THE HOME SHELTER

Your personal construction book.

HOME Shelter Construction Book

THE HOME SHELTER CONSTRUCTION BOOK

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INTRODUCTION TO THE HOME SHELTER

The HOME Shelter started 30 years ago.

All this started 30 years ago when I began a career in human factors engineering at Lockheed Martin in 1974. At first, I was idealistic about applying human factors principles and design characteristics to hardware and software. When I'd suggest something, design managers would always say: "we can't do that – it's too expensive, too heavy, it doesn't meet the requirements." So I learned how to design things that conformed to requirements but cost less and weighed less. It wasn't until 2010 that I had the inspiration.

The inspiration was the Haiti earthquake. I knew there was a better way of providing emergency shelter for refugees than a tent. But the new design would be more than protection from the rain, wind, snow. It had to provide things like food, water, power, sanitation, ventilation, privacy, visibility, and even furniture. And it had to be easily set up, torn down, or moved. And it had to do it as simply as possible. It had to be systems engineered. And human factored. What do I mean by that?

Good human engineering means designing something that's extremely compatible with human limitations and capabilities whether it's mental, physical, emotional, cognitive. So I derived requirements. The HOME Shelter had to be easy to put together and tear down by unskilled, non-English speaking people, living under extreme conditions. It had to be set up without any infrastructure support like electric power for tools, written instructions, or heavy machinery. It had to be set up by three people in less than 2 hours. What I needed was a system requirements document to organize all these derived requirements. And so it began…

WHAT IS THE HOME SHELTER?

The HOME Shelter is a hexagonal, rigid-walled structure constructed of commercial grade lumber with walls and a roof but no floor. It's constructed of interchangeable panels that are fabricated in a shop and delivered to the site.

It has about 165 square feet of living space. The outer walls are six (6) feet high; the center is about seven (7) feet high. The roof slopes at about twenty (20) degrees. The center is supported by a column that takes much of the roof load. At the center of the roof is a module called the 'power cap'. All of the electronics are located in the cap.

The walls are vertical panels; each panel is four (4) feet wide and six (6) feet high. Panels are reinforced with stiffeners. Holes are drilled in each panel to provide 360 degree air circulation and an interface for the planters. Two (2) doors provide egress and ingress; doors are made from cutouts and slide on tracks.

A gutter system collects rainwater and channels it into a cistern placed outside the shelter. This water is filtered for debris but not pathogens; a clay and silver composite filter in a second cistern neutralizes bacteria and parasites.

TYPES OF SHELTERS

There are 3 types of shelter for refugees and IDPs – emergency, transitional and permanent. Tents are the best 'first responder' emergency shelter. Transitional shelter is usually a rigid roof structure with fabric or low solid walls. Permanent shelter has rigid walls and roofs, windows and doors, separate interior rooms, and conveniences like toilets.

EMERGENCY SHELTER

Emergency shelters are fabric tents. These are easy to set up within days after the disaster. Large tent cities take weeks and months to set up on level areas outside the disaster area. Tent cities provide shelter for tens of thousands of people in isolated camps set up in soccer fields, parking lots, stadiums and large open areas. Most large encampments are near roads and accessible by trucks. Rotary International Clubs 'Shelter in a Box' is one of the most successful emergency shelter relief programs in the world. But they are short term solutions since the material is shredded by wind; UV light destroys the fabric within a year or so.

TRANSITIONAL SHELTER

Transitional shelters are constructed with local materials, such as wood, sandbags, metal sheeting, commercial shelters are available. They are usually much larger than emergency shelter and can require manual or power tools to set up and tear down. They can take a day or more to build. Some require heavy machinery (i.e., forklifts) to emplace and contain loose parts (bolts, panels, tubes, windows, fasteners). They can require many trained personnel to assemble and use complex instruction manuals. Poor countries don't have that luxury.

The infrastructure needed is a hidden cost and burden (about 10%-20%) added to unit price. Transitional shelter is established usually months or years later after negotiations with governments, land owners, and agencies. Some refugees live in these rudimentary housing projects for years.

PERMANENT SHELTER

Permanent shelters are close to what refugees lived in prior to the disaster or displacement. They are vertical walled structures with windows, doors, solid walls and sloping roof. These are the types of structures that most displaced persons and refugees want – not domes or igloos.

HOW IS THE HOME SHELTER DIFFERENT?

The HOME is composed of several different integrated subsystems: power and electronics, interior design, agriculture, structure, water, heating and cooling, and personal hygiene. It is not just a structure but a system of systems all combined to work together. No other emergency shelter has this combination of features all wrapped up into one thing.

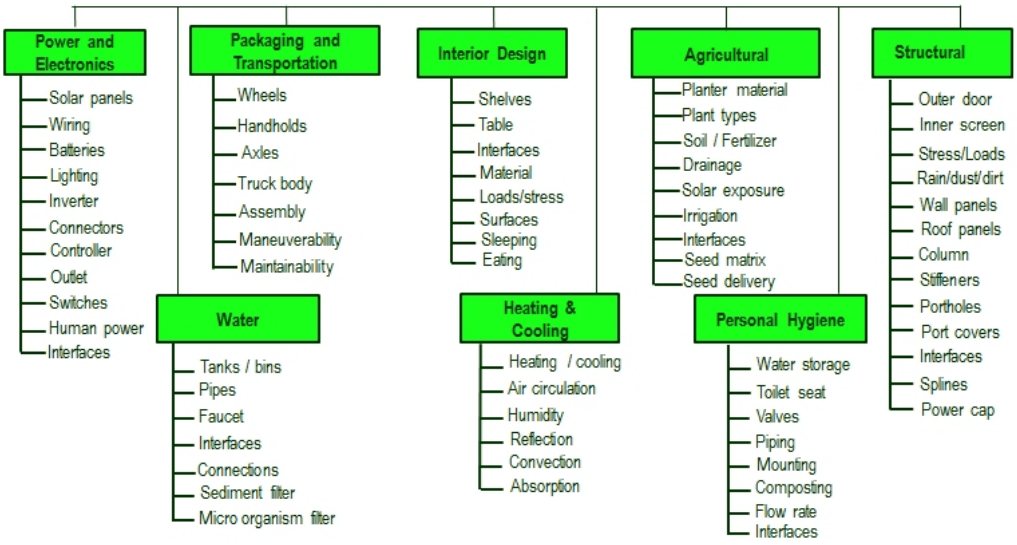


Figure 1 – System Architecture

The POWER AND ELECTRONICS subsystem is built into the **Power Cap**. The Power Cap is a self-contained sandwich of plywood and board lumber. Inside are the power inverter, gel battery, wiring, converter, connectors, light fixture, dual socket and power indicator.

The PACKAGING AND TRANSPORTATION subsystem is a separate subsystem not directly connected to the operation of the HOME. Yet, it is important since you need to transport the HOME Shelter from the drop-off point to the installation site. This gives you an alternative to a pickup truck, van, or other motorized form of transportation.

The INTERIOR DESIGN subsystem consists of: (1) fold-down panels mounted to the wall panels, (2) stand-alone transformer furniture, and (3) suspended shelving from the center of the HOME constructed of rigid plastic bin lids and rope. This shelving system is inexpensive, portable, sturdy, and accessible – all the features you need in a small space.

The AGRICULTURAL subsystem or food production is an add-on feature of the HOME. It consists of planters suspended from the portholes. Planter assemblies consist of a

metal wire coat hanger and a HDPE plastic planter pot. People add dirt, seeds and, if available, fertilizer to the mix to grow beans, cucumbers, tomatoes, etc.

The STRUCTURAL subsystem is the heart of the HOME that makes all the other subsystems possible. It consists of plywood and board lumber. The structure weighs about 1400 lbs. total.

The WATER subsystem is a separate entity to the basic structure. The primary rainwater collection subsystem consists of Corex products including flexible drain pipe, sump liner and lid, and rigid drain pipe. The separate filtration subsystem consists of an additional Corex sump liner and lid, plus the clay and silver cone filter.

The HEATING AND COOLING subsystem uses passive ventilation to maintain a moderate temperature inside depending upon the outside temperature.

The PERSONAL HYGIENE subsystem is a separate entity to the basic structure. That means you can build the basic structure and not include the personal hygiene equipment. It comes in two (2) versions. The first is for washing food and hands inside the HOME. The second is for feces collection and composting.

For safety sake and personal cleanliness, the personal hygiene system should be built in a separate HOME shelter used for human waste elimination and composting. Thus, human waste is separated from the regular living space.

Chapter

2

STRUCTURE SUBSYSTEM

This section describes the structure, dimensions, materials and other characteristics of the shelter structure.

This is a short paragraph that describes more of what you will read about in this chapter like the basic shape, size, materials, and interfaces.

SHAPE, SIZE AND DIMENSION OF HOME SHELTER

The basic shape is a hexagon; each side is eight (8) plus feet in width. A side is composed of two (2) four-foot wide x six (6) foot high pieces of 0.5 inch thick commercial grade plywood plus the connecting spline. The center spline is flat; the two (2) corner splines are angled at 120 degrees.

The perimeter measures about 48 feet. The diameter is 16 feet. The interior angle is 120 degrees and the central angle is 60 degrees. The exact area is 166 square feet.

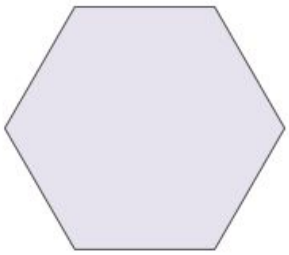
The roof slope is about 10 – 15 degrees from the exterior wall to the outer edge of the power cap. This gentle slope allows slower rainwater runoff into the Corex flexible gutter system.

The volume of the HOME shelter is about 1,100 cubic feet.

This model has no rigid floor; however, a flexible mat floor is available from an Australian company, Cgear. I have the eight (8) foot square model for a beach mat.

The following figure provides some of the dimensional details of the HOME.

Visual representation:



(drawn with rotation angle 0°)

Combinatorial properties:

vertices	6
edges	6

Properties: Less

circumradius	8 feet
inradius	$4\sqrt{3}$ feet ≈ 6.9282 feet
height	$8\sqrt{3}$ feet ≈ 13.8564 feet
diameter	16 feet
area	$96\sqrt{3}$ ft^2 (square feet) ≈ 166.277 ft^2 (square feet)
perimeter	48 feet
central angle	$60° = \frac{\pi}{3}$ rad ≈ 1.047 rad
interior angle	$120° = \frac{2\pi}{3}$ rad ≈ 2.094 rad
interior angle sum	$720° = 4\pi$ rad ≈ 12.57 rad

Figure 2 - HOME shape and dimensions

MATERIAL DESCRIPTIONS

All materials are Commercial off the Shelf (**COTS**) to make purchasing easy. No special materials are needed. Materials include: plywood, wood screws, wood adhesive and standard lengths of board lumber, metal pipe and threaded flanges. These are available in large hardware stores.

STRUCTURAL INTERFACES

The HOME Shelter, itself, fits together with splines and tracks on the plywood panels and lumber. Constructing the reinforced plywood panels and splines together requires aligning plywood and board lumber cut at certain angles and gluing, nailing, or screwing them together. This process takes some attention but once you make one of the panels or splines, then you can duplicate the process to make the rest of the panels and splines.

ESTIMATED TIME TO FABRICATE COMPONENTS

Total time to make all components (once the lumber is stacked and accessible in the work area) is about **XX.X hours.**

A recommended fabrication area is about **600 sq. ft.** with two (2) or more 20 amp electrical outlets.

TOOLS NEEDED

Constructing a HOME shelter requires the following power tools:

- Table saw, 10 amp, 10 inch, recommended
- Radial arm saw, 10 inch, 3 HP recommended
- Circular saw, 10 – 20 amp, 7 ¼ inch blade
- Pneumatic nail gun
- Wood adhesive
- Cordless electric power drill, 3/8 inch chuck
- Sawzall, 10-15 amp
- Electric outlet (20 amp) or portable compressor
- Wood working square
- Wood workers adjustable triangle
- Measuring tape, 20 ft.

MANPOWER AND EXPERIENCE

The HOME shelter **requires at least two (2) people**.

