing windows and warms the room up to the point of discomfort. Even after the system is turned off, the stored heat in the floor mass will continue to dissipate sometimes for hours. Meanwhile, unless the other areas of the house are on different zones, the rest of the house is getting cold, because you turned the heat down. Careful planning is required to ensure that such areas can be properly controlled.

Hydronic Radiant floor summary:

Pros-

- Virtually invisible- no ducts, registers, radiators or pipes.
- No dust carried by ducts or by convection radiators.
- Steady heat, no temperature cycling as with FHA. Set it and forget it.

Cons-

- Highest up-front cost, usually several times that of other systems.
- Solar gain or loss through large areas of glass can cause rooms to be excessively warm or cool.
- Works best with hard floors, not with carpet.
- More complex distribution system, largely concealed means problems or leaks are not easy to spot and fix.

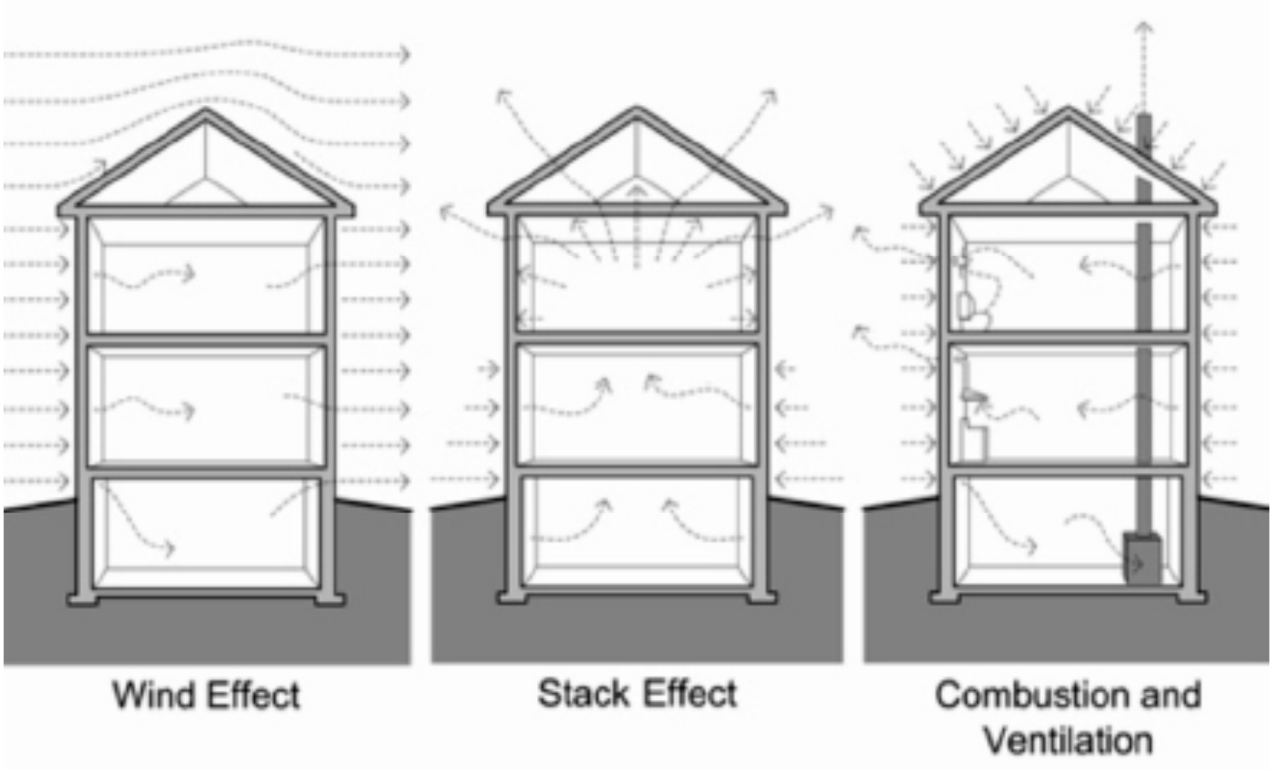
Ductless, Mini-Split Heat Pumps

Ductless, mini-split-system heat pumps (mini splits) make good retrofit add-ons to houses with "non-ducted" heating systems, such as hydronic (hot water heat), radiant panels, and space heaters (wood, kerosene, propane). They can also be a good choice for room additions where extending or installing distribution ductwork is not feasible, and very efficient new homes that require only a small space conditioning system. Be sure to choose an ENERGY STAR® compliant unit and hire an installer familiar with the product and its installation.

