



COLD CLIMATE HOUSING RESEARCH CENTER

**CCHRC**

# Construction Manual

## Integrated Truss Home

**Alaska State Department of Homeland Security and  
Emergency Management  
First Edition**



Cold Climate Housing  
Research Center

2014

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Construction Manual  
Integrated Truss Home  
Alaska State Department of Homeland Security and Emergency Management

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**IMPORTANT — READ BEFORE BUILDING.**

*The information contained in this manual was originally developed and published as a reference for experienced building professionals and aid workers as a tool to help respond to the replacement housing needs of communities affected by natural disasters. The manual documents the techniques utilized in the construction of the Integrated Truss Home in order to further enable experienced building professionals incorporate these techniques in future home construction projects. This manual is not a substitute for a detailed architectural plan set or site-specific engineering. Any application of knowledge contained in this manual will need to consider site-specific issues including but not limited to applicable codes and structural design considerations for soil type, weather, and wind and snow load conditions. It is essential that a structural engineer review the plans to ensure they meet design criteria appropriate to the site. While this home is simple to construct, it has many elements that require specialized knowledge. We strongly recommend that the installation of the spray foam insulation, plumbing, electrical, and ventilation work be done by professionals.*

*Always use proper safety gear and precautions when building.*

*It is important to note that this manual is a SUPPLEMENT to the detailed, site-specific planset, and that it generalizes multiple approaches to detailing. If the plans and the manual conflict in any way, the plans take precedent.*

CCHRC sincerely appreciates its partnership with the Alaska State Department of Homeland Security and Emergency Management, as well as the Federal Emergency Management Agency, in the design and construction of this prototype home.

**Cover Photos:** *Top Left:* Maurice Mochin of Atmautluak, Alaska. *Top Right:* A fully-framed Integrated Truss Home. *Bottom Right:* Two finished homes after nine weeks of construction.



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# Disaster Relief Housing

## Overview

Earthquakes, flooding, forest fires, and other natural disasters have historically affected a significant percentage of communities across the state of Alaska. Responding to the needs of Alaska communities affected by natural disasters can be especially challenging due to the lack of road access to many communities, short building season, and cold winters that push responders to come up with housing solutions very quickly. The variables involved in disaster response housing are daunting. The needs of community members are not uniform, nor are the resources available to help. Even organizations dedicated to disaster relief encounter logistical difficulties that call for rapid, sophisticated coordination.



Figure 0.1 (Above) The community of Galena in the aftermath of the 2014 flood of the Yukon River. Rebuilding in a remote community not connected by road presents special challenges.

Figure 0.2 (Right) A sample page from the State Disaster Housing Matrix. The Matrix is a guide to aid decision-making during disaster response scenarios where residents will hope to replace damaged or destroyed housing in their community.

MATRIX; WALLS & ENVELOPES									
		Integrated Truss (SIPAP)	Integrated Truss (Couscous)	REACTITE Wall (micro foam)	Quiltbag Wall (SIPAP)	Standard Wall (micro foam)	Structurally Insulated Panels	Log Wall	
<b>SITE</b>									
Floodplain									
[deep] Permafrost									
[degrading] Permafrost									
High Wind									
Water & Precipitation (wind driven rain)									
<b>SEASON</b>									
Breakup									
Summer									
Autumn									
Winter									
<b>LOGISTICS</b>									
Road									
Barge									
Cargo Plane									
Helicopter									
Train									
<b>SCORE</b>									
IDEAL									
ACCEPTABLE									
MARGINAL									
IMPRACTICAL									
<b>RANK</b>									

For Consideration:

(1) \_\_\_\_\_

(2) \_\_\_\_\_

(3) \_\_\_\_\_

DHS&EM\_HOUSING MATRIX\_29 [2013 JULY 9 DRAFT]

## The Disaster Housing Matrix

An inclusive approach to designing and building disaster relief housing in rural Alaska was pioneered by the Alaska Division of Homeland Security and Emergency Management (DHS&EM), the Cold Climate Housing Research Center (CCHRC), and the faith-based group Samaritan's Purse in 2011. The Alaskan community of Crooked Creek was flooded by an ice jam on the Kuskokwim River and nine homes were lost, as well as many more damaged. DHS&EM, recognizing the resource potential within different groups in the state, formed a Task Force to coordinate efforts to rebuild. With DHS&EM management, CCHRC designed a model replacement home that was affordable and energy efficient, and Samaritan's Purse volunteers constructed the homes. Before the onset of winter, all families that had lost their homes were in new structures.



This success, along with lessons learned in responding to past disasters, led DHS&EM to establish an ongoing project entitled the Disaster Housing Matrix. The primary goal of the Matrix is to aid in making design decisions during time-sensitive disaster response. The Matrix is meant to be a living document that is developed during peacetime, so that directly following a disaster, there is an established process for selecting appropriate housing retrofit and replacement strategies for the unique Alaska environment.

The Matrix assists homeowners, aid organizations, and local governments in achieving the following goals:

- To design homes that use materials that substantially reduce time of construction;
- To design homes that can be built by construction crews of varying abilities, from experienced carpenters to volunteer labor;
- To produce homes that are healthy to live in;
- To design homes that suit the lifestyle of the inhabitants;
- To build homes that are at least 50% more energy-efficient than current average housing stock; and
- To build these homes for close to half the cost of average current new construction.

### REMOTE Wall

**INSULATION:** RIGID FOAM

**Description:** Residential Exterior Membrane Outside-Insulation Technique

**Assembly:** Traditional framing and flashing techniques; Pressure equalized rain screen

**Materials:** Standard

**Logistics:** standard wood/steel framing travels well | transport of bulky rigid foam can prove costly over long distances

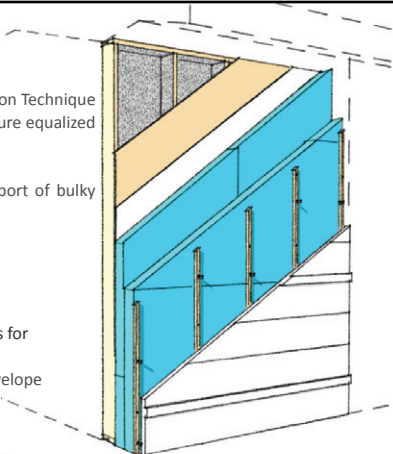
**Construction:** year round possible

**Cost Factors**

**Increased costs:** Fly-in only Sites (as rigid foam is bulky)

**Decreased costs:** Road system builds | Decreased O&M costs for occupants

**Benefits of design:** Very tight and well-insulated thermal envelope



### Integrated Truss

**INSULATION:** SPRAY FOAM or CELLULOSE

**Description:** Prefabricated whole-house truss

**Assembly:** Basic wood frame construction

**Materials:** prefabricated super-structure, standard materials otherwise

**Logistics:** Transportable by road or barge. Air transport may be possible depending on design.

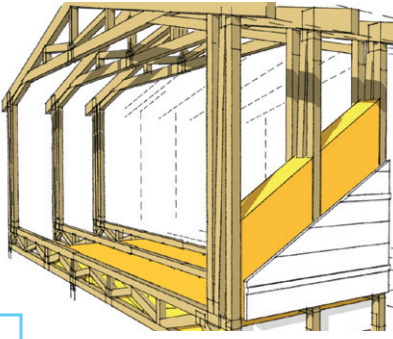
**Construction:** year round possible (potentially limited by use of spray foam)

**Cost Factors**

**Increased costs:** Long shipping distances | logistic size restraints

**Decreased costs:** Road system builds | multiple units (economy of scale)

**Benefits of design:** Rapid construction time, less labor required



\* Fast assembly time

Figures 0.3 and 0.4 (Left) A sample page from the State Disaster Housing Matrix. The Matrix provides basic schematic information on different foundation, structure, wall assembly, and logistical approaches and their relative applicability to different disaster response scenarios. The Integrated Truss Assembly (Left) is the subject of this construction manual.

## The Integrated Truss Home

One of the most successful design packages to come from the Disaster Housing Matrix is the Integrated Truss Home. This design technique was originally implemented in Crooked Creek, and has since been adapted and vetted in the communities of Atmautluak, Buckland, Quinhagak, and Galena. In order to help construction crews and homeowners evaluate this building technique, DHS&EM funded the creation of a ready-to-build architectural plan set, as well





as this construction manual. The Integrated Truss Home has found widespread success in disaster relief scenarios because:

- It is compatible with various foundation types.
- It can be assembled extremely rapidly.
- The thick walls allow for various levels of insulation in different climates.
- The insulation is applied such that it creates a monolithic thermal and air barrier with no thermal bridging.
- The standardized shape of the trusses allows for various homes of various square footages and floorplans to be constructed with minimal changes to the design.

The following chapters of this manual will address the building processes involved in the Integrated Truss Home. In addition, the manual will address certain design variations that may be encountered in application of the technique to different areas of the state. While this design is simple to build, the intended audience for this construction manual are the foremen and superintendents who will be leading construction crews or advising homeowners in rebuilding efforts after a disaster.



*Figure 0.5 Integrated Trusses are staged for the start of construction in the Yukon River village of Galena.*



*Figure 0.6 Trusses are tipped-up without heavy equipment by an all-local crew and one CCHRC Instructor in the Yukon/Kuskokwim Delta village of Atmautluak.*



*Figure 0.7 A modified version of the Integrated Truss with eave window placement between trusses in the Northwest Arctic Village of Buckland*



*Figure 0.8 A small Integrated Truss efficiency cabin built by volunteer labor to replace a home destroyed in the Upper Kuskokwim village of Crooked Creek.*

## House Plans and Materials Package

Please note that plans and a full materials list for the design are available at [cchrc.org](http://cchrc.org).





# Foundation Options

## Overview

Foundation design in Alaska is site specific. Due to the many variables inherent in foundation design, it is beyond the scope of this construction manual. Discontinuous permafrost can and will destroy conventional foundations. Heat transfer from the building to unstable soils underneath can cause the soil to heave and slump, compromising the structure and leading to premature building failure. Generally, the most economical solution is to isolate the building from the ground by raising it several feet using post and pad construction or by using driven piles. Elevated foundations are especially common in areas subject to flooding. A structural engineer will need to consider site-specific issues including but not limited to applicable codes and structural design considerations for soil type, weather, and wind and snow load conditions. **This manual assumes that a foundation has been engineered by a licensed engineer familiar with the specific site.** From that point, the manual will outline construction beginning at the beams that rest atop the foundation. It is important to note that foundation design and construction, especially on permafrost or in remote communities, takes considerable lead time. Due to the short building season, it is important in disaster-response situations that the foundation system be selected and staged well ahead of the rest of the construction process. **A full analysis of methods for selecting the appropriate foundation for replacement housing can be found in the DHS&EM Disaster Housing Matrix Document.**



Figure 1.1 The Integrated Truss home in Crooked Creek rests on Glu-lam beams fastened to cribbing with hold-down connections. The cribbing rests on a built-up gravel pad that has been properly compacted.



Figure 1.2 Steel piles welded to steel wide flange beams keep a replacement home above the 100-year floodplain in Galena. The Integrated Trusses will be erected atop the wood double top plate.



Figure 1.3 Glu-lam beams in Atmautluak are connected to steel piles via an adjustable saddle bracket. The bracket allows for the occupant to re-level the home should any changes in the permafrost create movement in the foundation.



Figure 1.4 In Buckland, the Integrated Trusses are mechanically fastened to treated grade beams on a built-up gravel pad.



# Beams

## Beams

Within the scope of this manual, two different beam scenarios will be outlined. Scenario One will outline the sequence and considerations for framing the Integrated Truss Home on glu-lam wood beams. Scenario Two will outline the sequence and considerations for framing on wide-flange steel beams.