You should have about **100 – 200 hours experience** using these power tools. Constructing the HOME shelter is not a job for amateurs.

Making the parts for the HOME requires experience measuring and marking angles and lumber lengths, routing lumber using a table saw, drilling, and driving self-

tapping screws. This manual will instruct you in the dimensions to measure but it cannot substitute for the experience you need to handle measuring and cutting lumber safely.

FINISHED COMPONENTS

Here is a look at the finished components of the basic HOME Shelter. No dimensions or angles are shown. These are provided in the detail assembly steps.

GROUND RAIL BOARDS

Rail boards are 2" x 4" x 8 ft. boards with a ¾ inch deep channel routed / ripped down the center. These hold the wall panels vertical temporarily while you assemble the HOME Shelter. The figure below shows the simple geometry of a ground rail board.

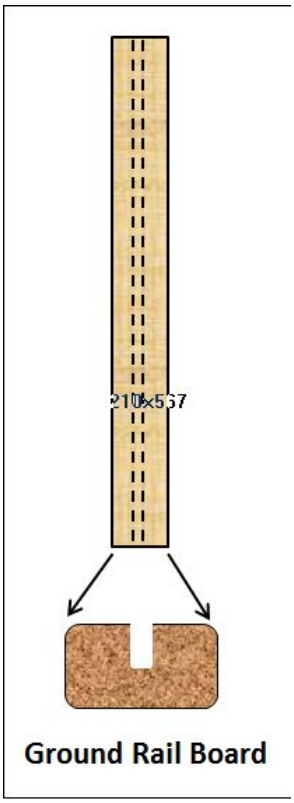


Figure 3 - Ground Rail Board

SPLINES

Splines hold the HOME Shelter together without nuts or bolts or screws when you assemble the HOME at the site. The figure below shows the two (2) basic types of splines – straight and angled.

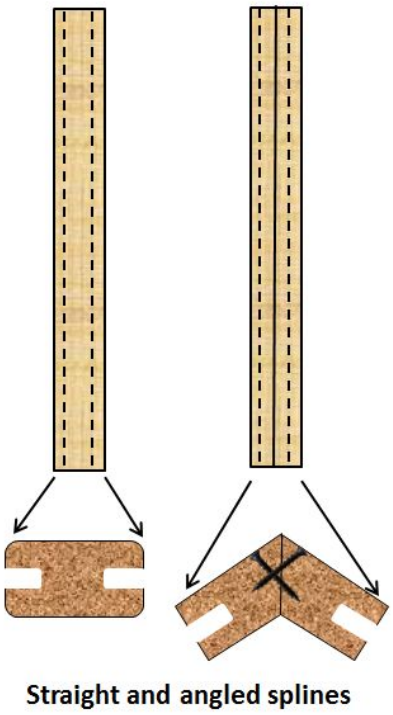
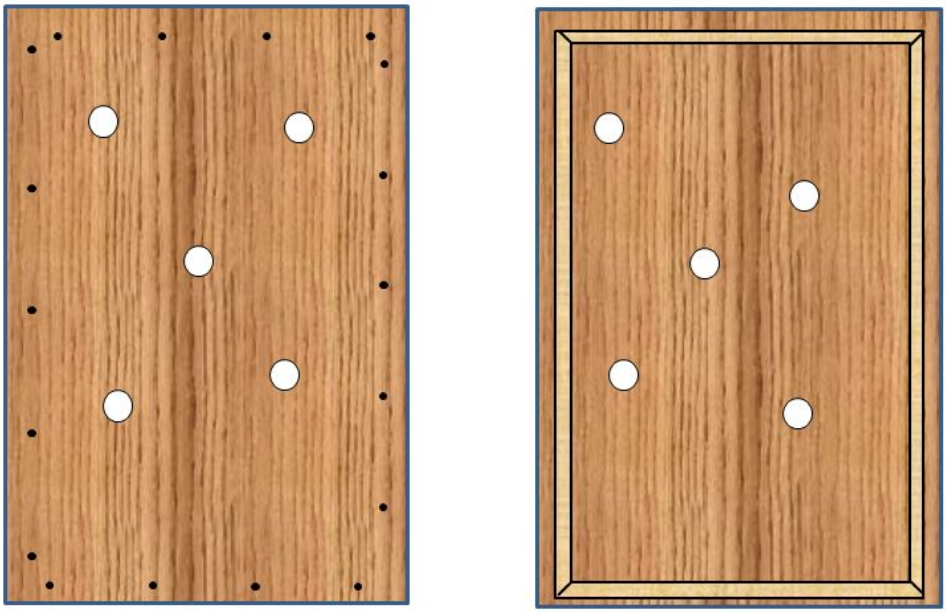


Figure 4 - Straight and angled splines for wall and roof panels

WALL PANEL

Wall panels are simple constructions made from a single piece of plywood and 2 x 2s. The 2 x 2s are attached around the entire perimeter to stiffen the panel. The figure below shows the exterior and interior surfaces of an assembled wall panel.



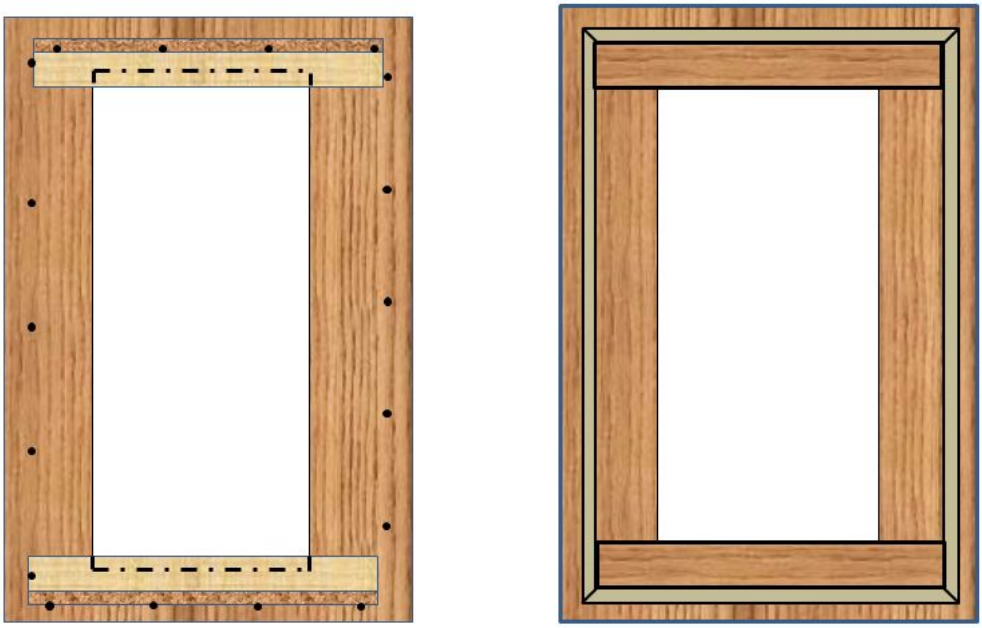
Wall panel, exterior view

Wall panel, interior view

Figure 5 - Wall panels

DOOR PANEL

A door panel is a wall panel with a cutout and additional board lumber on the interior and exterior surfaces. The cutout becomes the sliding door after vertical stiffeners are added on the exterior surface. The figure below shows the interior and exterior surfaces of a door panel. Each HOME Shelter has two (2) door panels.



Door panel, exterior view, with sliding door track

Door panel, interior view

Figure 6 - Door panel

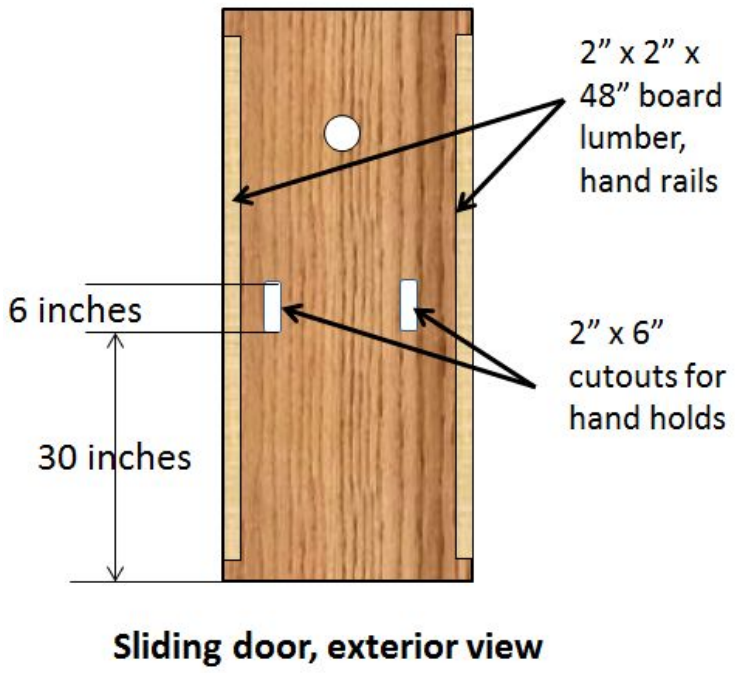
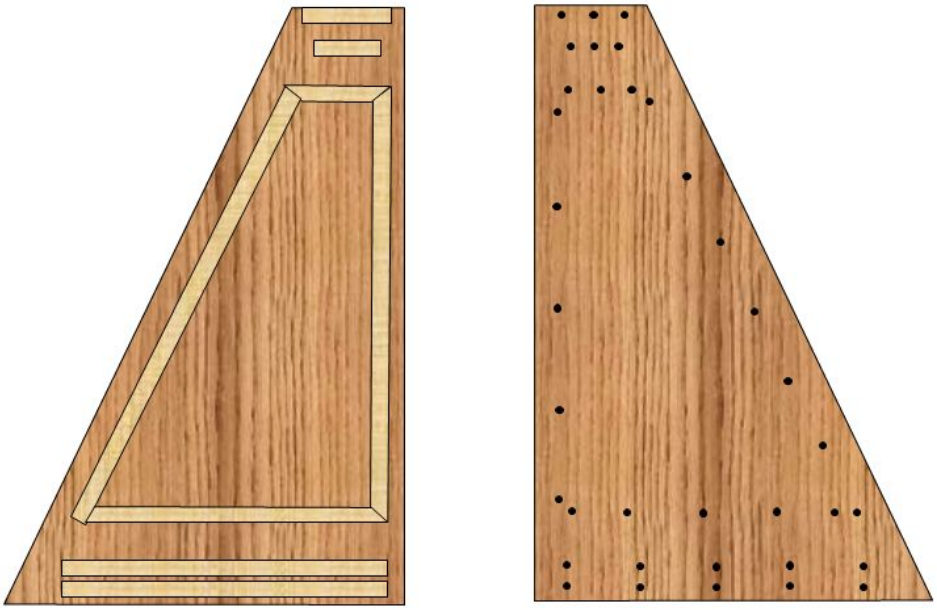


Figure 7 - Sliding door cutout from a wall panel

ROOF PANEL

A roof panel is probably the most complicated piece of hardware in the HOME Shelter. It is a single piece of plywood cut at an angle along one side. The perimeter stiffeners follow the edge lines. Two different pairs of boards run in parallel at either end. These pairs of boards straddle either the wall panel plywood or part of the power cap.