Like standard air-source heat pumps, mini splits have two main components -- an outdoor compressor/condenser and an indoor air-handling unit. A conduit, which houses the power cable, refrigerant tubing, suction tubing, and a condensate drain, links the outdoor and indoor units.

Advantages

The main advantages of mini splits are their small size and flexibility for zoning or heating and cooling individual rooms. Many models can have as many as four indoor air-handling units (for four zones or rooms) connected to one outdoor unit. The number depends on how much heating or cooling is



As mentioned in the previous section on Heating and Cooling, modern building codes have strict requirements for ventilation. The 2012 IECC contains prescriptive requirements for residential ventilation. The Energy Codes set limits on how much air is permitted to leak out of the homes' thermal boundary. In the Northern United States, air leakage is not permitted to be more than three air changes per hour when tested at a pressure of 50 pascals (ACH50) . (Our homes often test <u>much</u> lower than this)

See section 2 of the accompanying *Air Leakage Guide.*

What does all this mean? **Air changes per hour** refers to the volume of the building, and the volume of air that is required per hour. When in building is pressure tested using a blower door, the fan pressure is at 50 pascals, which is a unit of barometric pressure.

But, going a little deeper, we can determine exactly how much fresh air is required in CFM (cubic feet per minute). ASHRAE 62.2 (ASHRAE.org) provides a formula based on the floor area plus the number of occupants:

$Qv = 0.01\ A_{floor} + 7.5(N_{br}+1)$

Where:

Qv = ventilation flow rate in cubic feet per minute (CFM)
A_{floor} = floor area in square feet
N_{br} = number of bedrooms; not less than 1

Example- a 2 story 2000 sf home in NH with 3 bedrooms. 0.01(**2000**) + 7.5 (**3**+1) = 50 CFM

Heating and Cooling

A timber frame with foam core SIP or curtainwall panels creates a high performance, extremely energy-efficient building that will perform in an entirely different way than standard construction. It very important that anyone involved in designing an **HVAC** (Heating Ventilating & Air Conditioning) system for these buildings is aware of these differences. The following information is intended to help you understand the basic principles involved, and to give a brief overview of the different systems available to you.

Heat Flow

A brief explanation of heat physics will help you understand why heating and cooling a SIP enclosed building requires new thinking. The first principle is that heat always moves from hot to cold, not vice versa. It's easy to remember that heat moves "downhill" from higher temps to lower. There are 3 ways that heat can travel: *Conduction*, *Convection*, and *Radiation*.

Conduction-

This is the most familiar and predictable type of heat flow. Grab a hot frying pan, and you get burned because the pan's heat conducts into your skin. As an object becomes warmer, the molecules become more active, expanding and passing heat through the material. This flow of heat is always from higher temperature to lower temperature. Different materials conduct at different rates. Copper is a very good conductor of heat, while wood is a poor conductor. A poor conductor is known as an insulator.

Convection-

Convection is heat transferred by a moving fluid like air or water. We all learn that hot air rises- in fact heat moves in all directions, but hot air is less dense than cold air, and expands and rises. Denser cold air moves in from below to replace it, causing air currents or drafts.

Radiation-

Radiant heat travels through space from one object to another. The radiant waves do not heat the space in which they travel; they only heat (or lose heat to) the surfaces they strike. The sun is the most obvious example of this. Radiated heat from the sun strikes a white surface, and much it bounces or is reflected off while the surface remains cool. When it strikes a black or dark surface, it is absorbed and the surface warms or conducts the heat to a colder area. In this same manner, a window with a reflective coating will bounce radiated heat back into the room and not conduct as much heat outside, when compared to a window with no coating. This is how "Low-E" windows work. The inside face of the insulated glass is coated with a mostly transparent film which helps reflect indoor heat back into the room.

A Thermos jug resists **conducted** heat loss by eliminating the air between the inner and outer container (the vacuum seal). **Convected** heat loss is stopped by placing a cover on the jug, and **radiated** heat is reflected back by the shiny inner coating. To maintain a consistent indoor temperature, a building also must prevent temperature change by all 3 kinds of heat loss.

cool down or warm up, unlike other heating systems which can warm a room in a few minutes with a flick of the thermostat. A warm floor will stay warm, even if the sun shines through the south-facing windows and warms the room up to the point of discomfort. Even after the system is turned off, the stored heat in the floor mass will continue to dissipate sometimes for hours. Meanwhile, unless the other areas of the house are on different zones, the rest of the house is getting cold, because you turned the heat down. Careful planning is required to ensure that such areas can be properly controlled.