### Scenario One: Glu-Lam Beams Sequence and Considerations

1. Begin by taking field measurements of pilings. Using graph paper sketch a foundation layout (pilings, cribbing, etc); include measurements between pilings and measurements for diagonals to determine square. The information gathered at this stage will be used later to help determine which sides to square using the Pythagorean Theorem.
2. Establish a uniform starting height.
3. Mark the midpoint on each side of the center supports. This is the point on those supports where the two beams in that row will meet end to end. This is a critical location for proper support.
4. Using a builders level bring the base of each support to the same elevation (See Figure 2.1).
5. All hands on board, lift beams into place. The center midpoint of the beams should be aligned with the previously marked spot on the center support (See Figure 2.2).
6. After all beams are set, fasten the beams at the center midpoint to the foundation as per engineering plans.
7. Using the information gathered on the graph paper determine which eave side of the home will be squared with gable back end (the end opposite of the entry deck).
8. On the selected gable end square off the ends of the beams. Note: some beams may not need to be squared. Remove the minimum amount of material to square the ends.
9. After the ends of the beams are squared measure in 12" from the end and draw line across the top of each of the three beams. This line is parallel to the end.
10. On the selected eave side tack a 2x4 block at the far ends of this beam (previously two beams and now joined at the center midpoint) along the top outside edge of this beam. Note: do not drive the nails home, leave at least 1" showing.
11. Run a string line fastened to nails between the two blocks. Note: this string must be taut and touching the wood blocks along the surface. The purpose of this exercise is to form a straight line from one end to the other along the top edge of this beam.
12. Using a third wood block go to the midpoint where the beam(s) are joined and slide the wood block along the surface of the beam and behind the string line. The block must slide between the beam and the string line. If the block touches the string or if there is a gap between the block and the string line then the beam must be adjusted accordingly to achieve a straight line. Adjust the beam by tapping the base plate in or out as needed.



13. Using a tape measure (minimum 30') and a pencil measure mark 20' along the top outside edge of the eave beam starting the line drawn 12" in from the end of the beam.
14. Using the tape measure and pencil mark 15' along the 12" line drawn across the top of the end beams starting at the same point as the 20' measurement.
15. Hold one end of the tape measure on the 15' mark and measure the diagonal distance to the 20' mark. The desired distance is 25' (a right triangle) for the two sides to be squared (90 degrees).
16. If the measurement is more than 25' then the center beam must be driven with a sledge hammer towards the porch side until the desired distance is achieved. If the measurement is less than 25' then the beam must be driven towards the back side until the desired measurement is achieved.
17. Next run a string line across the tops of the three beams over the previously drawn 12" line. If the string line covers all 3 pencil lines the building is square. If the string does not cover the line on the center beam then the beam on the opposite eave must be adjusted north or south in order for the line to cover the center beam. Note: do not move the eave beam previously straightened or the center beam as they are already square.
18. When the back gable (all 3 beams) is square to the selected eave beam then fasten the eave beam to the foundation. Fasten to the foundation on the back gable end of the other beams. Use fasteners specified in the plans.
19. Next adjust the center beam to be parallel to the selected eave beam. Use the measurement between the supports on the end already squared. Adjust the center and opposite eave supports.
20. Measure from the center beam to the opposite eave beam and adjust the center and opposite gable support to achieve parallel to center beam.



*Fig 2.1* Using a builder's level, the base of each crib/pile/etc is brought to the same elevation.



*Fig 2.2* All hands on board, the beams are lifted beams into place. The center midpoint of the beams should be aligned with the previously marked spot on the center foundation supports.





*Fig 2.3* Squaring the foundation. Do not assume that the driven piles are square.



*Fig 2.4* In this particular adjustable foundation design, the brackets are fastened to the glu-lam beam using carriage bolts or structural log screws, and the structure is brought to level using a wrench. In non-adjustable foundations, this will not be necessary.



*Fig 2.5* Once the beams are square and level, the bottom plate of the bracket assembly is welded to the top of the steel pile.



*Fig 2.6* The cut ends of the beams are treated with a water seal coating. The long edges of the windward sides of the beams may also be water sealed to ensure the glu-lam's longevity. This should be repeated every 2-3 years.



*Fig. 2.7* Depending on the height of the foundation, lateral bracing may be required. This bracing is assembled with mechanical connections to a welded tab on the steel piles and to the glu-lam beams. In adjustable foundations, bracing will need to be unconnected during future re-leveling of the home.



*Fig 2.8* If lateral bracing is required, it should be applied along both axes of the home.



## Scenario Two: Steel Beams Sequence and Considerations

1. Once the I-beams are set, squared, and fixed in place, lay an isolation membrane on the top flange of each I Beam. This membrane prevents the wooden sill plates from coming in direct contact with steel. The membrane should run the entire length of each beam and can consist of tar paper, strips of self adhering flashing such as Grace Ice & Water shield, rolls of foam sill sealer, or similar.
2. Cut sill plates to length and place on top of I-beams. Plates can be centered over the flanges of the beams. Areas that will be covered by decks and exposed to the weather will require treated wood plates, however plates under the house may use untreated fir lumber. Verify plate material selection with plans. Plates may need to be doubled up to provide adequate attachment for the hurricane ties/seismic anchors that connect each truss to the plates. Verify with plans.
3. Clamp plates in position and drill holes for bolted connections through the plates starting the drill from underneath the top flanges of the beams, using the pre punched holes in the beam flanges as a guide. Remove any shavings that may have lodged between the beams and the plates and then bolt the plates into place.
4. Once the plates are bolted down, truss layout can be placed on all three plates. NOTE: The beams (and plates) as they sit on the pilings may be neither square nor parallel, however it is critical that the truss layout be square and that the last gable end truss on the on the end of the house with no deck rests on all 3 beams.
5. The trusses are designed with specific bearing points over the beams in order to adequately transfer structural loads from the house to the foundation. The location of these bearing points and the amount of truss overhang beyond the outer beams must be verified with the plans.
6. One approach to locating the house on the beams is to establish visual and measurable reference points by nailing 2x4's cut to the width of the house across (perpendicular to) the beams. The outer edges of the 2x4's will represent the outer faces of the gable end trusses. The 2x4's are to be spaced the length of the house apart as measured from outside edge to outside edge. With the 2x4's nailed or clamped in place straight, use the Pythagorean theorem and/or diagonal measurements between the corners of the 2x4's to ensure the last gable truss has full bearing on all three plates. Adjust the 2x4's side to side and front to back as needed to square the house and to ensure the last truss bears fully on all three beams.
7. With the 2x4's located in their final position and clamped square and parallel, mark the location of the gable end truss on each plate by tracing along the outer edge of the 2x4's.
8. IMPORTANT: Assuming the beams are braced and stable, before removing the 2x4's, use the Pythagorean theorem to snap a chalk line down the length of one of the plates. In other words, this chalk line should be square to the gable end of the trusses as referenced by the outside edge of the 2x4's at each end. The chalk line can be then be reinforced with pencil to resist weather as it will later serve as a measurable reference to ensure the individual trusses are installed straight and square to one another.
9. With the 2x4's removed, use the gable end truss layout on the three beams as a starting point and lay out all remaining trusses on the plates as well as the locations of the deck joists at the far end. **Verify with the plans the distance of the second (inner) gable end trusses from the outermost on each end as this layout will not fall on the same 2 foot centers as the field trusses.**
10. With the truss and deck joist layout placed on all beams and verified for square, truss raising and deck construction can begin.





*Fig 2.9* Plates can be centered over the flanges of the beams. Areas that will be covered by decks and exposed to the weather will require treated wood plates.



*Fig 2.10* Hold-Down connection for the steel beam scenario requires double sill plates.



*Fig 2.12* Hold-Down connection for the glu-lam beam scenario.



*Fig 2.11* Cut sill plates to length and place on top of I-beams.



# The Integrated Truss

## Overview

The Integrated Truss is engineered with four primary design criteria in mind:

1. To carry all of the structural loads of the roof, walls, and floor in one prefabricated assembly.
2. To create a thick cavity that allows ample space for high R-value insulation in cold climate homes.
3. To provide a protected chase for mechanical equipment as needed.
4. To speed construction in remote northern villages with extremely short building seasons.

The integrated truss is a single structural framing unit that combines the exterior walls, floor joists, and roof into one structural assembly. The assembly is tipped up either by hand or with the aid of a boom, greatly accelerating the speed of construction. The integrated truss system allows the home to be framed in a single day. The truss design lends itself easily to a super-insulated envelope, as the depth of the walls, roof, and floors are scaled to accommodate more insulation. The structural requirements of the trusses make them deep enough to fit a very high R-value of insulation with enough remaining uninsulated warm space to run wiring and mechanical systems. Since each element of the truss (walls, floor, and roof) is comprised of an inner and outer chord with webbing in between, conductive heat loss due to thermal bridging is greatly reduced.

The integrated truss is assembled in a factory setting (truss plant) to guarantee uniformity and compliance with engineering specifications. The trusses are then shipped via barge to the community. For communities on the road system, the trusses are designed to conform to height and length requirements for highway transportation.

The trusses are designed in three or four profiles. Each profile has identical exterior dimensions, but different interior geometry. The 'field' profile is the most numerous, and forms the main living area of the home. There is a profile for each of the two gable ends. The gable profiles incorporate door and window rough openings. It should be noted that the gable profiles, like the field profiles, are assembled with dimensional lumber on the flat as is typical for roof truss construction, instead of on edge as in traditional stick framing. There is also an optional fourth profile in certain models with a drop floor for an Arctic Entry. This dropped floor forms a passive cold trap at the entrance to the home that saves on heating demand.

## Sequence and Considerations

1. Refer to the house plans and verify the truss overhang distance beyond the outside beams on the eaves, and the truss bearing points over the beams, as referenced in the applicable section of the Beams chapter (I beams or Glu-lams). Note the overhang distance on both gable ends as required to install the trusses square to one another. Be aware the overhang distance may not be the same on either end relative to the beams. What is important is that the trusses are installed square to one another as described in the respective layout portion (I-beam or Glu-lam) of the beam chapter. The end overhang distances will be needed to ensure the proper location of a string line at each gable end location to ensure the trusses are installed straight and square. Alternatively, a chalk line can be snapped along the length of one of the plates before the trusses are set. If this chalk line is parallel to the outside edge of the trusses and perpendicular to the gable ends, it can serve as a measurable reference to ensure the individual trusses are installed straight and square. See beams chapter Scenario 2, Step 8.