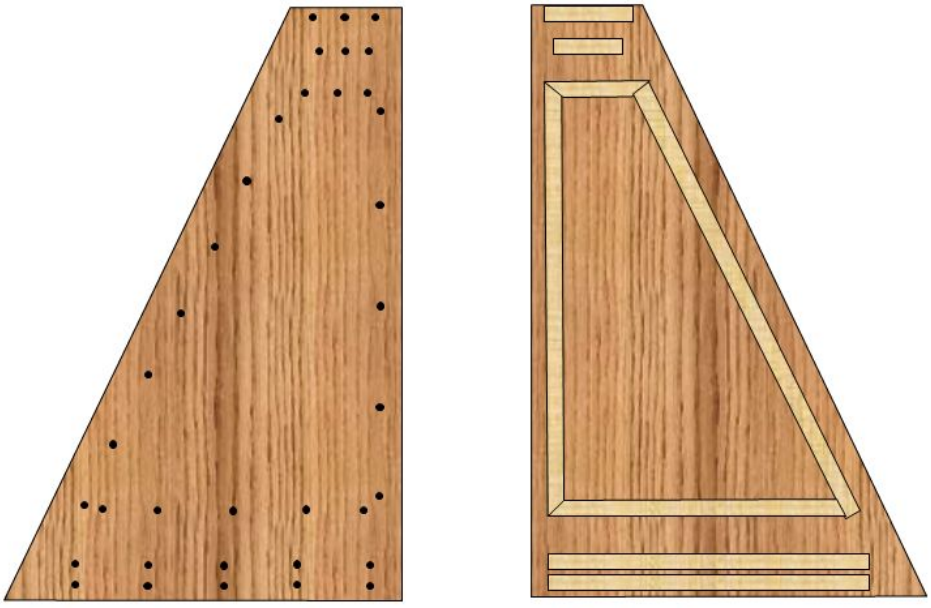
The following figures show the topside and underside of both the right and left side roof panels.



Right side roof panel, underside, showing screw patterns

Right side roof panel, topside, showing stiffeners and tracks

Figure 8 – Right side roof panel, underside and topside



Left side roof panel, topside, showing screw patterns

Left side roof panel, underside, showing stiffeners and tracks

Figure 9 - Left side roof panel, underside and topside

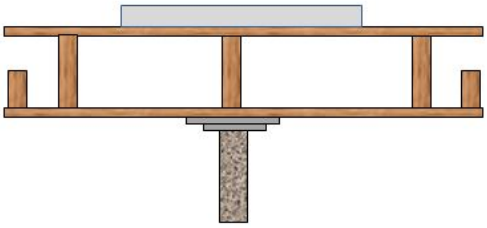
POWER CAP

The power cap is a fairly complicated assembly since it must house the electronics and provide an interface for the roof panels. It is constructed out of plywood and board lumber in standard lengths. The solar panel is attached on top. Wiring runs through the top piece of plywood to electronics below it.

A set of short boards form a spacer in the center of the power cap. This spacer distributes the compression load from the metal center support and from the roof panels. Without the spacer, the power cap would collapse eventually.

The figure below shows a top view of the power cap and a side view.

Power cap, top view, with solar panel, hidden risers



Power cap, section : showing risers, spacer, support column, flange, & solar panel

Figure 10 - Power cap, top view, showing solar panel

CENTER SUPPORT COLUMN AND BASE

The center support column and base hold up the roof and power cap. The column and base are steel pipes threaded into separate metal flanges. The flanges are attached to either the bottom of the power cap or a piece of plywood.

After the center column is attached to the power cap, the entire assembly is lifted and inserted over the slightly smaller in diameter base stanchion. This arrangement stabilizes the power cap while the roof panels are attached to the walls and power cap cutouts. Also, it allows you to rotate the power cap to align the external riser in the power cap with the roof panel channel.

Since the roof panels float up or down in the power cap, slight differences in elevation of the column base relative to the outside walls can be tolerated.

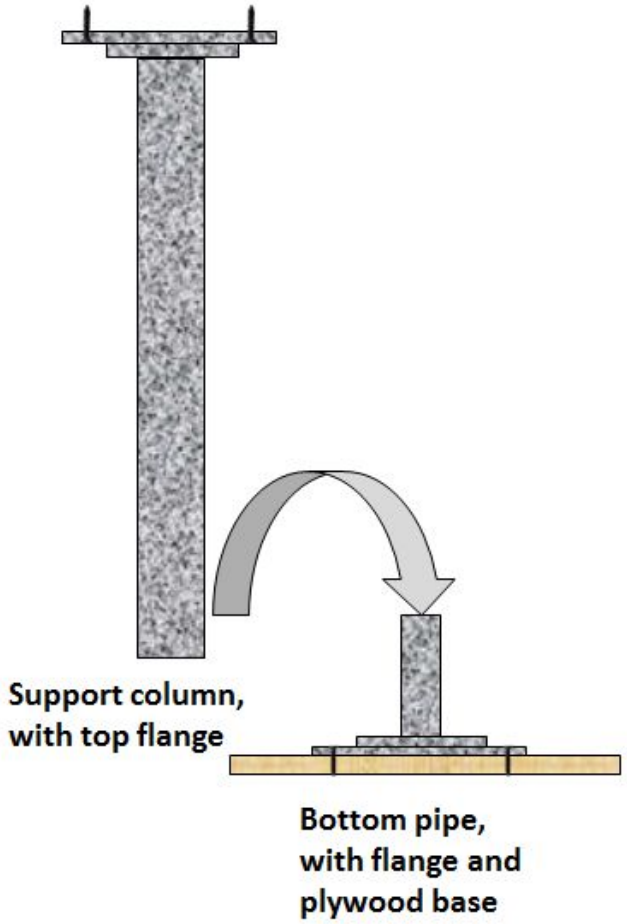


Figure 11 - Center support column showing top and bottom flanges.

MAKING THE GROUND RAIL BOARDS

Rail boards (6) have three functions:

(1) they stabilize the wall panels during assembly,
(2) they align the panels horizontally,
(3) they prevent moisture from entering the panel edges.

Once a wall panel is inserted into the rail board track, it is relatively steady and allows you to align panels. They hold the wall panels vertical during assembly. They are

placed on the ground in the shape of a hexagon when you begin to assemble the finished wall and roof panels.

Rail boards are eight (8) foot long, 2" x 4", pressure treated lumber available from local hardware store. Each has a 'track' running the full length of the board that is a half (1/2) inch wide and three quarters (3/4) inch deep. This depth leaves about ¾ inch of wood on the ground.

MATERIALS FOR RAIL BOARDS

1. Six (6) eight foot long, 2" x 4", pressure treated lumber.

TOOLS

1. Table saw, 10 amp, 10 inch, recommended
2. Radial arm saw, 10 inch, 3 HP recommended
3. Circular saw, 10 – 20 amp, 7 ¼ inch blade
4. Cordless electric power drill, 3/8 inch chuck

MEASURING AND CUTTING RAIL BOARDS

1. Measure in from the edge 1.75 inches to make a center line
2. Mark the center line the entire length of the board
3. Measure out from the center line 0.312 inches, both sides, and mark the length of the board.

> *This is the track you will rout out.*

4. Set your table saw blade to a height of 0.75 (3/4) inch.
5. Rout / rip out the track on the rail board.

MAKING THE WALL PANELS

Each wall panel is cut from a single sheet of 4 ft. x 8 ft. piece of 0.5 inch (1/2) thick plywood.

Pressure treated (all weather) plywood is recommended but more expensive than untreated – about 40% more. Untreated sheet costs about $20; a pressure treated sheet costs about $28.

MATERIALS FOR 12 WALL PANELS

1. Twelve (12) sheets of 7/16 inch thick, 4‘ x 8’ plywood, pressure treated (recommended), CDX grade, Rtd sheathing.
2. Twenty four (24) 2 inch x 2 inch x 10 ft. pressure treated lumber for the wall panel perimeter stiffeners.
3. Wood screws, 1 5/8 inch, self-tapping, star-drive, all-purpose, coated, countersunk, steel, flat head
4. Wood glue

TOOLS FOR 12 WALL PANELS

1. Table saw, 10 amp, 10 inch, recommended
2. Radial arm saw, 10 inch, 3 HP recommended
3. Circular saw, 10 – 20 amp, 7 ¼ inch blade
4. Cordless electric power drill, 3/8 inch chuck
5. Star driver bit,

MEASURING AND CUTTING THE WALL PANEL PLYWOOD

1. From one end of a sheet, measure up 72 inches (6 ft.).
2. Mark both sides at 72 inches and rip off the 24 inch piece.
3. From the 24 inch piece, measure six (6) 4 inch strips.
4. Rip the six (6) 4 inch strips and set aside.

> *These strips are used for retaining the door cutout.*

5. Repeat for all 12 sheets of plywood.

MEASURING AND CUTTING THE STIFFENERS

Each wall panel needs two 2“ x 2”x 6 ft. boards and one (1) eight (8) foot 2 inch x 2 inch board as perimeter stiffeners. You are going to make a rectangular box of these stiffeners on the interior side of the wall panel with the board lumber.

MEASURE AND CUT THE VERTICAL STIFFENER

1. Measure and mark 5 ft. 9 and ¾ inches (69.75 inches) from one end of each 6 ft. board.
2. Measure, mark and cut a 45 degree angle, as shown in the following figure.
3. Measure, mark and cut a corresponding 45 degree angle on the opposite end, as shown.

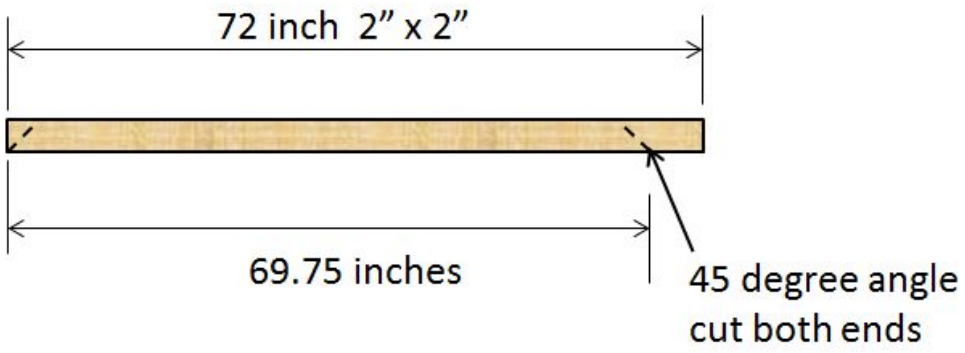


Figure 12 – Vertical wall panel stiffener – cut pattern

MEASURE AND CUT THE HORIZONTAL STIFFENER

Using the eight ft. board, cut into lengths, as follows:

1. Cut the 8 ft. board in half (2 48 inch lengths).
2. Measure in from one end 3 inches and cut at a 45 degree angle.
3. Cut the opposite end at 45 degrees, as shown below.
4. Repeat for each set of wall panel stiffeners.

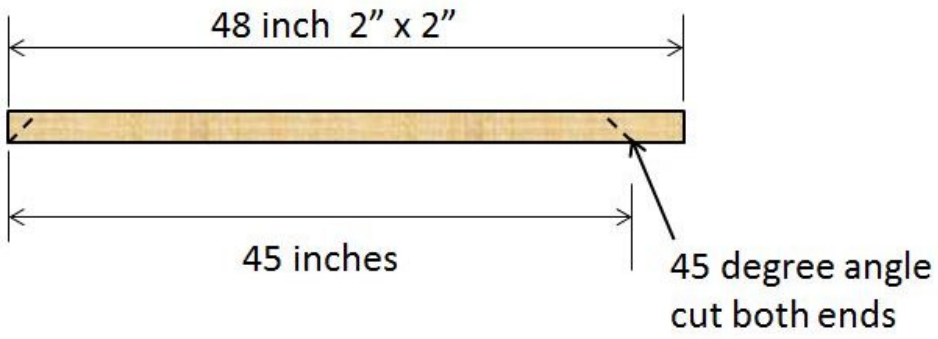


Figure 13 – Horizontal wall panel stiffener – cut pattern

ASSEMBLING A WALL PANEL

After you assemble one wall panel, then you've basically assembled all of them; they are identical.

You will modify two wall panels into two (2) door panels by cutting out the center and adding some retainers and track boards.

Assembling one wall panel starts with measuring an offset from all four outside edges and marking them on the panel. You should have a large rectangle marked on the panel. This is the edge line for aligning the perimeter stiffeners.

A shallow offset is needed on the bottom so that the bottom stiffener rests on the ground rail board. A deeper offset is needed on the top for the stiffener to rest against the corresponding roof panel stiffeners.

NOTE: THE BOTTOM STIFFENER IS OFFSET .75 INCHES FROM THE BOTTOM EDGE. THE TOP STIFFENER IS OFFSET 1.5 INCHES FROM THE TOP EDGE.