Hydronic Radiant floor summary:

Pros-

- Virtually invisible- no ducts, registers, radiators or pipes.
- No dust carried by ducts or by convection radiators.
- Steady heat, no temperature cycling as with FHA. Set it and forget it.

Cons-

- Highest up-front cost, usually several times that of other systems.
- Solar gain or loss through large areas of glass can cause rooms to be excessively warm or cool.
- Works best with hard floors, not with carpet.
- More complex distribution system, largely concealed means problems or leaks are not easy to spot and fix.

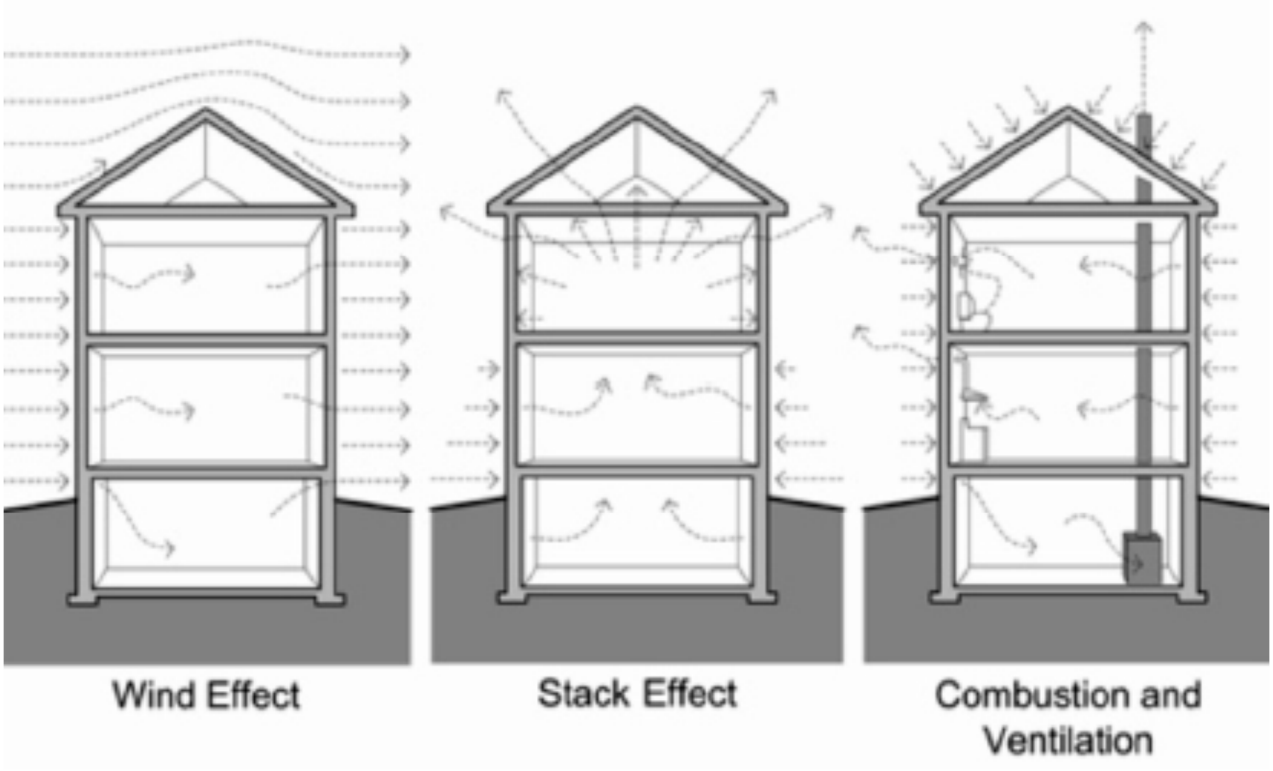
Ductless, Mini-Split Heat Pumps

Ductless, mini-split-system heat pumps (mini splits) make good retrofit add-ons to houses with "non-ducted" heating systems, such as hydronic (hot water heat), radiant panels, and space heaters (wood, kerosene, propane). They can also be a good choice for room additions where extending or installing distribution ductwork is not feasible, and very efficient new homes that require only a small space conditioning system. Be sure to choose an ENERGY STAR® compliant unit and hire an installer familiar with the product and its installation.

Like standard air-source heat pumps, mini splits have two main components -- an outdoor compressor/condenser and an indoor air-handling unit. A conduit, which houses the power cable, refrigerant tubing, suction tubing, and a condensate drain, links the outdoor and indoor units.