2. Cut and assemble shear blocking as per the plans to be attached to each truss during truss erection. In high-wind areas, shear panels may be required by an engineer. Check the plans to see whether shear panels are required on the building. If so, they may be constructed and attached before tip-up, or after the trusses are laid out and plumb, as per the contractor's preference. (See Figures 3.18 and 3.19).
3. Stack the trusses in the order of erection. Site access, worker safety, and foundation height will determine whether the trusses are raised from front to back or back to front. In some cases, particularly if heavy equipment is available, it may be feasible to pick and set the trusses starting from any point within the stack, provided the trusses are staged in the appropriate raising sequence.
4. The Simpson Strong Tie structural truss spacers included in the materials package are enough to complete four lengthwise runs (36') of bracing. These braces are to be used as needed to stiffen the outer chords of the roof and wall sections during truss erection (See Figures 3.10 and 3.11).
5. Pre-cut and construct gable end rake overhangs with appropriate sized 2x framing stock. Do not install at this juncture (See Figure 3.9).
6. If the trusses rest on Glu-Lam Beams, install 2x blocks on the back end (opposite the porch end) of the laminated beams. These blocks should extend a minimum of 6" above the top of each beam. The blocks will prevent the first gable end truss from kicking out or sliding off the top of the beams during erection (See Figure 3.7).
7. In a steel beam arrangement, a plate of drilled steel or plywood can act as a stop for the first truss. The L-Plate can be attached to the double top plate and keep the truss from kicking out. (See Figure 3.8)
8. Install dead man anchors on the ground and in line with the beams on the back end of the home if truss erection begins from this end (See Figure 3.6). If the trusses are raised starting from the deck end, then the deck framing (if completed) or the deck sill plates may serve as anchor points. Ultimately, when all trusses are raised, the structure should be braced from both ends as described above to protect against racking forces from either end.
9. Prepare to install trusses: have adequate 16' 2x4's available for bracing and push poles as needed to position and brace the first truss.
10. Place first gable end truss on top of beams. Truss should be laid flat. Slide truss left or right as necessary to attain proper bearing and overhangs as determined during the layout stage. Reference marks may be drawn on the truss bottom chord to aid in side-to-side alignment with either a string line or chalk line snapped square between the gable ends on top of a plate.
11. Install pre built gable end rake overhang with truss laid flat (See Figure 3.9).
12. Install precut/built structural blocking to truss underside. If Simpson Strong Ties are to be used, have them available for installation with second truss.
13. With the truss laid flat, attach push poles (3) to underside of truss and attach diagonal braces (3) to the top-side of the truss with one brace as close to each beam as possible. If trusses will be raised using equipment, push poles may not be required.
14. Erect truss. (See figure 3.13)
15. Using a 6' to 8' level, plumb to the truss at the three locations where the diagonal braces are attached to the truss. Nail off the braces and toenail the bottom chord of the truss to the beam. Note: make sure that the truss is properly spaced from the edge of the beam/sill plates to maintain square. **Proper erection, leveling, and spacing of the first truss are critical.** Make sure to refer to layout, as gable end layout is different than field truss layout for desired wall thickness.
16. With the first (outer) gable truss set and braced, proceed to the location of the last gable truss. Install a 2x4 on the flat at this location with enough overhang to allow attachment for a string line that can be used set all remaining trusses in their proper location. Brace 2x4 as needed to resist string tension. It may be easiest if the string line is hung and stretched slightly below the bottom chords of the trusses so as not to interfere or





get bumped during the raising process. All subsequent trusses can be marked at the same reference point along the bottom chord to allow for easy alignment over the string line. Alternatively, a chalk line parallel to the outside edge of the trusses can be snapped on the plates before the trusses are set and used as a reference. The key is to create a means of reference to ensure the trusses are installed square.

17. Continue raising and bracing trusses. Install Diagonal braces along the inside and outside of the exterior wall as necessary for stability. Refer to plans and install structural blocking between each truss before erection as needed. Typically, it is easiest to nail any structural blocking to the leading face of each truss before it is raised. Installing the blocking in this manner is safer, saves labor, and helps strengthen the frame during erection.
18. When raising without equipment, the use of a come-a-long may be necessary to erect last 2 to 4 trusses on the far end of the home.
19. Be sure to continuously check layout as the trusses and blocking are added to the assembly in order to ensure that all trusses continue to land on proper layout. Spreader boards with truss layout and Simpson structural braces can help to maintain layout.
20. Once the frame raising has been completed, it is critical that sufficient temporary cross bracing be installed to allow safe installation of the roof sheathing, and to protect the building from any potentially destructive wind forces.

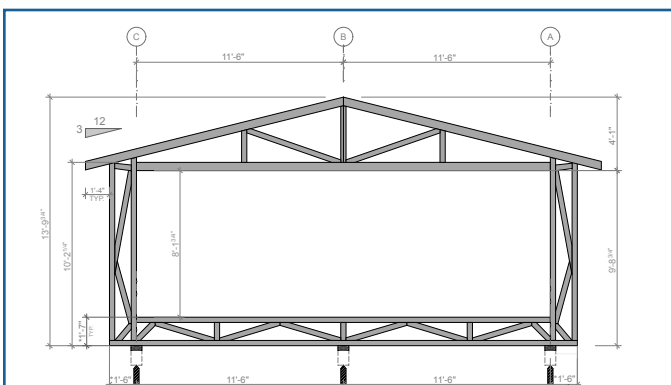


Fig. 3.1 Truss Profile A: the Field Truss

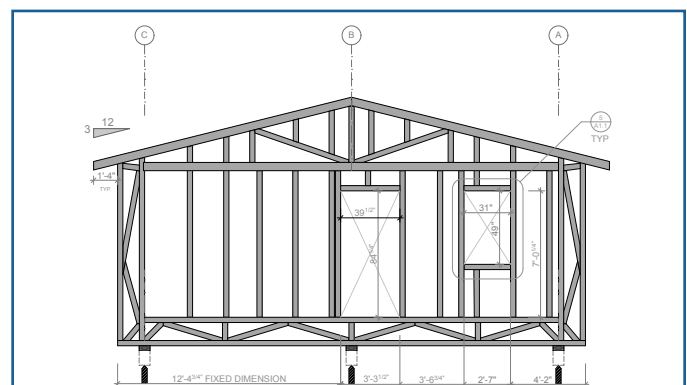


Fig. 3.2 Truss Profile B: the Front Gable End Truss

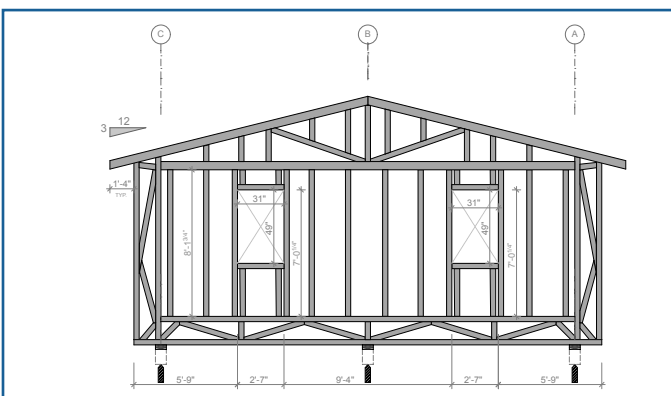


Fig. 3.3 Truss Profile C: the Back Gable End Truss

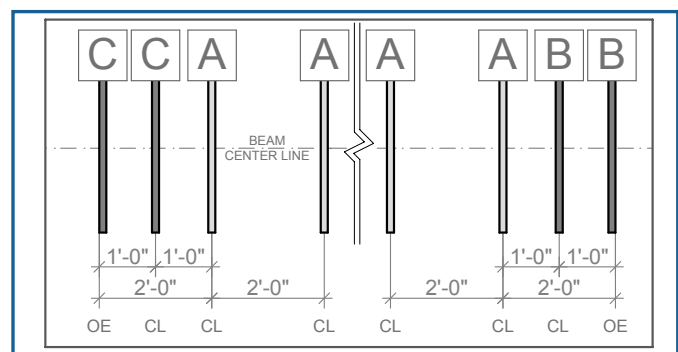
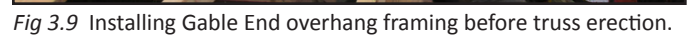
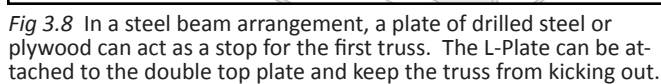
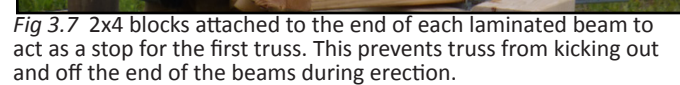
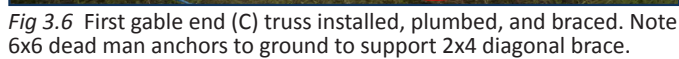
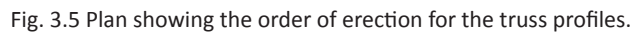


Fig. 3.4 Truss layout outlining the spacing of Gable End trusses in relation to Field Trusses





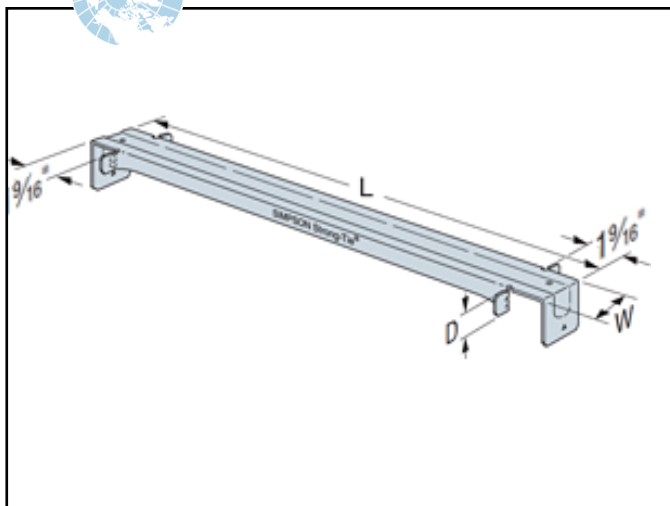


Fig 3.10 To ensure equal spacing of trusses, prefabricated spacers will keep the trusses on layout. Strong-Tie. REPRINTED FROM THE SIMPSON STRONG TIE CATALOG.

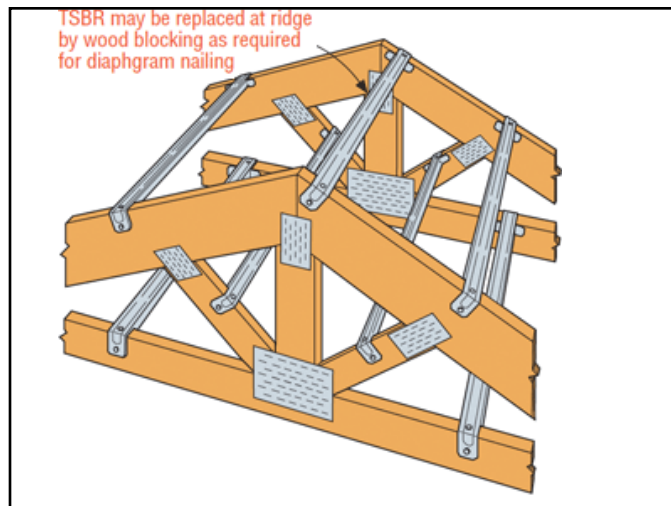


Fig 3.11 Truss spacer arrangement by Simpson Strong-Tie. REPRINTED FROM THE SIMPSON STRONG TIE CATALOG. The prefabricated pieces ensure even layout.



Fig 3.12 If prefabricated spacers are unavailable, they may be made with dimensional lumber on site. 2x blocks pre-installed on each truss to assure proper spacing (12"OC or 24"OC). PRE-INSTALL ALL BLOCKING BEFORE RAISING THE TRUSS.



Fig 3.13 Erecting trusses using 2x4 push poles.



Fig 3.14 Trusses installed. Note: Plumbing each truss is not necessary if first truss is installed correctly.



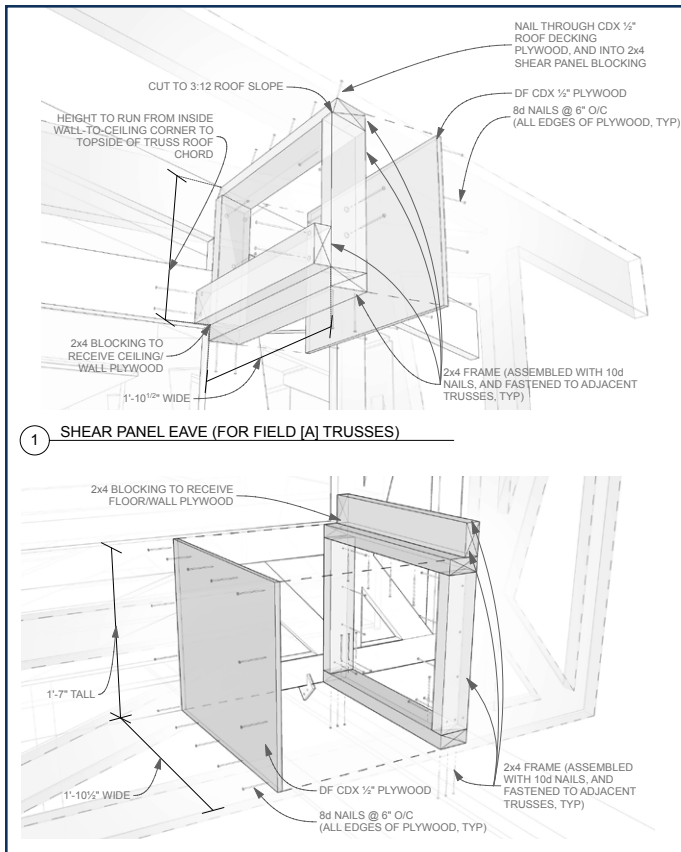
Fig 3.15 There are many methods to brace the trusses, depending on the type of foundation and beam support. It is important to have the trusses properly braced to maintain a safe work site.