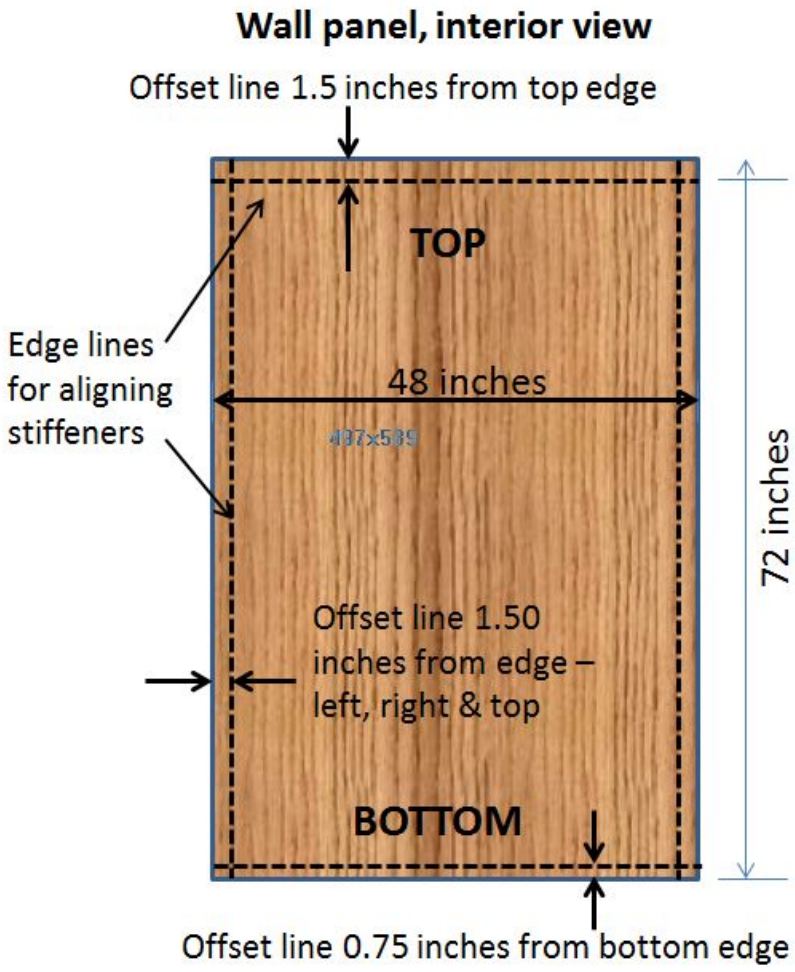


Figure 14 – Wall panel, interior view, marking the offset lines

1. Measure the outside lines for the stiffeners, as shown in the following figure.
2. Place the panel on its long edge.
3. On the bottom, place one short stiffener .75 inches (3/4 inch) in from the edge.
4. Hold or clamp in place.
5. From the exterior side, screw the bottom stiffener to the plywood panel by driving 6 wood screws, one every 6 inches.
6. Measure in 1.5 inches from the top and attach the top stiffener
7. Hold or clamp in place.
8. Drive 6 wood screws from the exterior side every 6 inches.
9. Line up the long vertical side stiffeners and screw (attach) to the door panel.

The following figure shows the interior view of a wall panel with dimensions.

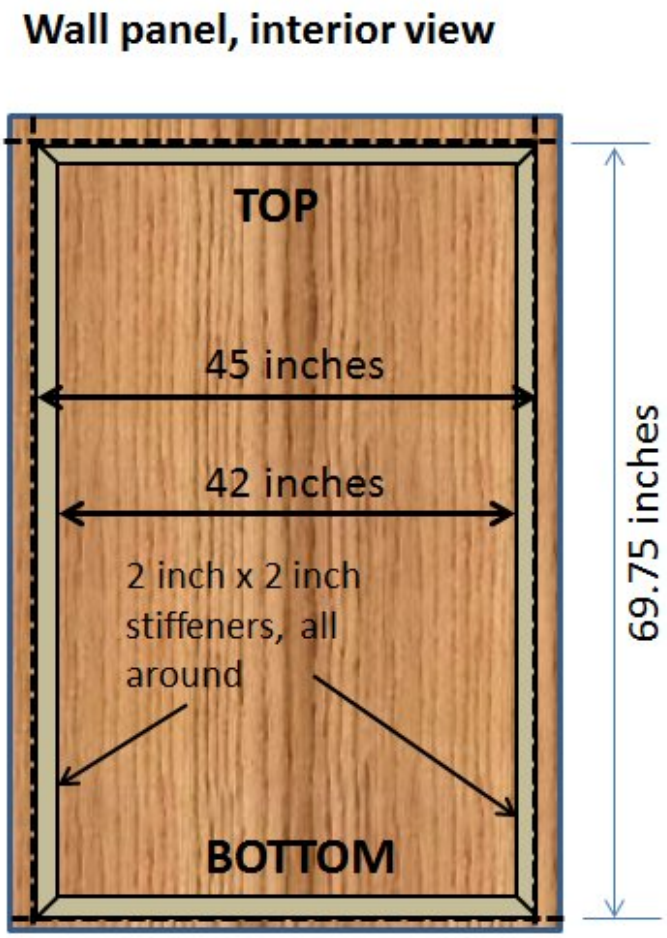


Figure 15 – Wall panel, interior view, showing the perimeter stiffeners

MAKING THE WALL SPLINES

Both straight and angled wall splines are needed to hold the wall and door panels together.

MAKING THE DOOR PANELS

The HOME shelter has two (2) door panels; these are the same dimension and construction as the regular wall panels. Each door panel will have a 2 ft. x 5 ft. cutout centered in the door panel. Two (2) doors for each shelter are required by United Nations Shelter Guidelines. The cutout is framed inside and out by other board and plywood lumber.

The exterior bottom and top board lumber serve as guide tracks for sliding the door left or right. The interior plywood lumber top and bottom serve as retainers to keep the door from falling inside the HOME.

MATERIALS FOR DOOR PANELS (2)

1. Two (2) wall panels
2. Four (4) 40 inch long plywood strips (from trimming sheets)
3. Two (2) 40-inch long 2 x 4 boards
4. Wood screws, Deckmate, All-purpose coated, 24, #8 x 1 – 5/8 inch, star drive.

TOOLS

1. Table saw, 10 amp, 10 inch, recommended
2. Radial arm saw, 10 inch, 3 HP recommended
3. Circular saw, 10 – 20 amp, 7 ¼ inch blade
4. Cordless electric power drill, 3/8 inch chuck
5. Star driver bit,
6. Sawzall, 12 amp, reciprocating saw, 1.25 inch or more depth

ASSEMBLING THE DOOR PANEL

MARK THE OPENING

1. Mark a rectangle, as shown in the following figure, centered in the wall panel.
2. Measure in from both edges, 12 inches.
3. Measure in from top and bottom edges, 6 inches.
4. Mark the rectangle with a carpenters pencil or similar.
5. Using the Sawzall, cut out the rectangle.

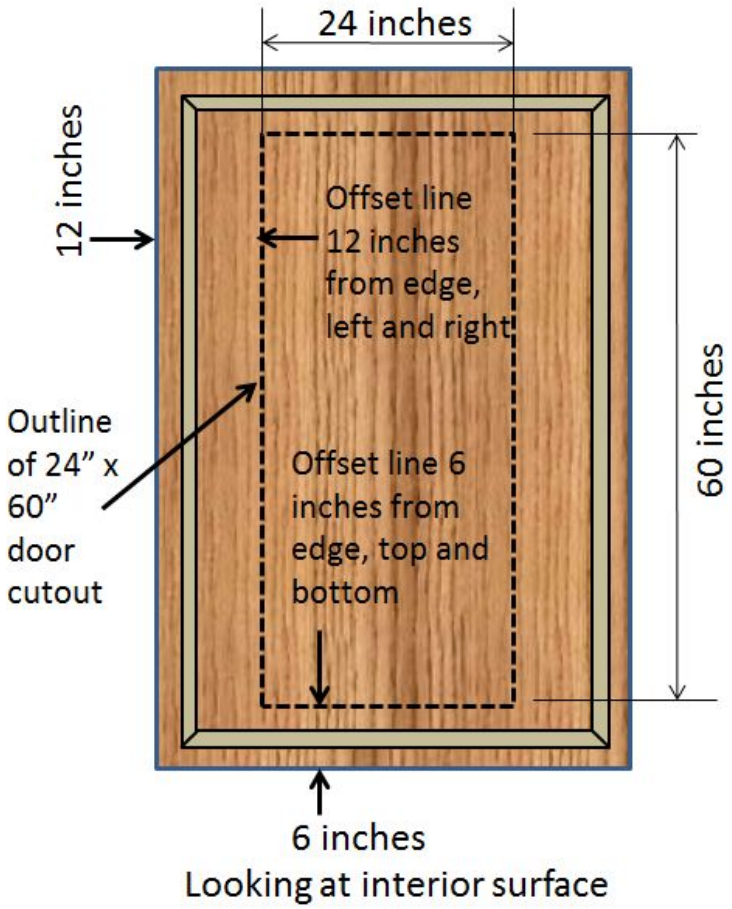


Figure 16 - Wall panel, converting to a door panel, marking the cutout

ATTACH THE EXTERIOR SPACER BOARDS ON A DOOR PANEL

1. Cut a 40 inch long 2 " x 4 " board lumber
2. From inside interior side, screw in the top spacer board in 4 places with wood screws
3. Form inside interior side, screw in the bottom spacer board in 4 place with wood screws.

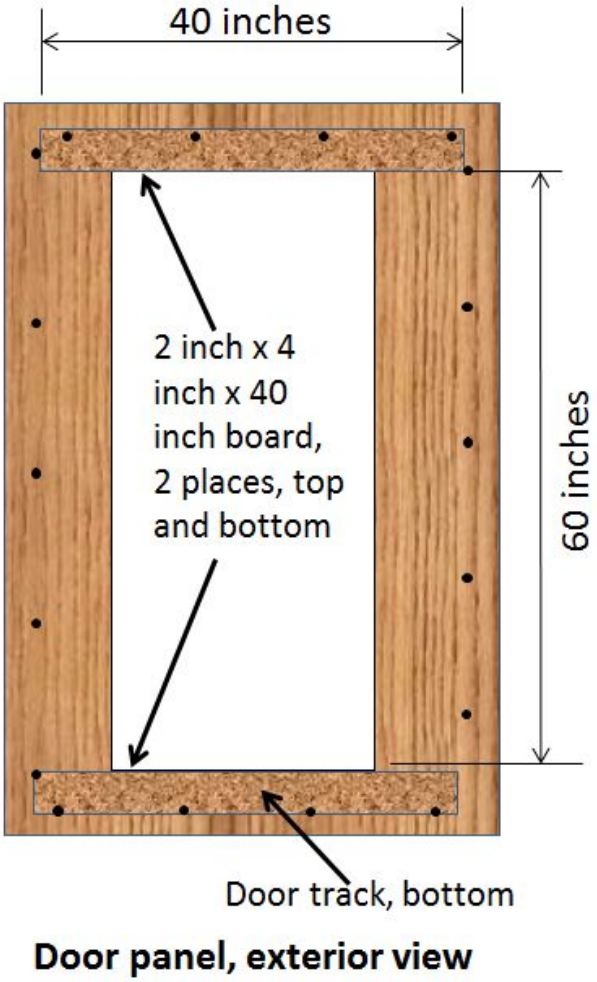
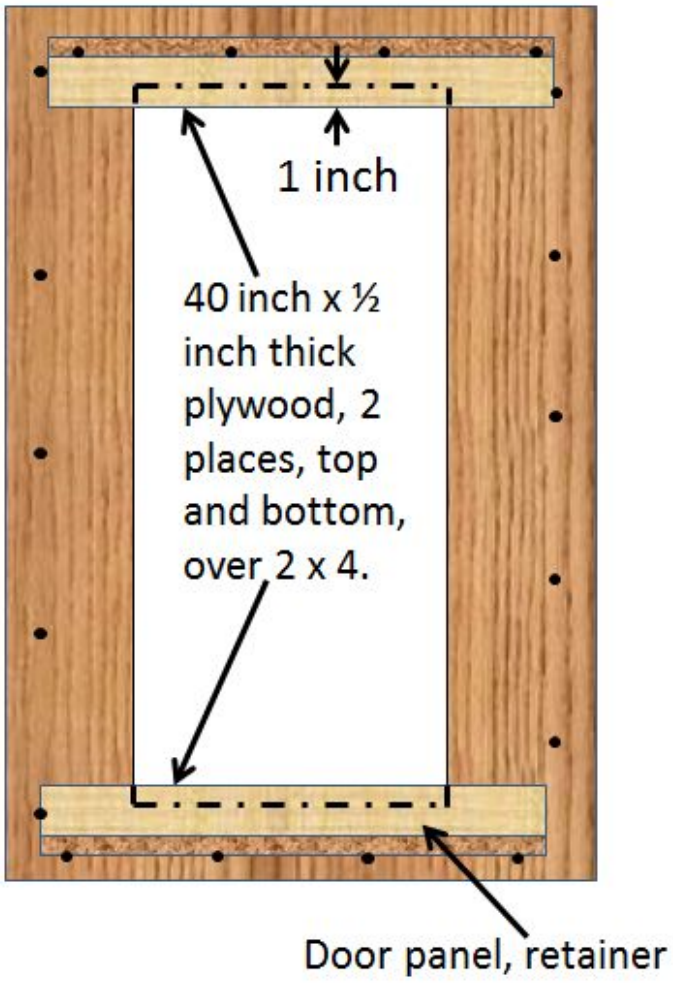