Advantages

The main advantages of mini splits are their small size and flexibility for zoning or heating and cooling individual rooms. Many models can have as many as four indoor air-handling units (for four zones or rooms) connected to one outdoor unit. The number depends on how much heating or cooling is



As mentioned in the previous section on Heating and Cooling, modern building codes have strict requirements for ventilation. The 2012 IECC contains prescriptive requirements for residential ventilation. The Energy Codes set limits on how much air is permitted to leak out of the homes' thermal boundary. In the Northern United States, air leakage is not permitted to be more than three air changes per hour when tested at a pressure of 50 pascals (ACH50) . (Our homes often test <u>much</u> lower than this)

See section 2 of the accompanying *Air Leakage Guide.*

What does all this mean? **Air changes per hour** refers to the volume of the building, and the volume of air that is required per hour. When in building is pressure tested using a blower door, the fan pressure is at 50 pascals, which is a unit of barometric pressure.

But, going a little deeper, we can determine exactly how much fresh air is required in CFM (cubic feet per minute). ASHRAE 62.2 (ASHRAE.org) provides a formula based on the floor area plus the number of occupants:

$Qv = 0.01\ A_{floor} + 7.5(N_{br}+1)$

Where:

Qv = ventilation flow rate in cubic feet per minute (CFM)
A_{floor} = floor area in square feet
N_{br} = number of bedrooms; not less than 1

Example- a 2 story 2000 sf home in NH with 3 bedrooms. 0.01(**2000**) + 7.5 (**3**+1) = 50 CFM

BSC Information Sheet 611

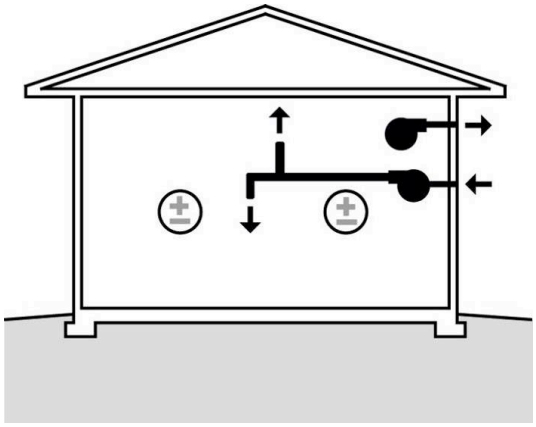
Balanced Ventilation Systems (HRVs and ERVs) *for All Climates*

Why a Ventilation System?

All buildings require controlled mechanical ventilation, or the controlled, purposeful introduction of outdoor air to the conditioned space. Building intentionally leaky buildings and installing operable windows does not provide sufficient outside air in a consistent manner throughout the year.

Building enclosures must be "built tight and then ventilated right." Why? Because before you can control air you must enclose it. Once you eliminate big holes it becomes easy to control air exchange between the inside and the outside.

With a tight building enclosure, both mechanical ventilation and pollutant source control are required to ensure that there is reasonable indoor air quality inside the house. These approaches are shown schematically in the following figures.



- Conceptual diagram of a balanced ventilation system

- Heat recovery ventilator (HRV) installed in a basement, connected to a central air handler system

Balanced Ventilation Systems (HRVs & ERVs)

A balanced ventilation system (as opposed to supply-only or exhaust-only system) has two fans: one bringing outside air into the building, and the other exhausting stale interior air, resulting in roughly balanced airflows. These systems do not significantly affect the pressure of the interior space with respect to outdoors.

In most balanced ventilation systems, heat—and sometimes moisture—are exchanged between the two airstreams, reducing the heating and cooling loads caused by outside ventilation air. These systems are known as HRVs (heat recovery ventilators) and ERVs (energy or enthalpy recovery ventilators). HRVs only exchange heat between the airstreams, while ERVs exchange both heat and moisture.

HRV/ERV Configurations

These systems can be configured in a variety of ways; the options have a range of installed costs, energy efficiency levels (due to fan energy and recovery efficiency), and effectiveness at distributing the ventilation air throughout the house. In addition, system configuration will depend on the presence or absence of a central air handler, which can be used to distribute ventilation air.

Some designs or configurations can cause poor distribution, excess air leakage, exacerbated humidity control problems, or poor flow. The designs shown here are some of BSC's recommendations for the best performance. Additional options for good performance (as well as configurations to avoid) are discussed in BSC's *Ventilation Guide*.

This Information Sheet has been prepared by Building Science Corporation for the Department of Energy's Building America Program, a private/public partnership that develops energy solutions for new and existing homes. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States government or any agency thereof.

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