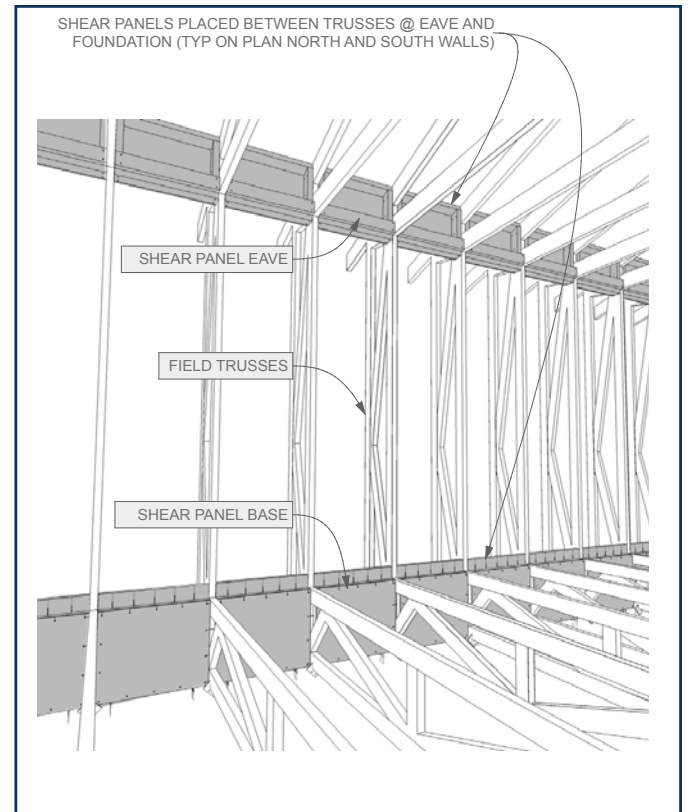
**Fig 3.16** Trusses  $\frac{3}{4}$  installed. Note diagonal bracing with 2x4s. In this early version, shear panels were not required in this region. Check the plans for shear panel blocking requirements.



**Fig 3.17** Truss and bracing installation complete.



**Fig 3.18** Shear panel construction guides



**Fig 3.19** Shear panel construction guides





# Sheathing of Roof, Floors, & Walls

## Overview

At this juncture, with the structure framed and securely braced plumb, level, and square, the next steps are to sheathe the roof and the floor. In general, the sheathing will provide additional stability to the structure, while sheathing the roof as soon as possible will protect the structure from the elements. The trusses must be dry before spray foam insulation can be applied. Depending on the available equipment and site conditions, the order of events involving the sheathing process can take place in several ways. If the equipment exists to load the sheathing on the roof, then roof sheathing can begin immediately and is not dependent on the floor sheathing being in place. Given the height of the structure above grade, if the sheathing must be carried manually to the roof, it will be easiest and safest to install the subfloor first as it will allow workers to stage ladders and materials inside the structure and then pass them up through the trusses to the workers above. If the floor will be insulated from underneath, the subfloor can be installed permanently. If the floor will be sprayed from above, the subfloor will either need to be installed temporarily, or just enough subflooring will need to be laid out to provide a safe working surface for those workers passing materials to the roofing crew.

**CAUTION:** When staging the sheathing on the roof, particularly when using equipment, be aware that a 4x8 unit of sheathing can weigh upwards of 3,000 pounds. This can place a tremendous load on only a few trusses in a structure that is not braced and sheathed to its full structural capacity. Consequently, it is much safer to stage the roof sheathing in smaller piles spaced around the roof to distribute the loads more evenly. Keep in mind that during the roof sheathing process, the structure will have to withstand the active loads generated by workers moving and installing sheathing on the roof deck. It is critical that the structure be diagonally braced internally and/or externally to resist racking.

## Roof Sheathing

1. Plywood roof sheathing will be installed with a 1 ½" overhang along the eaves and at the gable ends. The overhang will be nailed to the sub-fascia and sub-rake at a later date (See Figure 4.6).
2. Measure up the roof slope 46 ½" from the end of the rafters at each gable end, mark, and snap a chalk line. Plywood is to be applied across the top chords to the chalk line. Plywood will overhang rafter tails by 1 ½". Gable end starter sheets will need to be trimmed to fall on 2' OC truss layout such that the factory edge of the sheet lands on the center of a roof field truss.
3. Verify fastener size, type, and spacing with plans. (8d galvanized ring shank typ.)
4. Once the roof sheathing is completed, the self-adhering roofing underlayment can be installed on the roof deck (See Figure 6.1). Note: To promote proper drainage, the eave flashing (drip edge) must be installed between the plywood and the self-adhering membrane. As a result, it will either be necessary to install the sub fascia and the drip edge (recommended) before applying the roofing membrane, or leave an ~ 8" strip of backing on the bottom edge of the membrane until the drip edge is installed. Cover plywood roof sheathing with ice and water shield as per manufacturer's instructions.

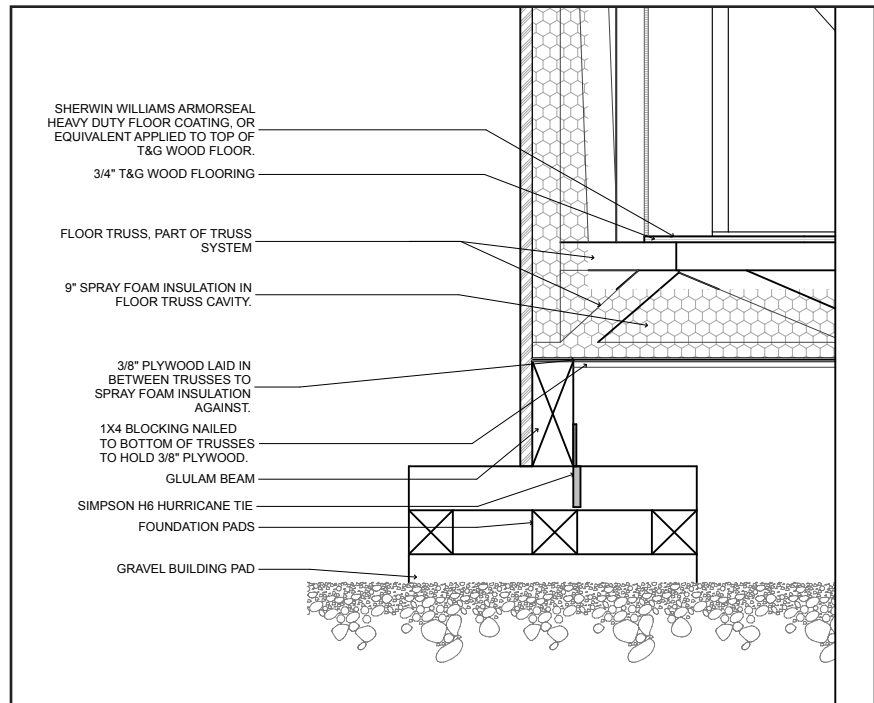


## Floor Sheathing

### Option 1: Install under-floor sheathing and insulate from above:

When insulating the floor, it is typically more desirable to apply the foam from above than from below. If the foam is sprayed from above and against the under-floor sheathing, then the remaining air space (8"-10" typ.) between the top of the foam and the underside of the subfloor will become part of the heated enclosure and thereby provide a heated space to safely route plumbing waste and supply lines under the floor. Since the entirety of the floor will have a large air space between the top of the insulation and the subfloor, supply and waste connections can be routed in any direction desired with much less difficulty than would be encountered when building plumbing chases and insulating from below. In order to insulate from above, it will be necessary to either temporarily install the

*Fig 4.1* Typical foundation detail showing 1x4 blocking to hold plywood for option 1: spraying insulation from above.



subfloor while the roof work is taking place and then remove it to spray insulation in the floor, or install just enough subflooring and/or planks so the sprayers can access all areas of the floor comfortably. To make the spraying easier for the installer, it may be convenient to have a laborer on hand who can move planks around as needed so the spray crew can remain focused on the task of insulating

### Option 2: Install subfloor and insulate from below

If the spray foam insulation in the floor will be sprayed in from underneath (less desirable), then the subfloor will need to be installed first. Install any remaining shear blocking as per plans. Where the subfloor sheathing butts against the inside face of the inner gable truss, consider notching the sheathing by  $\frac{3}{4}$ " around those areas where the vertical (wall) truss chords intersect the top chord of the floor truss such that the sheathing lands on the center of the truss. An additional piece of subfloor sheathing can then be notched and fitted to carry the subfloor out to the outer face of the first gable truss. The goal is to provide a continuous subfloor against which the foam can be sprayed from below. This includes the space between the inner and outer gable trusses on each end of the house.

**NOTE:** When insulating from below, it is necessary that all the in-floor plumbing (waste and supply lines) be installed beforehand, once the subfloor is in place. A chase will need to be framed around all plumbing lines before the foam



*Fig 4.2* Applying construction adhesive to the top chord of each floor truss prior to the installation of the plywood subfloor. In this scenario, the insulation will be sprayed upwards from below.



*Fig 4.3* In this scenario, insulation was sprayed from above. Subfloor is fastened permanently in place after spraying is complete.

is sprayed to ensure that the lines remain inside the heated envelope and that no spray foam can come between the lines and the subfloor.

If feasible, it will also be easier to locate and install any additional systems that must pass either through or in the joist bays before the foam is sprayed, as installation and good air sealing will be more difficult after the foam is in place. This would include combustion air ducting for the wood stove and the passive makeup air stack behind the fridge

## Exterior Wall Sheathing

Install ½" plywood jambs on all four sides of each window and the exterior door opening (See Figure 4.8). These jambs are installed flush to the exterior and interior framing surfaces. Install side jamb extensions first in order to minimize potential distortion from closed-cell foam insulation.

The outside of the exterior wall is to be covered with a weather barrier membrane such as Tyvek House Wrap (See Figure 4.7). 10' wide rolls should cover the eave walls in one pass. The height of the gable end walls will require using several passes of house wrap. Tape and seal overlapping seams of house wrap with polyethylene (Tyvek) tape. The house wrap serves as backing when the foam is applied from the interior and provides a weather barrier behind the siding. The house wrap should be installed with staples and then 1x stock is fastened vertically over the house wrap to the vertical edge of each truss (See Figure 4.5). The vertical 1x4 furring serves as a rain screen, but it also clamps the house wrap securely so that it cannot tear loose when the foam is applied against the back side.

**Note:** All edges of the house wrap must be adequately secured to resist tearing loose when the spray foam insulation is applied from the inside. On the eave walls, a row of 2x10 blocking at the top and 2x6 blocking at the bottom provides solid backing for a closely spaced row of staples so that the foam cannot pull loose in these areas. The top and bottom edges of the house wrap on the gable ends will need to be secured in a similar fashion using closely spaced rows of staples.

At the window and door openings, the house wrap can be trimmed flush around the opening. When the self adhering flashing is applied inside the window box, it will lap over the house wrap at the edge of the window to provide a continuous drainage plane. The insides of the window boxes should be flashed after the house wrap is installed, but before the 1x4 furring strips are installed around the window opening.





Fig 4.4 Roof sheathing installed on one side of roof. Note plywood for the other side of the roof stacked on the subfloor.



Fig 4.5 Installing 1x spacers for rain screen.