Figure 17 - Door panel, exterior view, with 2 x 4 spacer, top and bottom

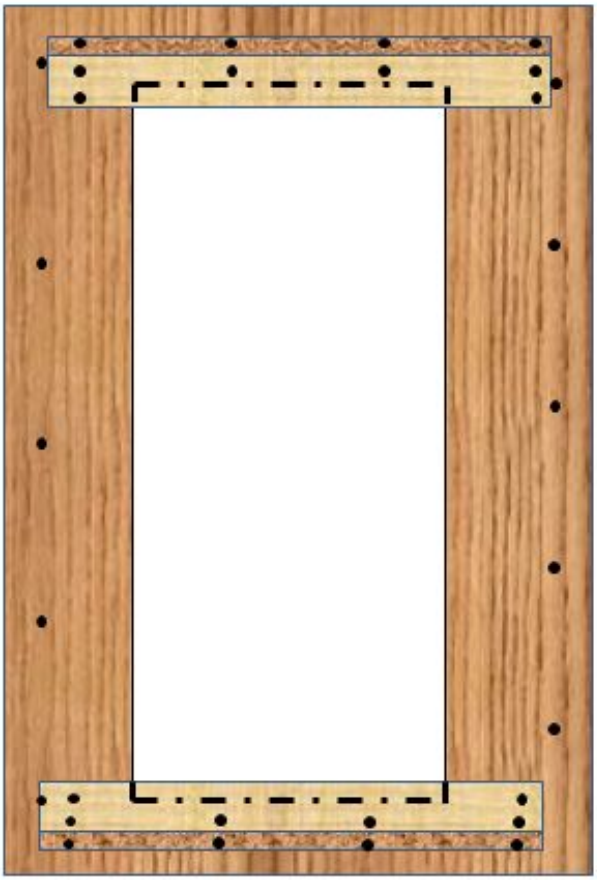
ATTACH THE EXTERIOR RETAINER BOARD

1. Position the top exterior retainer board one inch (1 inch) down from the top of the 2 x 4 spacer so that there's a one inch (1 inch) gap, as shown in the figure below.
2. Repeat for the bottom exterior retainer board.



Door panel, exterior view

3. Using six (6) wood screws, attach a 40 inch long, ½ inch thick ripped piece of plywood to the top spacer board.
4. Using six (6) wood screws, attach a 40 inch long, ½ inch thick ripped piece of plywood to the bottom spacer board.



Door panel, exterior view

Figure 18 - Door panel, exterior view, with retainer strips, top and bottom

DOOR FRAME – CROSS SECTION

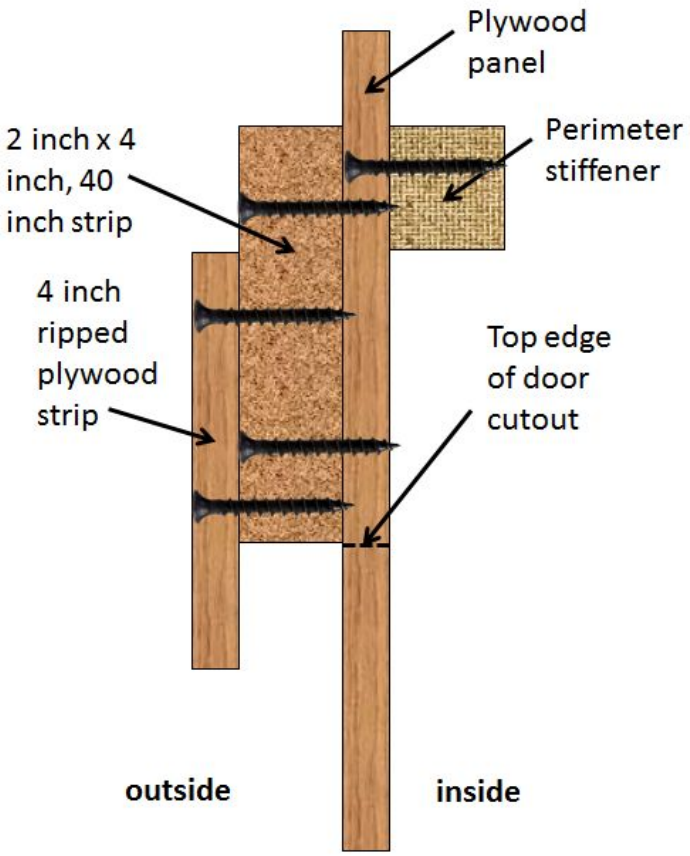


Figure 19 - Door panel, exterior view, showing cross section

ATTACH THE INTERIOR RETAINING STRIPS

1. Using one of the ripped, 4 inch wide plywood strips, insert it into the top space between the vertical stiffeners.
2. From the exterior side, attach the top retaining strip using six (6) wood screws, as shown below.
3. Repeat for bottom strip.

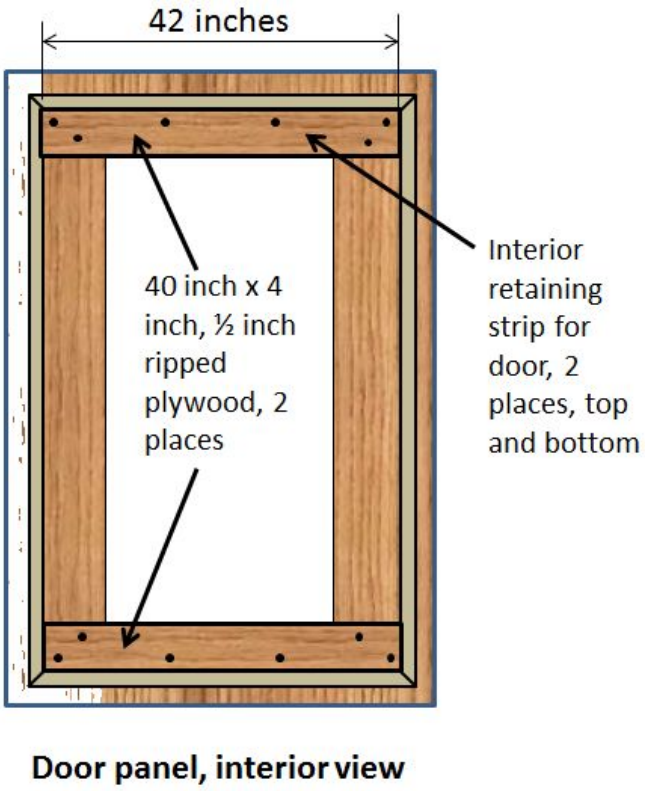


Figure 20 - Door panel, interior view, with retainer panel strip

ATTACH THE EXTERIOR VERTICAL STIFFENERS AND CUT HANDHOLDS IN THE DOOR PANEL

1. Cut two (2) foot long (4') pieces of 2 x 2 board lumber.
2. Align the stiffeners along each edge, left and right.
3. Using six (6) wood screws, attach the vertical stiffeners drilling from the interior side of the door panel.
4. Using the Sawzall, cutout a two (2) inch wide X six (6) inch high opening about 30 inches from the bottom.
5. Using the 2 ½ inch hole saw, drill out an opening about five (5) feet from the bottom.

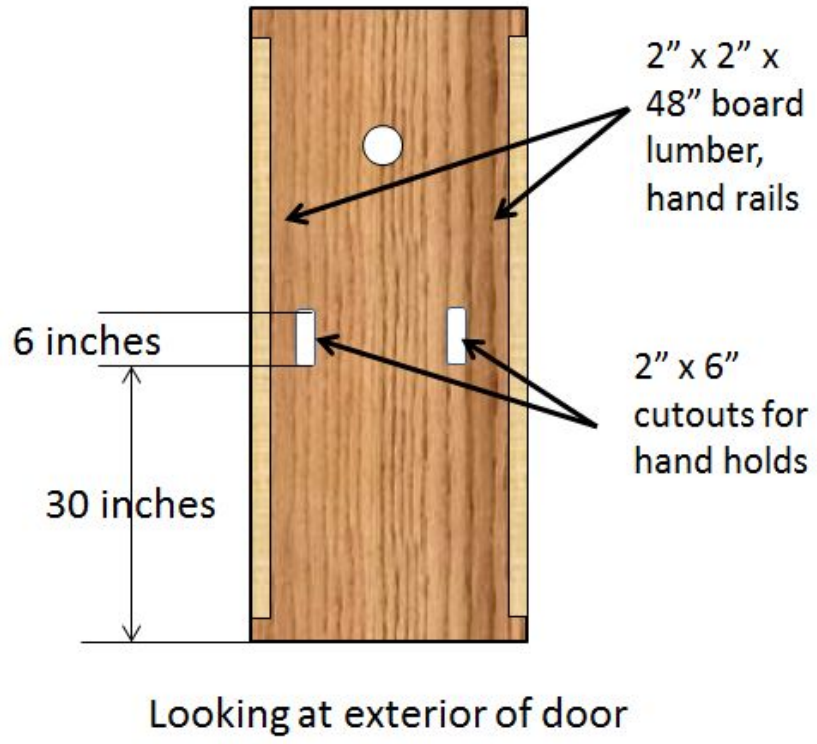


Figure 21 - Sliding door, exterior view, showing vertical stiffeners and cutouts

CROSS SECTION –DOOR FRAME

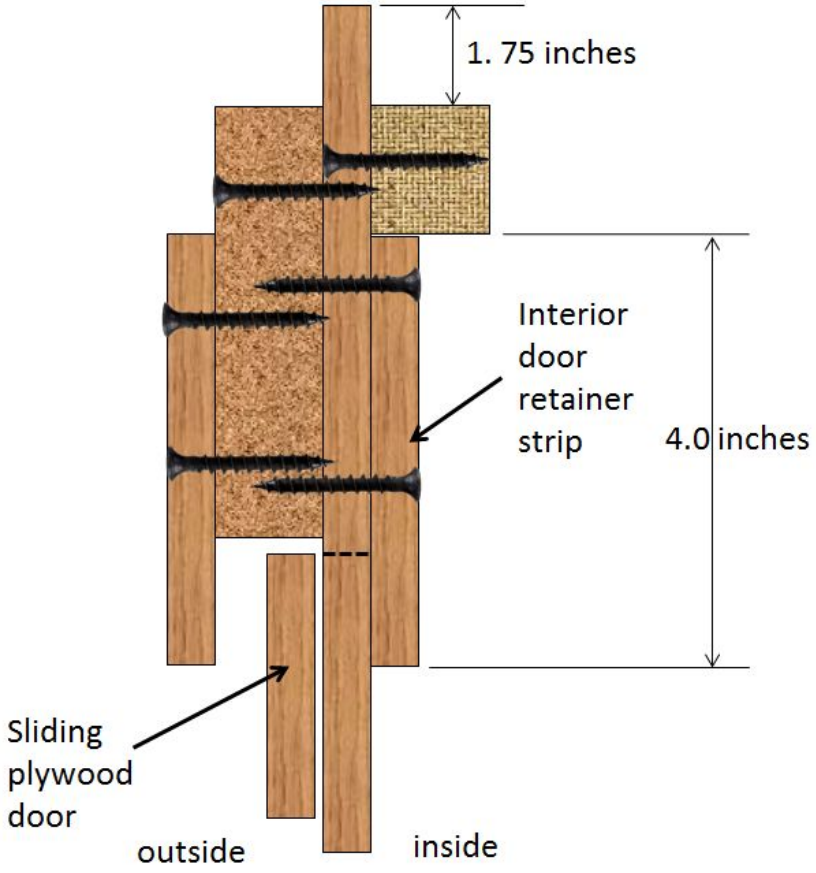


Figure 22 - Door panel, cross section, showing sliding door panel

The completed door panel is shown in the following figure.