Fig 4.6 Plywood sheathing extends 1 1/2" beyond top chord of roof truss. It will cover top edge of 2x sub-facia.



Fig 4.7 Tyvek rain screen and 1x spacer blocks installed over the exterior chord of the wall truss.



Fig 4.8 The sheathing for the window jamb is installed after the rain screen is completed.





Fig 4.9 Outside corner of spacers attached.



Fig 4.10 Installing insect screen at bottom edge of the building, allows air movement, prevents insect infiltration.



Fig 4.11 Installed metal siding. Note siding is held 1" below bottom chord to hide edge of 3/8" plywood that will form the underside sheathing after the floor is insulated from below.



Fig 4.13 Installing siding. Siding is held off the corners and a 90-degree trim will cover the joints.



Fig 4.12 Installing siding. The siding is oriented horizontally for less cuts and to allow lateral ventilation of the rain screen. The upper course overlaps the lower.



# Windows and Exterior Doors

## Overview

The windows are vinyl clad triple glazed casements and fixed lite units. Windows are of the flangeless type that is attached inside the window rough opening rather than attached to the exterior via nail fins. Consequently, the windows will receive an interior and exterior jamb extension. The exterior door will open to the interior and come with factory installed jamb extensions sized to the finished opening depth of the gable end wall.

## Sequence and Considerations

1. Eave wall windows are designed and to fit between 24" on center layout trusses. Window openings are to be lined with  $\frac{1}{2}$ " plywood and windows should be sized to fit inside this rough opening (See Figure 5.1). Verify eave wall window heights with plans and/or measurements taken from gable wall window heights, which are fixed. Note that kitchen window height may not be the same as the others in some cases. The plywood window sill should be sloped approximately  $\frac{1}{2}$ " to the exterior to facilitate drainage. In order to attain this slope, the 2x4 block between the trusses at the exterior sill must be dropped accordingly.
2. Gable wall window widths and heights are predetermined by the rough openings framed in the gable trusses. Like the eave wall windows, the gable wall window rough openings are to be lined on all 4 sides with  $\frac{1}{2}$ " plywood. In this case, the plywood extends flush to the interior face of the inner gable truss. In order give the sill plywood the proper slope to the exterior, the 2x4 truss framing that supports the outer sill must cut down in place by approximately  $\frac{1}{2}$ ".
3. Once the gable and eave wall window rough openings have been wrapped in plywood, and the exterior house wrap has been installed and trimmed around the window opening, the window openings can be flashed using a self adhering flashing/membrane (See Figure 5.7). Note that self adhering flashings are pressure sensitive and the bond between the membrane and the plywood will be stronger if the membrane is pressed into place using a rubber laminate roller or similar. The membrane should extend completely to the interior of the window rough opening, as this will protect the rough sill not only from weather, but also potential window condensation from the interior. Once the rough openings are flashed, the windows can be installed.
4. **IMPORTANT:** Determine the location of the window in each rough opening by measuring the depth of the pre-built interior jamb extension (with casing applied) AS DELIVERED ON SITE (See Figure 5.2). Note: allow for  $\frac{1}{2}$ " AC plywood wall finish on the inside. Verify that the receiver flange on the window is  $\frac{3}{8}$ " wide by  $\frac{1}{2}$ " deep and then allow for  $\frac{3}{16}$ " of play in locating the window. This will cover any anomalies in the framing. Mark the location of the window in each opening and draw a reference line on each side jamb using a level.
5. Install the windows to the line and fasten in place with screws through the metal flanges located on each window. Plumb and level each window as necessary using conventional methods.
6. Determine the depth of the exterior window jamb extensions. Note that the depth of the exterior jamb extensions will vary significantly between the gable end walls and the eave walls as the gable end walls are thinner. Corresponding widths of PVC jamb material have been supplied depending on the location of the exterior jambs (eave or gable). The jamb extensions are cut and assembled on site using 1x PVC stock. The receiving channel on





the exterior of the window is similar in style to channel located on the interior, however it should be wider to accommodate the thickness of the 1x PVC stock. Even so, the PVC stock may come thicker than the channel and may need to be rabbeted in advance in order to fit into the flange (See Figure 5.4).

7. On the sides and top, the jamb extension must be installed flush to the exterior surface of the 1x stock that has been applied over the Tyvek. The sill of the jamb extension must be installed with a 5 degree pitch to allow moisture to drain away from the window surface and extend far enough outward to cover the metal J-channel underneath which trims the siding.
8. During assembly, the jamb extension is glued at the corners using PVC cement and fastened with galvanized or ceramic coated deck/drywall screws. It will likely be necessary to pre-drill the holes for the screws.
9. Before installing the exterior jamb extension, caulk the remaining gap between the window rough opening and the window (See Figure 5.9). Use backer rod as needed to support the caulking. On the interior, fill the remaining gap around the window with minimal expanding spray foam and trim flush with the inner face of the window once cured. Be sure to foam the gap on the inside before installing the interior jamb extensions.
10. Once assembled, and with the window caulked to the rough opening on the exterior, the jamb extension can be fitted and caulked into the window receiver flange (See Figure 5.6). Note: this jamb extension is not fastened to the plywood frame and it does not have exterior casing applied. Instead, on the sides and the top the siding J-channel extend over the outer edge of the jamb extension and are held flush to the inside face of the finished window opening. Refer to plans for additional details.
11. The exterior door is sized to fit in the finished rough opening. As with the windows, the door rough opening should be sheathed with  $\frac{1}{2}$ " plywood and wrapped in self-adhering flashing with special attention paid to the sill. The door should come with brick mold and can be installed once the exterior 1x4 furring has been fastened around the rough opening. Once the door has been plumbed and fastened in place on the interior, then the brick mold can be fastened to the 1x4 trim on the exterior using corrosion resistant fasteners. Once installation is completed, the gap remaining between the door and the rough opening can be filled with a backer rod and minimal expanding spray foam from the inside.
12. When the insulation contractor is applying the spray foam to the exterior walls, care must be taken around the window and door openings. If the insulation is not installed in 2" lifts or less, it can and will expand to the point where the window and door rough openings become distorted.



*Fig 5.1* Plywood window jambs installed. Note plywood at top and bottom installed after sides to prevent closed cell insulation from distorting jambs.



*Fig 5.2* Pre-built interior window jamb extensions with casing applied. Determines placement of window in opening and dimensions of site built exterior jamb extensions.





Fig 5.3 Site built exterior window jamb extension.



Fig 5.4 Site built window jamb extension rabbeted out to fit into exterior window jamb receiver.



Fig 5.5 Site built exterior window jamb extension. Note the sill extends proud of the wall by up to an inch.



Fig 5.7 Ice and water shield wrap around window rough opening. This photo is not from the Pikat Construction job.

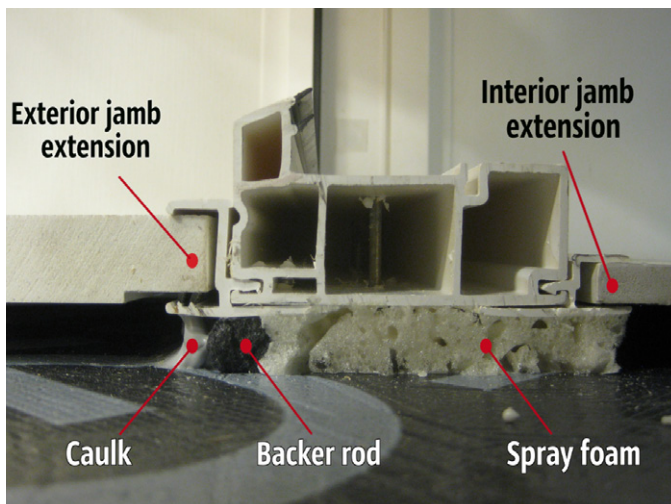


Fig 5.6 cross-section of window sealing from exterior to interior





*Fig 5.8* Installed windows. The impermeable peel and stick membrane is applied flush with the interior face of the rough opening, and the exterior field-built jam extension is in place. Foam air sealing is in place around the rough opening. The interior prefabricated jamb extension with casing will be attached after painting.



*Fig 5.9* Installing caulking at gap between window and framing at exterior face



*Fig 5.10* Reinforced poly covers windows to prevent over spray from closed cell foam insulation from damaging the windows.



*Fig 5.11* Door jamb is detailed with impermeable peel and stick membrane.



# Roof

## Overview

To best ensure durability and longevity in harsh climates, whenever possible all exposed materials should be a durable alternative to wood. On this project the exterior trim, roofing, and siding are coated metal and the windows are PVC. The two exceptions are the exterior door, which has a wood jamb and casing, and the entry deck framing, steps, and rail, which are treated wood. Note: Given site conditions and available staging it may make sense to install exterior trim, soffits, and siding on a particular side of the building before moving to another.

## Sequence and Considerations

1. Exterior Trim: If not previously installed, install specified 2x sub-facia and sub-rake. Install necessary 2x blocking to assure a level soffit and flat level rake overhang (See Figure 6.2).
2. Install specified metal fascia, rake and roof drip edge as per manufacturer's instructions.
3. Note in the plan details that the metal fascia tucks under the drip edge and will hang down past the 2x6 sub fascia the thickness of the soffit. The lower leg of the eave fascia that supports the soffit will be bent to the roof pitch while the gable fascia will be bent at 90 degrees.
4. Install specified soffit and rake overhang material including necessary beads and channels.
5. If gutters are supplied, install at this time with eave flashing.
6. If the lower edge of the self adhering roof membrane still has the backing in place, then remove the backing and apply over the eave drip edge or gutter flashing.
7. Roofing: Determine length from eave to ridge and along the ridge and the eaves. Square the roof on each side.
8. Determine the number of roofing panels needed for each side and pre-cut to length.
9. Review manufacturer recommendations for installation and location of fasteners and install accordingly.
10. Consider making a pattern for all the panels in the field and pre drilling all field sheets using this pattern to speed screw installation and reduce the chance of error.
11. Use 2-sided tape to seal overlap joint between panels (See Figure 6.3).
12. Install rake and ridge covers. Use foam gaskets as specified.
13. Install J-channel around all window and door openings as per manufacturer instructions.
14. Note: To help protect the under-floor sheathing outer edges from weather and improve appearance, the first course of siding on each of the four walls should hang past the bottom of the outer face of the under-floor sheathing a short distance (1" typ)
15. Siding: Taking the amount of overhang into account, snap a series of chalk lines on each wall to denote the location of the leading (upper) edge of each sheet of siding. The chalk lines will ensure that each course of siding will be installed straight and parallel to the other sheets and to the wall.





16. Fasten siding as per manufacturer recommendations.
17. Complete siding installation on one side, overlapping siding as specified. Cut and notch siding around window, door, and other openings as necessary.
18. Complete siding on all sides. Install metal corners with foam gaskets as specified



*Fig 6.1* Installing ice and water shield over plywood roof sheathing.



*Fig 6.2* Installing 2x sub fascia.



*Fig 6.3* Metal roof installation. It is important to comply with the fastener schedule provided by the metal roof manufacturer. Note 2-sided tape at roof panel overlap.



*Fig 6.4* Installing metal roof ridge cap and inside closure pieces to keep rain from getting under the cap.

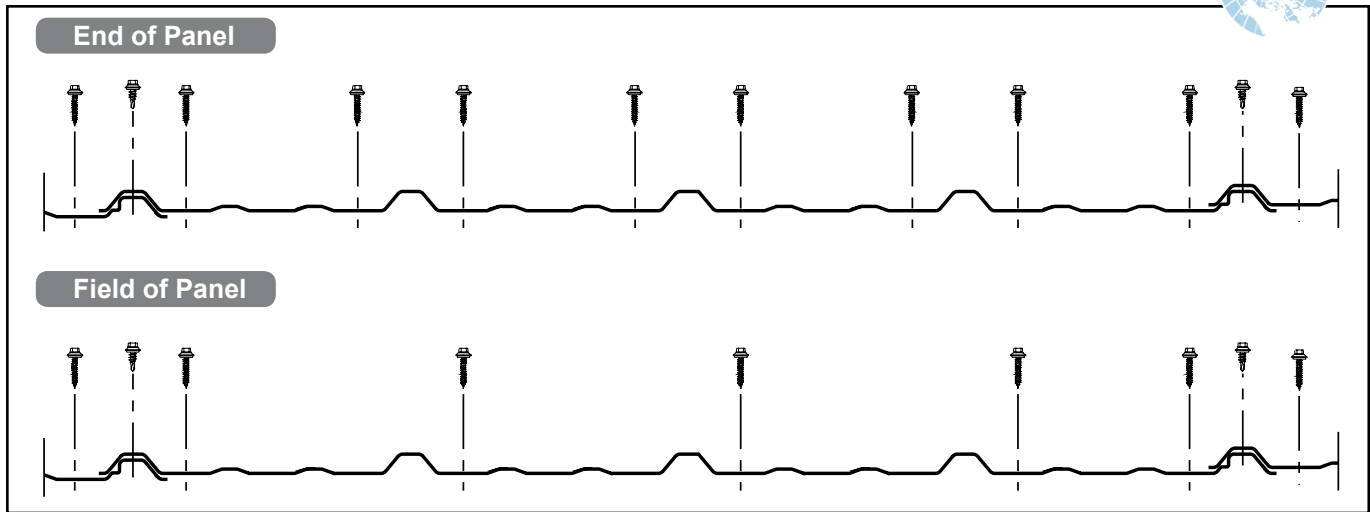


Fig 6.5 Metal fastener schedule for metal roofing and siding. Fasteners are spaced 8"-12" on center. For high wind regions, the closer spacing should be used.

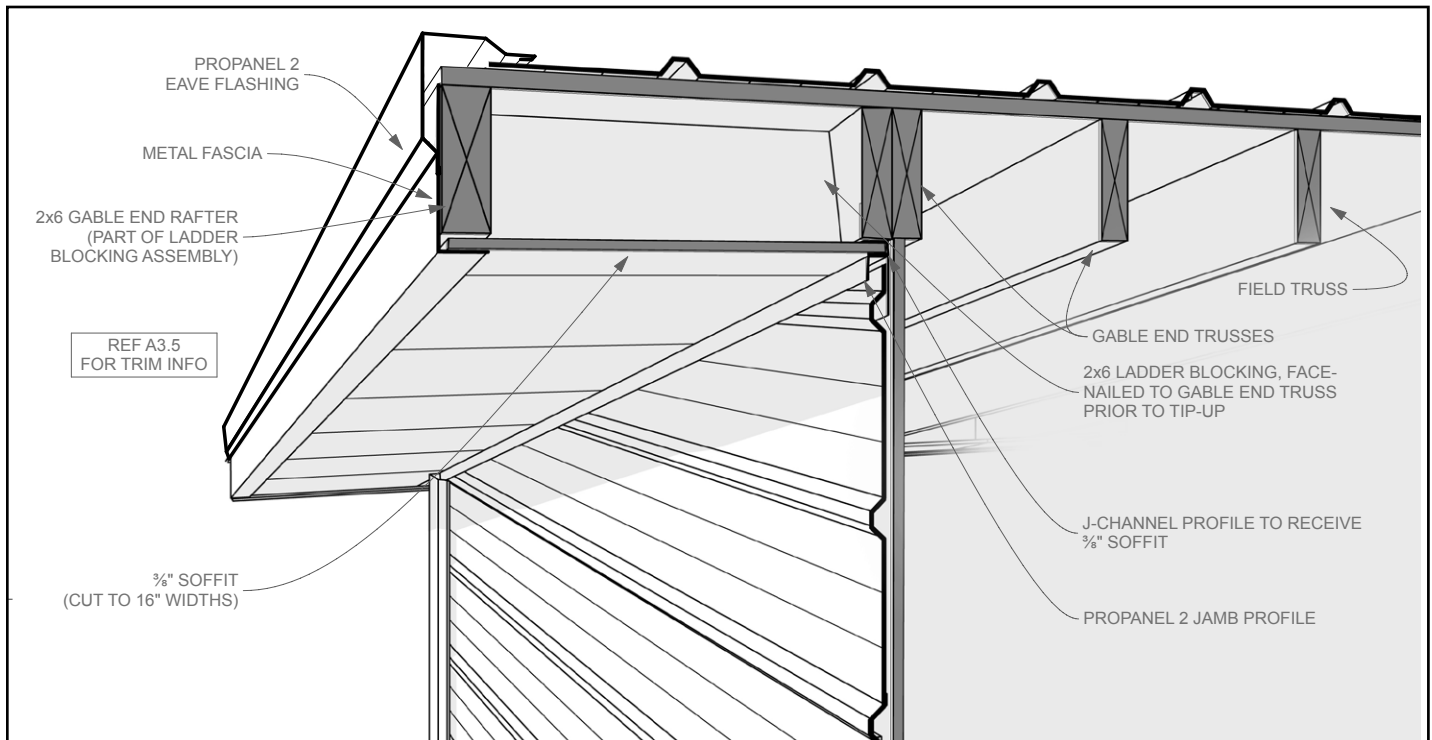


Fig 6.6 Detailing for perforated soffit, flashing, and fascia.



# Insulation and Interior Framing

## Overview

The construction sequence involved in building this type of home offers significant advantages in wet climates. The integrated truss assembly produces a fully dried-in building shell in a short amount of time. Once the spray foam has been applied to all areas of the building shell, the end result will yield an extremely airtight enclosure. Until mechanical ventilation is installed, workers should be aware of the indoor environment and keep the workspace well-ventilated by opening doors and windows, should the temperatures allow.

Once the structure is fully enclosed in a combination of house wrap and sheathing, it will become sufficiently airtight such that the interior can be temporarily heated (if needed) with a large space heater. If the framing and/or sheathing was exposed to rain or high humidity during construction, then the interior should be heated until all areas are dry and can be safely insulated.

If moisture in the framing is not a concern, then the interior surfaces can be brought to a workable temperature relatively quickly. Additionally, the heated enclosure will keep the spray equipment and all drums of insulation product at a temperature-stable environment for the duration of the insulating process. As the spray insulating may take several days, and if outdoor temperatures warrant it, an initial “flash coat” of foam can be applied to all exterior surfaces, allowing the building to hold heat with relative ease for the duration of the insulating process. It is extremely important that the drums and spraying equipment are stored in a warm environment before application. If at any time the drums get too cold or are allowed to freeze, the foam will be compromised and may become unusable.

The foam insulation used in the integrated truss homes is a two part closed cell spray applied polyurethane with a density of ~2lbs/cubic ft. One such product that has been used with success is Demilec’s HEATLOC SOY®. Other foams may also work well, but should have similar properties to the Demilec product.

## Sequence and Considerations

1. Before any spraying begins, it is advisable to perform a final walk-through to ensure that the house wrap is securely fastened in all areas and that blocking and other insulation stops are in place as needed to prevent the foam from spilling into unwanted areas. Cardboard can also be used in non-structural areas that will never be exposed to weather if an insulation stop is needed in an area that requires a complex shape.
2. Cover window openings and doors with 6 mil poly to eliminate foam overspray.
3. Whenever possible it is best to install chimneys and vent penetrations before the foam is sprayed. Installing ventilation ducting and chimney penetrations to the exterior beforehand saves time and creates a tighter and more durable seal than if the penetrations are cut in after the foam has been applied.
4. Caution: Spray foam should be applied in maximum 2” lifts around windows and doors to prevent the plywood around the openings from distorting.
5. NOTE: Around windows and doors, be sure to carry the insulation from the exterior all the way to the interior to cover the outer faces of the plywood boxes entirely at the specified thickness. Doing so will prevent cold spots from forming within the opening (See Figure 7.2).





6. Insulation installed as specified by the subcontractor.
7. The two-part foam comes in 55-gallon drums. The white or blue drums may be cleaned and reused for burn barrels, fuel drums, etc. The red drums contain hazardous materials and should not be reused. The red drums should be taken from the site and destroyed so no community members will use them after the project has finished. **None of the drums should under any circumstances be re-used to hold potable water.**
8. Once the insulating is finished, any mechanical systems, wiring, or remaining vent penetrations should be installed in the exterior walls so that the structural sheathing can be fastened in place. If it is not possible to complete installations in particular area, the structural sheathing covering the spot should only be tacked in place to allow for future access.
9. Determine locations of kitchen cabinets and areas in the exterior walls that will receive an intersecting interior partition and install ladder blocking and backing as needed (See Figure 7.10).
10. The ceiling must also be continuously sheathed to provide unbroken structural shear. **Interior partition framing can only begin once the structural sheathing has been applied to the ceiling.**
11. NOTE: It may not be possible to install all ducting and electrical runs in the attic before the ceiling sheathing is applied. Where feasible, leave a sheet (or sheets) of ceiling sheathing loosely fastened so that it can be removed to allow access to the attic to install ducting and electrical runs later as needed.
12. Once the walls and ceiling have been sheathed and shear nailed/screwed according the plans, interior framing and sheathing can begin.
13. When the partition walls are framed, install blocking for in those areas that will require structural attachment behind the plywood sheathing such as cabinet supports, towel bars, shelves, and closet rods. Once all the blocking has been installed, the electrical, ventilation, and plumbing subs can commence work.
14. Note: Install passive vents behind fridge and any other ducting, wiring, and plumbing, which are required to run in the partition walls. Only after all mechanical systems have been installed can interior wall sheathing and finishing begin. Leave sheets loose (or off) in any areas that will require future access by subcontractors.



*Fig 7.1* Installing closed cell foam. The roof and walls are sprayed in one continuous coat to form a monolithic thermal envelope. The foam is applied in 2" lifts.



*Fig 7.2* Foam installed around plywood window rough opening frame. It is important that the window box have the same thickness of foam as the wall insulation.



Fig 7.3 View of installed closed cell foam.



Fig 7.4 Foam at exterior wall intersection. After application, the excess foam must be removed from the studs so interior sheathing is uniform and flush.



Fig 7.5 Empty foam drums ready for recycling. The blue and white barrels may be cleaned out and re-used as burn barrels. The red drums should be destroyed.



Fig 7.6 Lay out interior walls with chalk line.

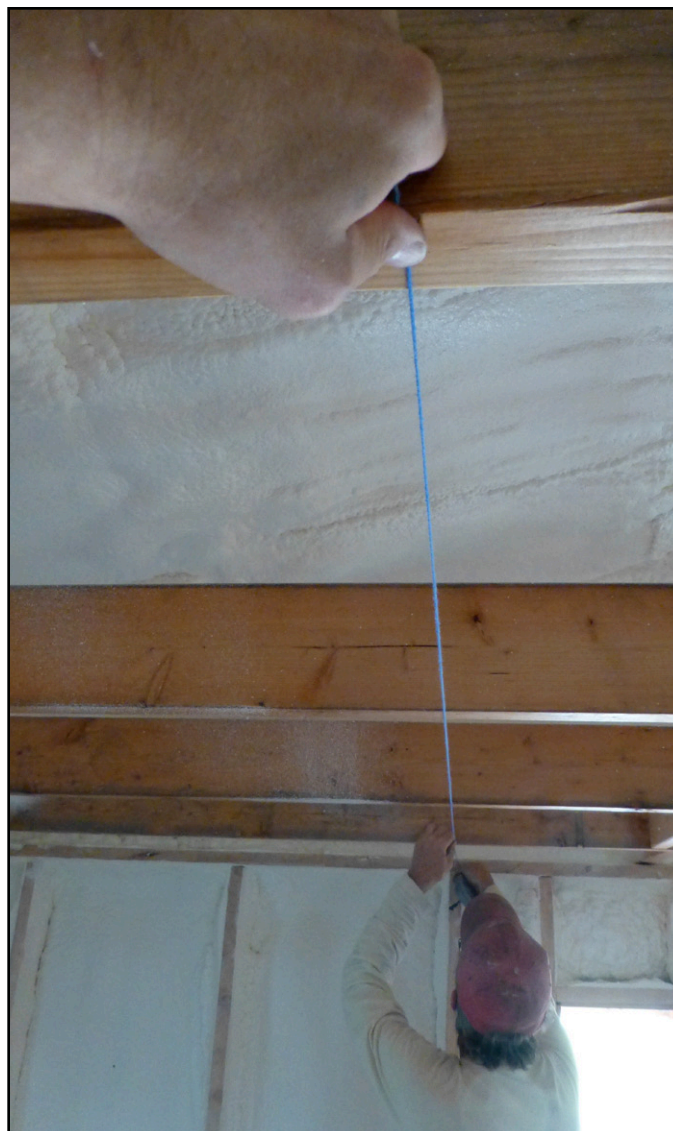


Fig 7.7 Lay out interior walls with chalk line.