Door panel, exterior view, with sliding door

Figure 23 - Door panel, final assembly

MAKING THE ROOF PANELS

Each roof panel is cut from a single 4 ft. x 8 ft. x 1/2 inch thick sheet of plywood. There are left side and right side roof panels, as shown in the following figures. Each roof panel weighs about 35 lbs. and is polygonal in shape with 'tongues' at both ends.

Each panel has interior side stiffeners plus 'tongues' that fit over interfaces in the power cap and on the adjacent wall panel.

Two (2) small brackets are screwed to the exterior side to hold the Corex drain pipe in place.

The top (or power cap) tongue slips over the exterior riser on the power cap. The bottom (or wall panel) tongue slips over the wall panel and rests on the horizontal inner stiffener.

MATERIALS FOR THE 12 ROOF PANELS

You need the following materials to construct the 12 roof panels.

1. Twelve (12) sheets of 7/16 inch thick, 4‘ x 8’ plywood, pressure treated (recommended), CDX grade, Rtd sheathing.
2. Twenty four (24) 2 inch x 2 inch x 10 ft. pressure treated lumber for the wall panel perimeter stiffeners, cut into the following lengths.
    a.
3. Wood screws, 1 5/8 inch, self-tapping, star-drive, all-purpose, coated, countersunk, steel, flat head.
4. Wood glue

TOOLS

1. Table saw, 10 amp, 10 inch, recommended
2. Radial arm saw, 10 inch, 3 HP recommended
3. Circular saw, 10 – 20 amp, 7 ¼ inch blade
4. Cordless electric power drill, 3/8 inch chuck
5. Star driver bit,

THE LEFT SIDE ROOF PANEL

The following figure shows a left side roof panel in place attached to the power cap and adjacent wall panel. To make one (1) roof panel, you will cut a single piece of 4 x 8 sheet of plywood to size and attach several stiffeners and brackets that hold the panel in place.

NOTE: CUTTING THE SHAPE IS CRITICAL TO FITTING THE ROOF PANEL IN PLACE. MEASURE EXACTLY.

The following figures shows the top and bottom sides of the left roof panel. There are pairs of brackets and a polygonal stiffener on the underside. The top side is fairly clean with only two (2) small brackets on the outside edge. These are the gutter brackets that hold the Corex split pipe in place.

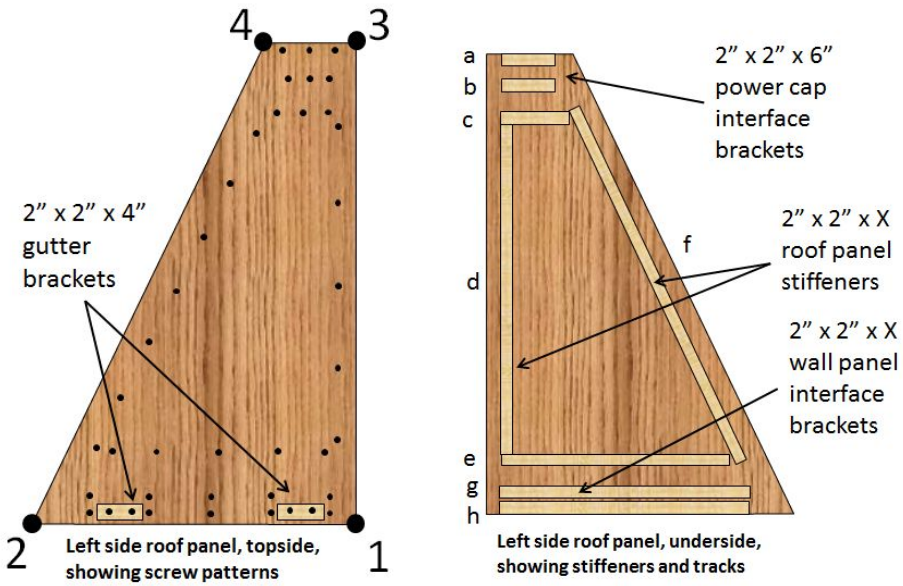


Figure 24 - Left side roof panel, top and under side views

CUTTING A LEFT SIDE PANEL

For a **left side roof panel**, here is the basic cutting technique:

1. From POINT 1 the lower right angle corner of a single sheet of plywood, measure exactly XX.X inches to the left.

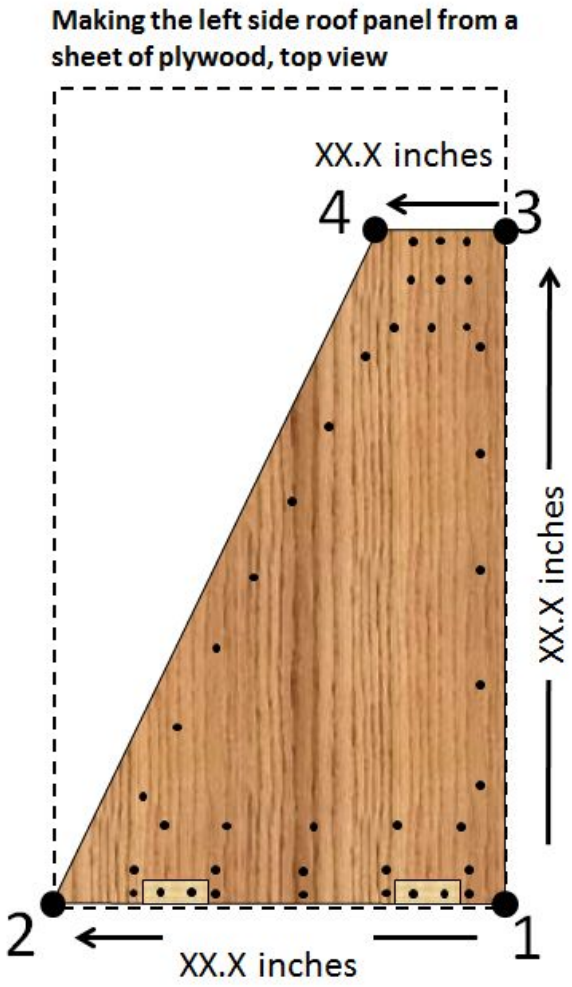


Figure 25 - Left side roof panel, topside, showing screw hole pattern

2. Mark as POINT 2.
3. From the lower right angle corner, measure up exactly XX.X inches.
4. Mark as POINT 3.
5. From POINT 3 the upper right angle corner, measure out (or to the left) exactly XX.X inches.
6. Mark as POINT 4.
7. Draw a line from the POINT 2 to POINT 4.
8. Cut along the line.

This is your left roof panel blank.

ASSEMBLING A LEFT ROOF PANEL

1. Align one2” x 2” x 6” outer power cap bracket (a) along the edge of the roof panel, as shown.
2. Place a 2” x 2” x 6” spacer next to it.
3. Place the second 2” x 2” x 6” inner bracket (b) next to the spacer and screw it into the roof panel.
4. Place stiffener (c) three (3) inches away from (b) and one (1) inch in from outside edge and attach to panel.
5. Place stiffener (d) one (1) inch in from edge as shown and attach.
6. Place stiffener (e) one (1) inch in from edge as shown and attach.
7. Place stiffener (f) on roof panel and attach using 7 screws – one screw every 6 inches.
8. Place wall panel interface bracket (h) along edge of roof panel and attach.
9. Place wall panel interface bracket (g) one half inch (0.5) in from (h) and attach.

Repeat steps 1 – 9 for all 6 left side roof panels

See the figure below for approximate locations.

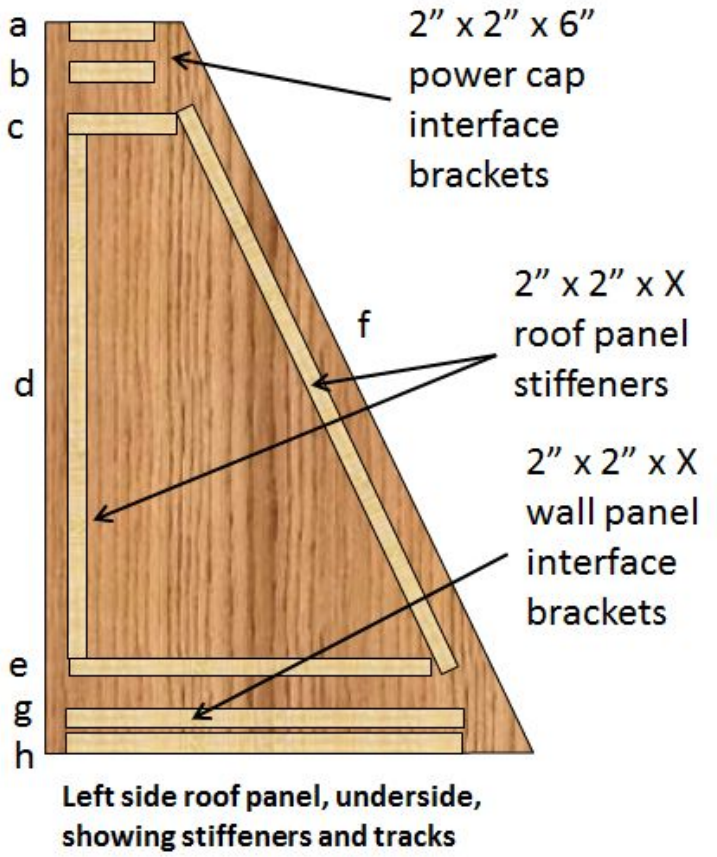


Figure 26 - Left side roof panel, underside, showing stiffeners

NOTE: DRILL AND SCREW FROM THE OUTER SIDE OF THE ROOF PANEL.

NOTE: SINCE YOU MAY END UP SCREWING 'BLIND' (WITHOUT SEEING THE BRACKET ON THE OPPOSITE SIDE), YOU NEED TO MARK THE OUTER EDGES OF BRACKETS ON BOTH SIDES.

NOTE: YOU SHOULD STAND THE ROOF PANEL ON ITS WIDE EDGE TO MEASURE AND MARK LOCATIONS OF THE BRACKETS.

See the figure below for dimensions.