Fig 7.8 Corners are marked for interior layout.



Fig 7.9 Once the ceiling is installed, the interior partitions may be framed and tipped up.



Fig 7.10 Blocking installed for kitchen cabinets and duplex outlet.

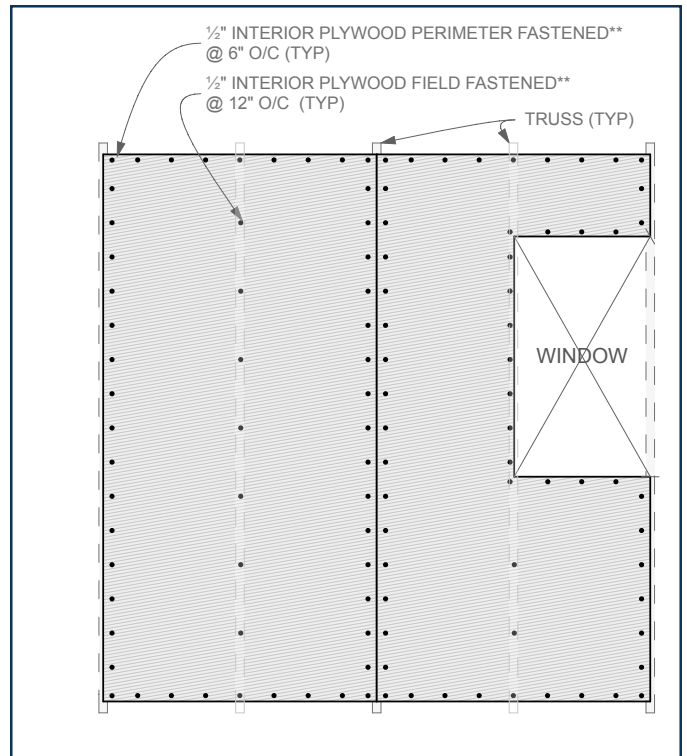


Fig 7.11 Interior plywood sheathing fastener schedule.



Fig 7.12 Blocking for light switch.





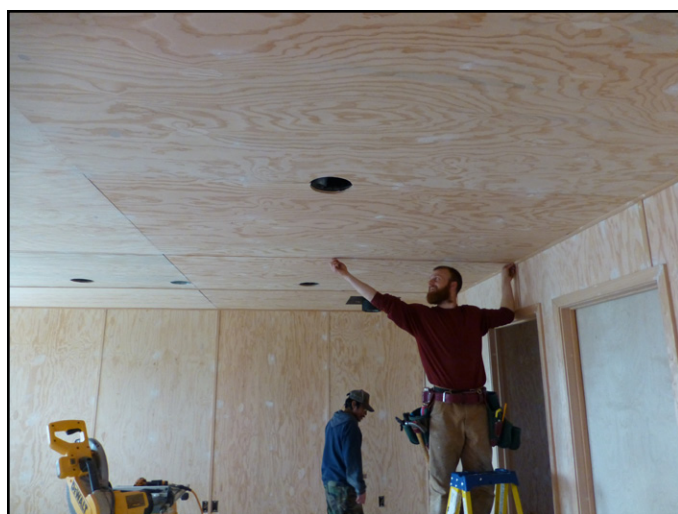
*Fig 7.13 Plumbing the hinge side of the door opening with shims prior to door installation.*



*Fig 7.14 Plumbing the hinge side of the door opening with shims prior to door installation.*



*Fig 7.15 Door frame installed.*



*Fig 7.16 Installing batten strips over plywood joints. Openings for lighting are cut with a hole saw.*



*Fig 7.17 Foam air sealing around window rough opening.*



# Electrical & Mechanical Systems

## Overview

For the most part, the Integrated Truss home employs electrical systems and installation processes that are common to residential construction. This means that the electrical system can be installed with readily available components and be adapted to meet specific requirements relatively easily. There are a few additional considerations to the mechanical system, however.

As the entire structure is encased in an unbroken envelope of spray foam insulation, it is extremely air tight. This translates to a very high level of energy efficiency, but it also makes adequate and reliable sources of ventilation critical to occupant health. A heat recovery ventilation system (HRV) in the mechanical room is the primary source of fresh air. Because this house is dependent on a dedicated source of fresh air, the HRV must remain on, and the supply air diffusers in the bedrooms must remain open. Secondary to the HRV, a 6" passive air duct leading directly outside has been installed behind the refrigerator. This passive air duct is designed: (a) to provide supply air when exhaust systems such as the kitchen exhaust or a clothes dryer are in operation; and (b) to supply air to the woodstove as needed. This duct **MUST** remain open at all times and is not to be considered an adequate substitute for the HRV. In the kitchen a range-hood exhaust with an in-line fan vents to the exterior through the gable-end wall.

CCHRC researchers developed the combined heating and ventilation system, called BrHEAThe, to ensure that new energy efficient homes are getting ample fresh air. As homes are being built tighter in Alaska to save energy, less air is able to leak into or out of the building, consequently water vapor and chemicals generated from cooking or furniture can remain trapped inside. Without ventilation, moisture and airborne pollutants can build up to harmful levels. Some occupants are wary of mechanical ventilation, such as fans or heat recovery ventilators (HRV), because they exchange heated air with cooler air. As a result, some homeowners turn off or disable their ventilation systems, creating unhealthy indoor environments. The BrHEAThe system marries together heating and ventilation so that incoming air is always warm and fresh.

**CCHRC requires that electrical and mechanical equipment in the home be installed by licensed professionals. Full drawings and specifications will be provided upon request.**

## BrHEAThe System Standard Operation

WHEN THERE IS NO CALL FOR HEAT:

1. The HRV operates independently based on ventilation requirements. The HRV delivers fresh air to the filter box/heat exchanger assembly where the positive air pressure closes the backdraft damper, flows past the filters, heat coil, and in-line fan to the air ducts to the rooms.

WHEN THERE IS A CALL FOR HEAT:

1. Fresh air from the HRV mixes with recirculating house air when the in-line fan is activated.
2. The HRV operates independently based on ventilation requirements. The HRV delivers fresh air to the filter box/ heat exchanger assembly.
3. Pump A turns ON (the boiler will fire as necessary), circulating glycol to the heat coil.
4. The in-line fan turns ON, pulling additional air from the house through the backdraft damper, through the filters, and across the heat coil to deliver heated air to the rooms.



#### WHEN THERE IS A CALL FOR HOT WATER:

1. The aquastat on the indirect fired hot water heater turns Pump B ON (the boiler will fire as necessary) and circulates glycol to the water heater.

## Sequence and Considerations

### Ventilation

1. **It is important to stage the Plumbing and Mechanical (ventilation and electrical systems) to arrive DIRECTLY AFTER insulation spraying is complete. Plumbing should occur before the subfloor goes in, mechanical installation should follow directly after plumbing.**
2. A hatch must be left open so that ducting can be installed above the ceiling .
3. Holes for supply and exhaust air ducting can be drilled into the exterior walls from both sides using a hole saw. Once the ducting is installed, seal the remaining gap between the ducting and the wall insulation with spray foam. Exhaust and supply hoods must be 10 feet apart on the wall horizontally to ensure that no stale exhaust air is re-entering the house.
4. The exterior hoods are sealed to the wall with closure strips and silicone. The hoods have a hinged flap to prevent backdraft. The flap is for the exhaust ports of the system. On the intake hoods, the flap must be removed when the hood is installed. This will allow exterior air into the system.
5. Ducting to the outside must be insulated. Insulated flex duct should be avoided, as it will significantly reduce airflow. Instead, 6" smooth wall sheet metal pipe can be insulated by removing the insulation jacket from 7" flex duct and sliding it over the 6" pipes. With some types of 7" flex duct, the core has a large enough diameter that it does not have to be removed. The easiest approach is to assemble and insulate the ducting in advance, then take apart in sections and reinstall in the attic.
6. Supply air is delivered through the bedrooms, bathroom, and living room. The diffusers should be located in areas where the cooler air will cause the least amount of occupant discomfort. The supply air should also be located away from doorways to prevent "short-circuiting" the air flows and to ensure good air mixing.
7. Return air is picked up through diffusers in the ceilings. The bathroom, entryway and kitchen should each have an exhaust air diffuser.
8. The condensate drain from the HRV should route away from mechanical equipment. The condensate drain must have a trap.
9. The range hood above the stove may also be used to exhaust humid air from the home. The passive vent behind the fridge will supply fresh air when the range hood, bath fan, and/or dryer are running. CCHRC recommends at least one mechanical exhaust route separate from the HRV system be installed in the home.
10. A 6" passive makeup-air vent is installed behind the refrigerator to provide supply air when exhaust appliances such as the kitchen fan or a dryer are turned on. It also provides supply air for the wood stove if the wood stove is not direct-vented. To avoid problems with backdrafting combustion appliances such as the wood stove or the furnace, this duct must remain open. The makeup-air duct must be insulated. It enters the wall through the underside of the building and runs vertically through the entry wall.
11. The hole for the makeup-air intake can be cut in with a hole saw passing through the plywood sheathing and spray foam under the floor. It should be screened so that insects cannot enter the duct.
12. The HRV unit should be hung from the bottom chord of the truss and have a few inches of clearance from surrounding walls to limit vibration. It should be plugged into a dedicated outlet.
13. The doors of the bedrooms should be undercut to leave a 1-1/2" minimum air space. This will allow stale air to return to the HRV and maintain an even temperature throughout the house.





## brHEAThe 2.2\_SYSTEM DIAGRAM

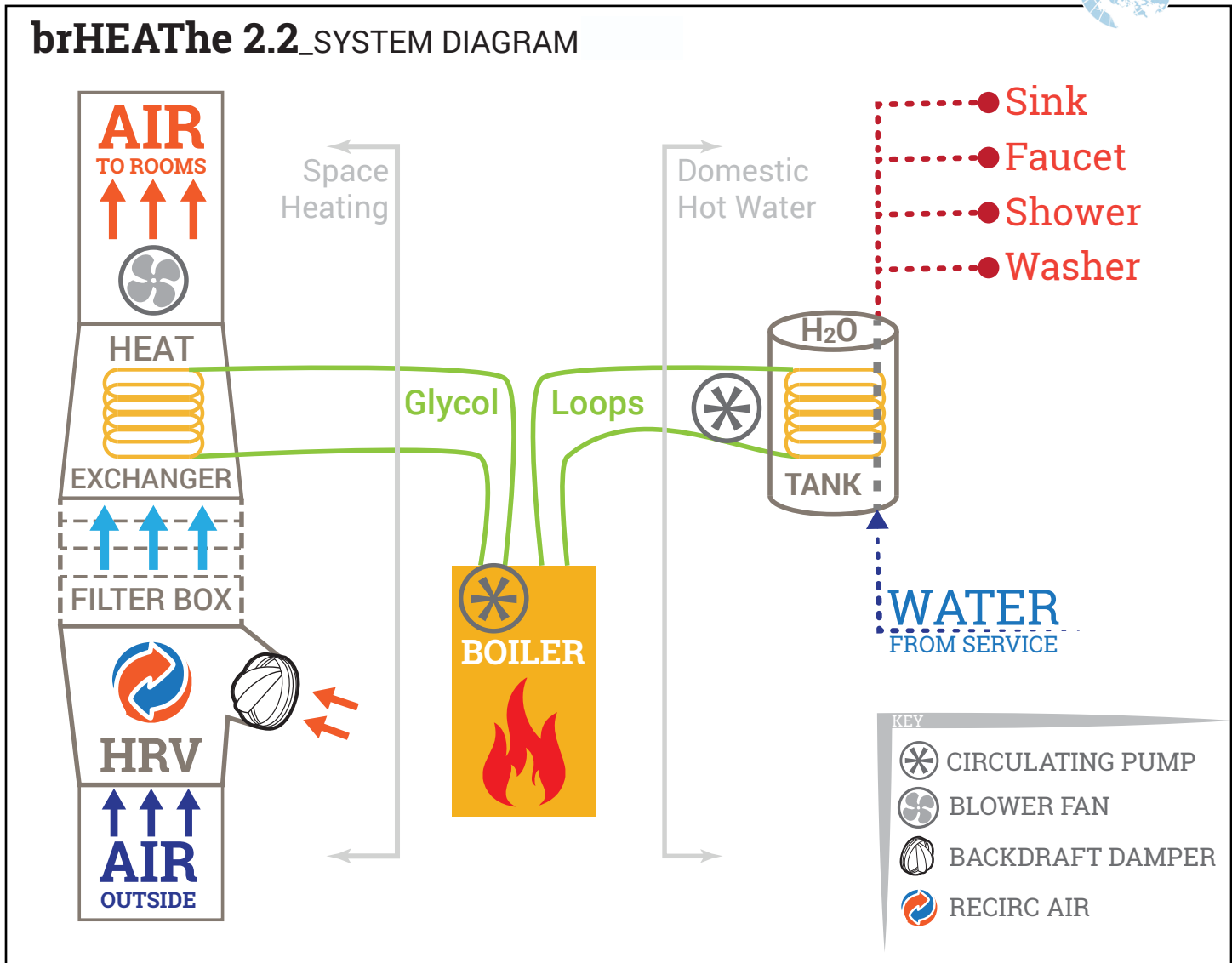


Fig 8.1 Schematic Diagram of the BrHEAThe combined heating/ventilation system



Fig 8.2 The fabricated heat exchanger mechanism before installation.



Fig 8.3 Mechanical ducting should be installed after the spray foam insulation and before the ceiling. Ducting to the outside must be insulated to avoid condensing. Warm-side supply and return ducting can be uninsulated. Refer to the installation manual of the HRV for port configuration.



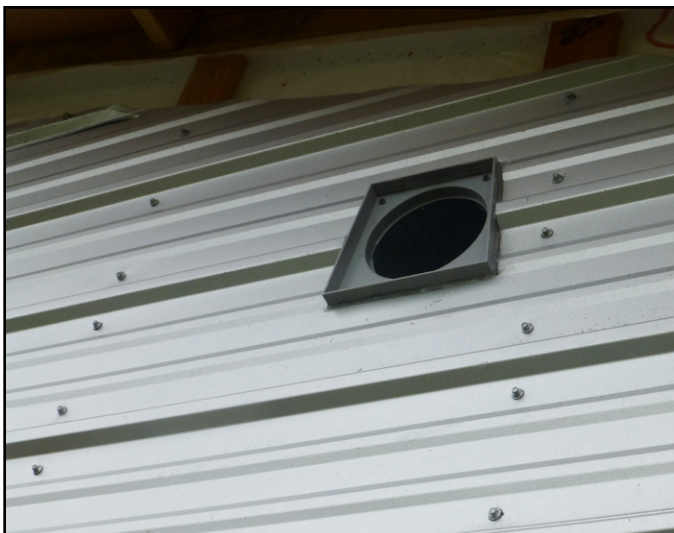
*Fig 8.4* View of the mechanical room with a typical BrHEAThe system configuration. HRV unit should be hung from the bottom chord of the truss structure and have a few inches of clearance from surrounding walls to limit vibration. The condensate line must have a trap.



*Fig 8.5* Ducting to the outside must be insulated. Insulated flex duct should be avoided, as it will significantly reduce airflow. Instead, 6" smooth wall sheet metal pipe can be insulated by removing the insulation jacket from 7" flex duct and sliding it over the 6" pipes.



*Fig 8.6* Space in the ceiling sheathing must be left so that the HRV can be connected to the ducting. A separate hatch must be left open so that ducting can be installed above the ceiling



*Fig 8.7* Holes for the intake and exhaust ports are made with a hole-saw. The port is installed and then sealed with spray foam from the inside, and weather strip and silicone from the outside.

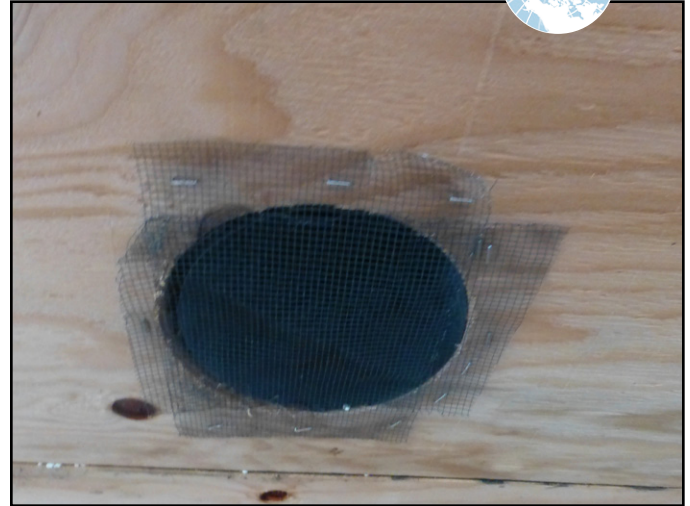


*Fig 8.8* The weather hood comes with an integrated hinged flap. The flap should remain in the exhaust hoods, but be removed in the intake hoods.





*Fig 8.9* A 6" passive makeup-air vent is installed behind the refrigerator to provide supply air when exhaust appliances such as the kitchen fan is turned on. The ducting from the floor intake to the room must be insulated.



*Fig 8.10* The passive makeup air intake through the floor of the home on the exterior. It is screened off to keep insects out of the building.



*Fig 8.11* The doors of the bedrooms are undercut to leave a 1-1/2" minimum air space. This will allow stale air to return to the HRV and maintain an even temperature throughout the house.



*Fig 8.12* The woodstove sits atop a fiber cement board platform. This model of woodstove has integrated heat shields, so that fiber cement board is not necessary on the walls behind the stove. Woodstoves without heat shields will need thermal protection from walls that complies with local fire codes. This stove comes with a direct-vent kit to limit backdrafting.



*Fig 8.13* The stack for the woodstove should be sealed with flexible boot or a thin-gauged metal chimney flashing and silicone. The stack should be a minimum of 2 feet higher than the ridge if located less than 10 feet from the ridge.





# Interior Finishes

## Overview

The interior finishes in the Integrated Truss Home were selected for durability and ease of application. However, they are also the area of design that will have the most variability in individual rebuilds, so only a cursory look at finishes will be dealt with in this manual. It is important to check the plans and specifications for differences between individual homes as homeowners will have different tastes, budgets, and capabilities regarding interior finishes.

The interior walls of all Integrated Truss homes are covered in half-inch AC plywood, which serves two purposes:

- Plywood sheathing provides the required shear strength for the exterior walls.
- If it doubles as an interior cladding it not only saves on shipping costs, but also is a more durable and moisture tolerant material than drywall.

Because drywall serves as an ignition barrier, exposed plywood may require a coat with low-VOC intumescent paint. Deciding whether or not a fire retardant paint is required may vary from region to region, and ultimately falls under the jurisdiction of the local code authorities. Another consideration with using plywood involves the seams. As mudding and taping is not an option, CCHRC uses inexpensive pine or hemlock batten strips to cover seams between sheets of plywood. For best results, the batten strips and all other trim should be finished separately and installed once the wall and ceiling painting have been completed. Base trim should be installed after the flooring is in place. Plywood that has been left out in the weather or not properly covered during barge shipment may have areas where the tannins have been brought out from exposure to moisture. These tannins will telegraph through the paint and be unsightly. A stain-blocking interior/exterior high-hiding primer/sealer should be used to cover water stains that may telegraph through the paint.

There are various flooring options for the home. Selected flooring types should be chosen based on durability, cost, and ease of transport by barge or plane. Preference is given to 'floating' floors that require no fasteners or glues. Finally, preference should be given to products that can be easily cut with a chop saw and do not require specialized labor to install.

**NOTE:** Typically any flooring should be installed before the baseboard trim is applied.

The windows come with an integrated PVC return. Interior doors are trimmed with casing in the field.



*Fig 9.1* Batten strips have been placed before painting.



*Fig 9.2* Batten strips have been stained and placed after all other finish work is complete.



*Fig 9.3* Electrical rough-in box. When using AC Plywood interior finishes instead of gypsum wall board, oversize plate covers should be ordered.



*Figure 9.4* Click-in-place flooring is placed directly on top of the tongue-in-groove subfloor. The joints are staggered for added cohesion.



*Figure 9.5* The rubber floor tiles can be connected using a rubber mallet or a hammer and block.



*Figure 9.6* The occupants chose to bring the rubber tile flooring into the house from the entry, creating a place for water storage and taking shoes off.



*Figure 9.7* The *Elaturaq* entry door threshold has a PVC extension to accommodate the extra wall thickness. The step up into the home from the entry will help form a passive cold trap.



*Figure 9.8* The interior window trim consists of an integrated PVC return. The trim should be measured in the field before the windows are placed to depth.





### INTERIOR WOOD TRIM INSTALLATION SEQUENCE:

**STEP 1:** INSTALL WALL-TO-CEILING INSIDE-CORNER TRIM

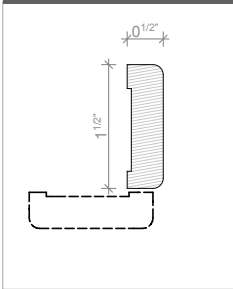
**STEP 2\*:** INSTALL WALL-TO-WALL INSIDE CORNER TRIM, BUTTED AGAINST WALL TO CEILING TRIM

**STEP 3:** INSTALL BASE TRIM AND DOOR CASINGS, BUTT BASE TRIM AGAINST WALL-TO-WALL INSIDE CORNER TRIM

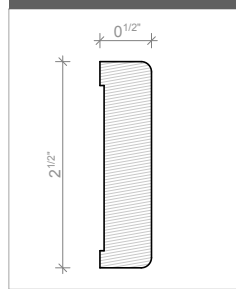
**STEP 4:** INSTALL BATTEN STRIPS AND OUTSIDE CORNER TRIM

\* WALL-TO-WALL INSIDE CORNER TRIM IS 8'-0" LONG AND MUST BUTT AGAINST INSIDE CORNER WALL-TO-CEILING TRIM **(IF WALL-TO-WALL INSIDE CORNER TRIM IS INSTALLED FIRST IT WILL BE TOO SHORT)**

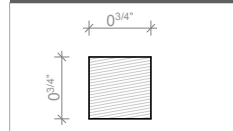
**BATTEN STRIP AND  
OUTSIDE CORNER TRIM**



**BASE TRIM +  
DOOR CASING**



**INSIDE CORNERS,  
WALL-TO-WALL +  
WALL-TO-CEILING TRIM**



NOTE: DIMENSIONS FOR WOOD TRIM ARE APPROXIMATE, **HOWEVER ROUND-OVERS MUST BE 1/8"**

Figure 9.9 The trim installation sequence.



Figure 9.10 The finished interior with linoleum flooring and Energy-Star appliances in place. Floorplans and kitchen arrangements will vary.