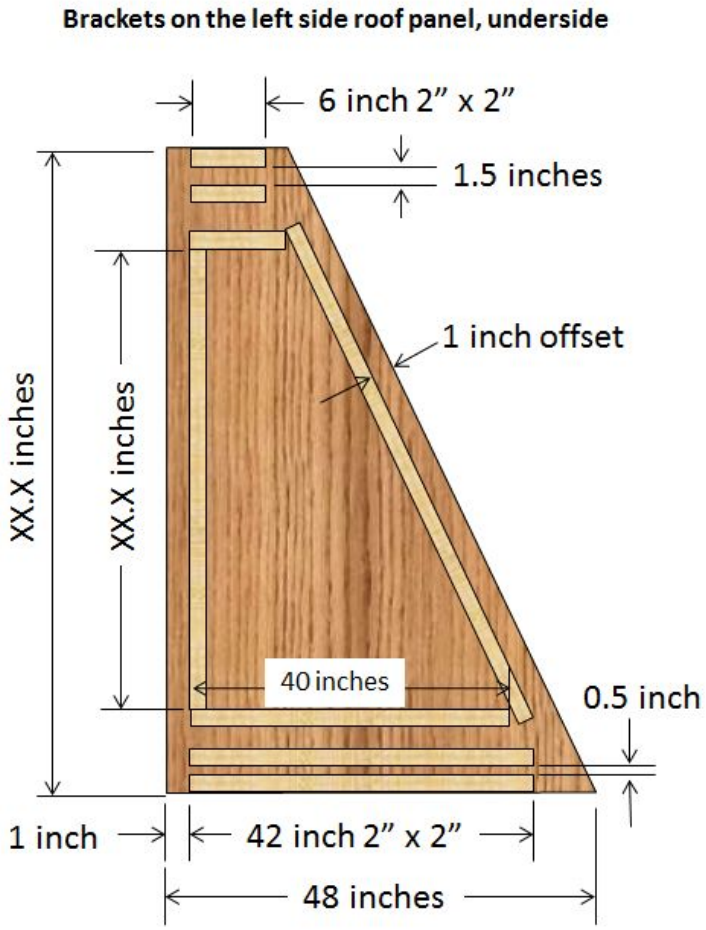
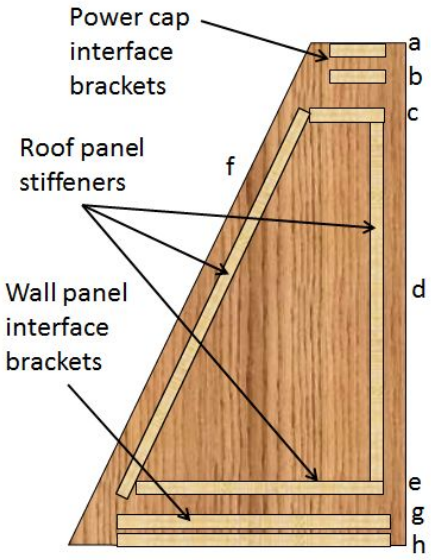


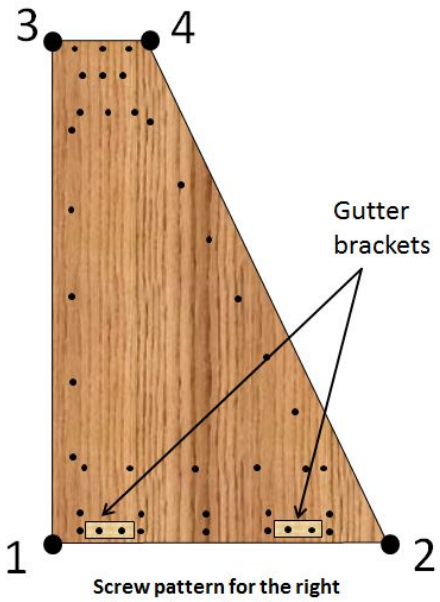
Figure 27 - Left side roof panel, underside

THE RIGHT SIDE ROOF PANEL

NOTE: CUTTING THE SHAPE IS CRITICAL TO FITTING THE ROOF PANEL IN PLACE. MEASURE EXACTLY.



Brackets on underside of right side roof panel, showing assembly sequence.



Screw pattern for the right side roof panel with gutter brackets, top view

For a **right side roof panel**, here is the basic cutting technique:

CUTTING A RIGHT SIDE PANEL

1. From POINT 1 the lower right angle corner of a single sheet of plywood, measure exactly XX.X inches to the left.

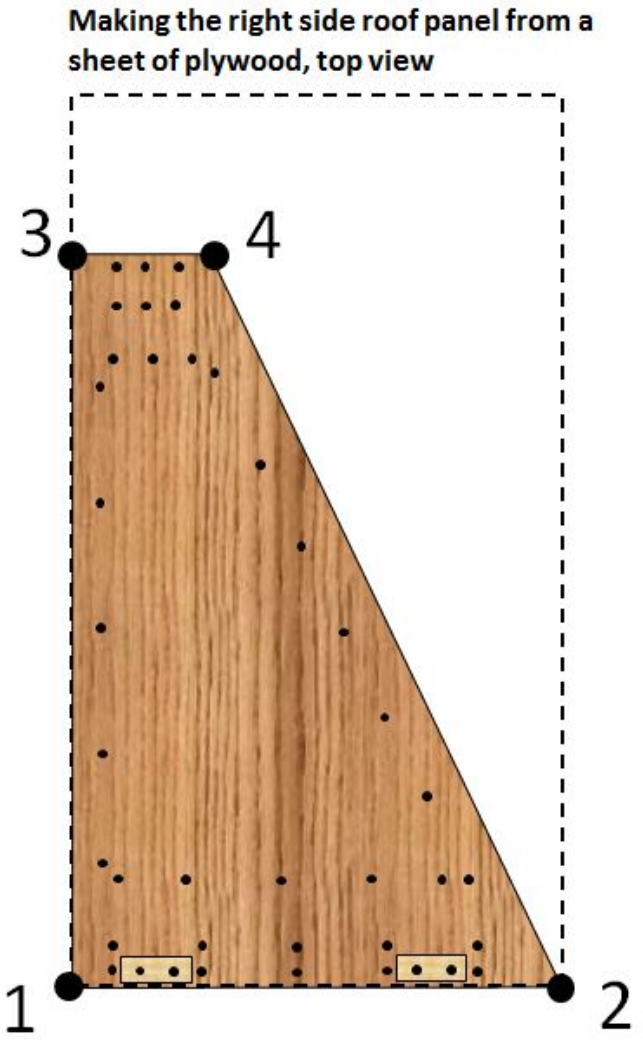


Figure 28 - Right side roof panel, topside, showing screw pattern

2. Mark as POINT 2.
3. From the lower right angle corner, measure up exactly XX.X inches.
4. Mark as POINT 3.
5. From POINT 3 the upper right angle corner, measure out (or to the left) exactly XX.X inches.
6. Mark as POINT 4.
7. Draw a line from the POINT 2 to POINT 4.
8. Cut along the line.

This is your right roof panel blank.

ASSEMBLING A RIGHT SIDE ROOF PANEL

1. Align one2” x 2” x 6” outer power cap bracket (a) along the edge of the roof panel, as shown.
2. Attach it to the roof panel with wood screws, as shown.
3. Place a 2” x 2” x 6” spacer next to it.
4. Place the second 2” x 2” x 6” inner bracket (b) next to the spacer and screw it into the roof panel.
5. Place stiffener (c) three (3) inches away from (b) and one (1) inch in from outside edge and attach to panel.
6. Place stiffener (d) one (1) inch in from edge as shown and attach.
7. Place stiffener (e) one (1) inch in from edge as shown and attach.
8. Place stiffener (f) on roof panel and attach using 7 screws – one screw every 6 inches.
9. Place wall panel interface bracket (h) along edge of roof panel and attach.
10. Place wall panel interface bracket (g) one half inch (0.5) in from (h) and attach.

Repeat steps 1 – 9 for all 6 right side roof panels

See the figure below for approximate locations.

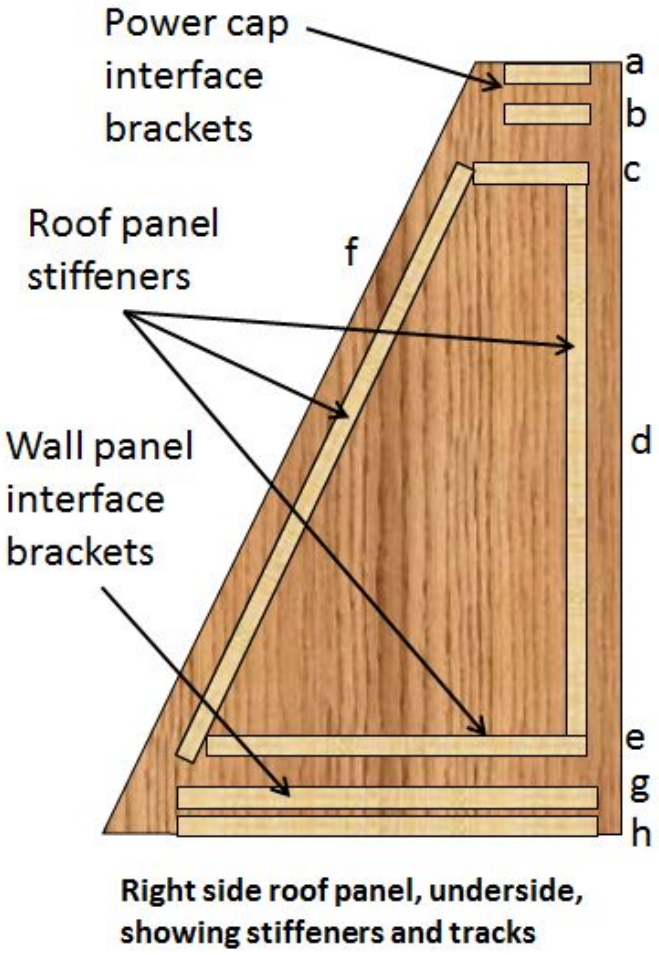


Figure 29 - Right side roof panel, underside

Note: Drill and screw from the outer side of the roof panel.

Note: Since you may end up screwing 'blind' (without seeing the bracket on the opposite side), you need to mark the outer edges of brackets on both sides.

Note: You should stand the roof panel on its wide edge to measure and mark locations of the brackets.

See the figure below for dimensions.

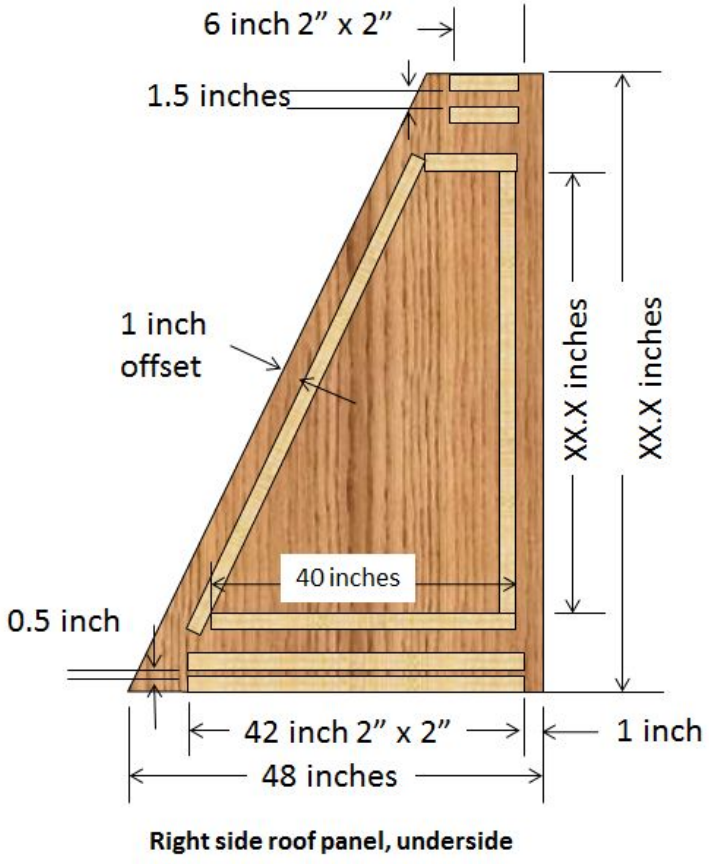
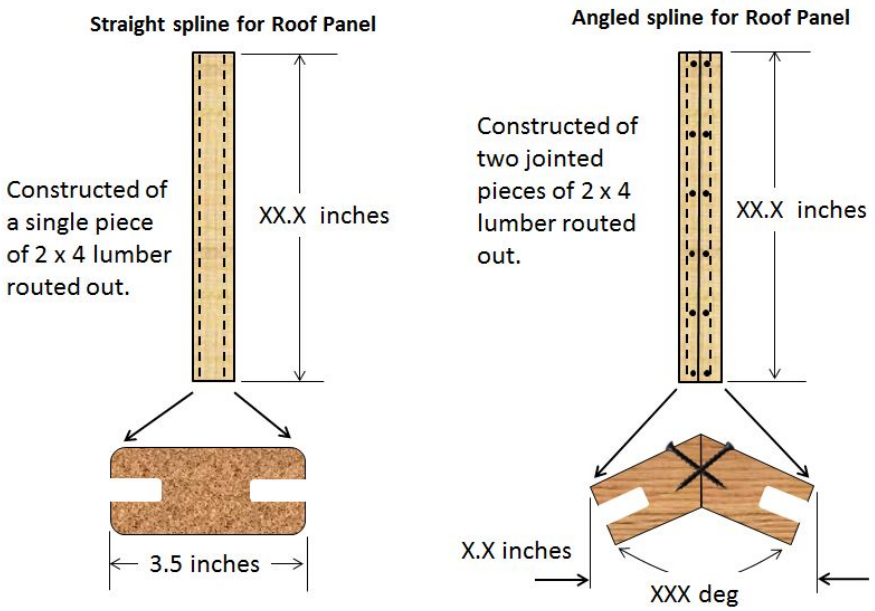


Figure 30 - Right side roof panel, underside, showing dimensions

MAKING THE ROOF SPLINES

Straight roof splines hold the left and right side roof panels together. There are 6 straight roof splines. Straight roof splines are constructed out of a single 2 inch x 4 inch x 6 foot board lumber. Each has a 1/2 inch wide x ¾ inch deep groove routed from end to end. The roof panels slip into the groove.

Angled roof splines hold right and left side roof panels at the corners of the Shelter.



CUTTING THE STRAIGHT ROOF SPLINES

1. From a single 2 x 4 x 8, measure off XX.X inches.
2. Cut
3. Measure in .75 inches from the edge and mark a line down the center of the cut 2 x 4.
4. Using the table saw, rout out a channel 0.50 inches wide x 0.75 inches deep down the length of the cut 2 x 4.
5. Set aside
6. Repeat 5 more times.

CUTTING THE ANGLED ROOF SPLINES

Angled roof splines connect the pairs of roof panels together.

Insert diagram of angled roof spline here.

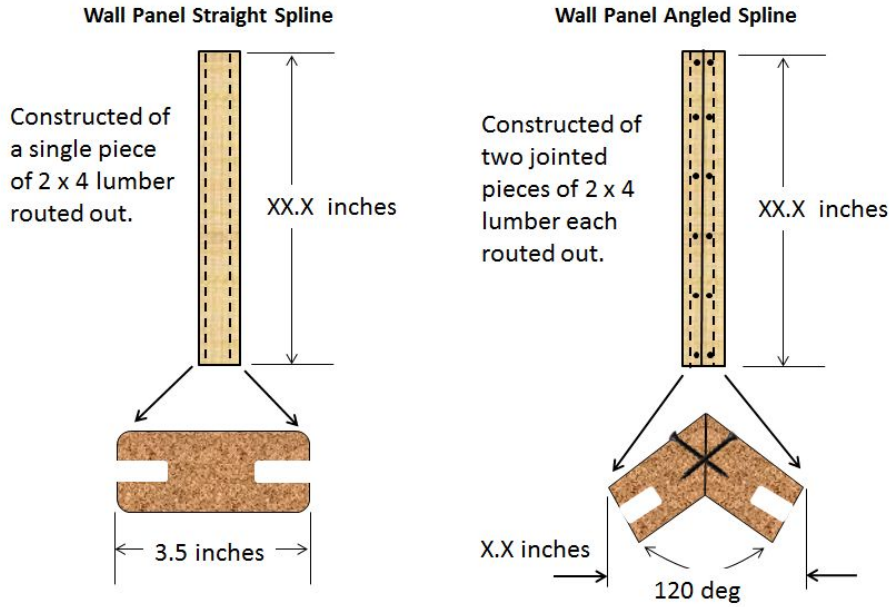
1. Measure
2. Cut
3. Measure
4. Cut

ASSEMBLING THE ANGLED ROOF SPLINES

MAKING THE WALL SPLINES

Straight wall splines hold the left and right side roof panels together. There are 6 straight wall splines. Straight wall splines are constructed out of a single 2 inch x 4 inch x 6 foot board lumber. Each has a 1/2 inch wide x ¾ inch deep groove routed from end to end. The wall panels slip into the groove.

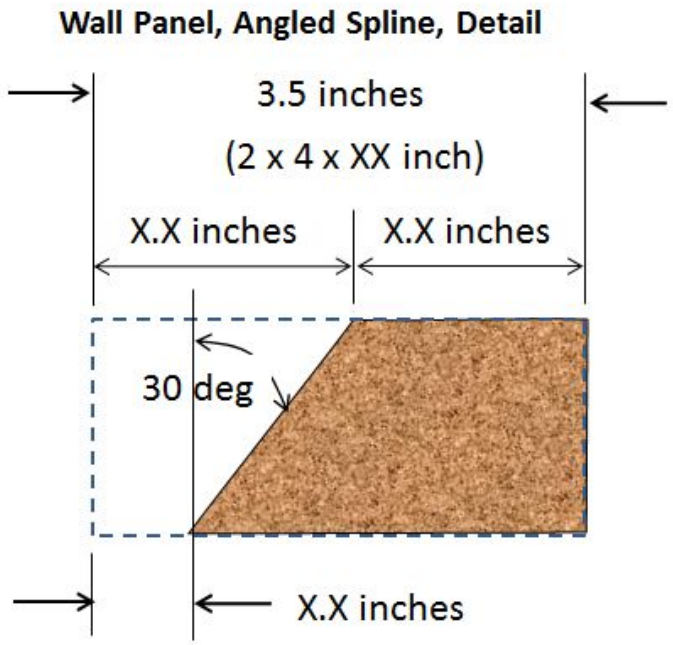
Angled wall splines hold the corner wall panels at the corners of the Shelter. Each angled spline is constructed of two (2) joined pieces of 2 x 4 lumber that are trimmed with a bevel at 60 degrees using a table saw.



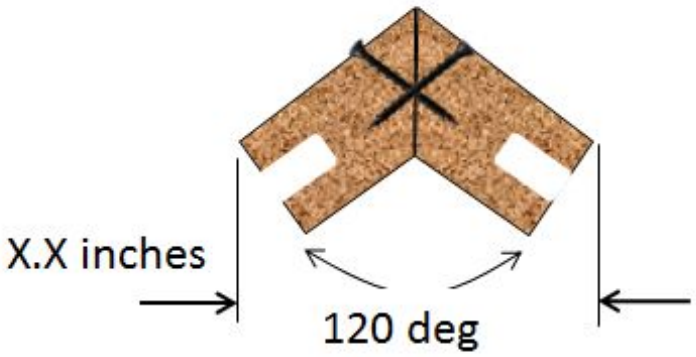
CUTTING THE STRAIGHT WALL SPLINES

CUTTING THE ANGLED WALL SPLINES

Angled roof splines connect the pairs of roof panels together.



ASSEMBLING THE ANGLED WALL SPLINES



ASSEMBLING THE ROOF PANELS AND SPLINES

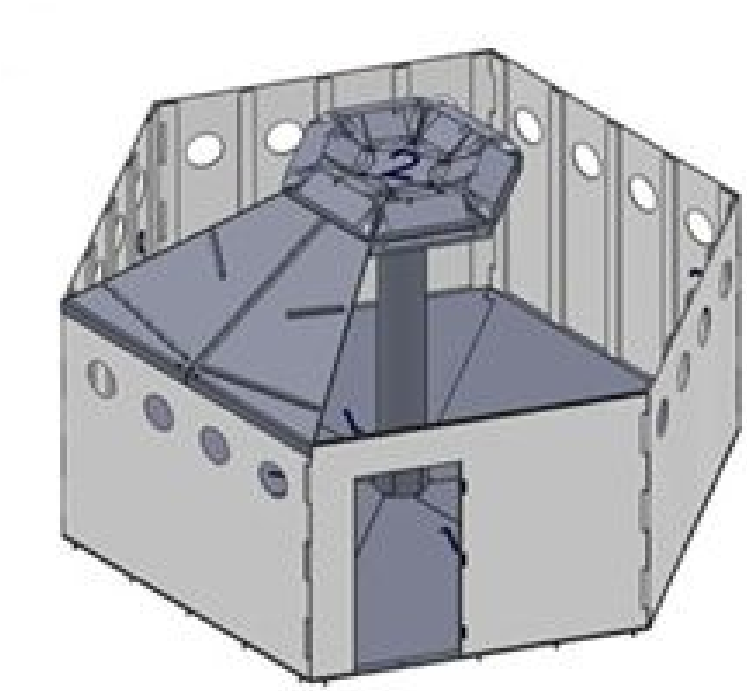


Figure 31 - Roof panels, left and right side installed

Paint the exterior roof panel surface with a sealant. If you live in a tropical environment, then paint the exterior roof with a reflective white paint. If you live in a temperate climate zone, then paint with a light or medium gray paint.

MAKING THE POWER CAP

The power cap is a small hexagonal shape measuring approximately 27 inches on a side and four (4) feet across. The top and bottom are made from a single sheet of 4 ft. x 8 ft. x ½ inch thick plywood. The electronics are sandwiched between the two (2) pieces of plywood.

The plywood sheets are separated by two (2) risers – the outer riser is made from standard 2 x 4s and does not support the plywood. The 2 x 6 inch inner spacer supports the top and bottom sheets. A load spacer of two (2) pieces of 2 x 6 inch lumber distributes to load from the cap to the metal column.

The Power Cap is the protective cocoon for the electronics as well as distributing the roof load. It is the primary interface for the roof panels and the center support column, also. Thus, the power cap is the structural and electronic 'heart' of the HOME Shelter.

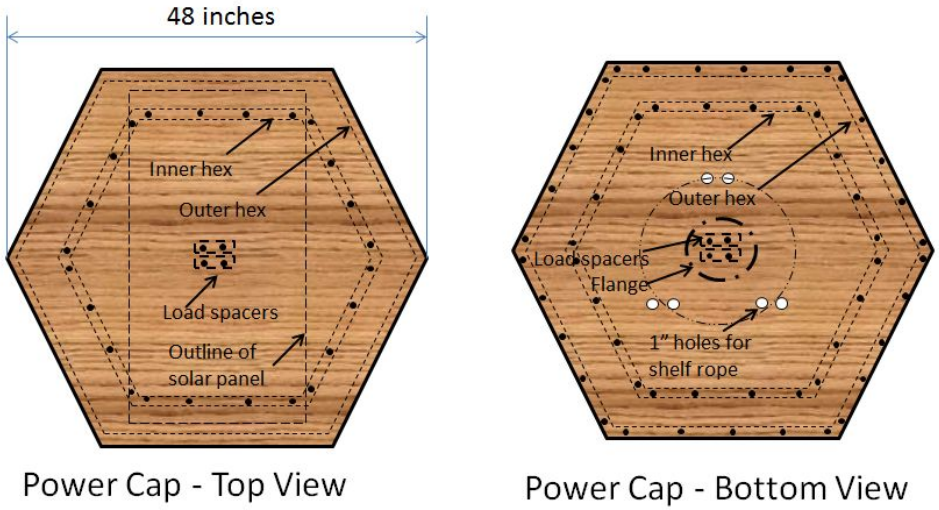
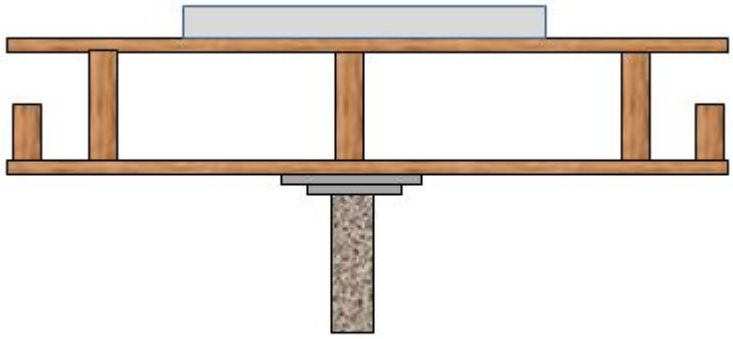


Figure 32 - Power cap, top view, showing screw pattern



Power cap, section : showing risers, spacer, support column, flange, & solar panel

Figure 33 - Cutaway side view of power cap

MATERIALS FOR THE POWER CAP

You need the following materials for the power cap.

1. Plywood, one (1) sheet of 4 ft x 8 ft. x ½ inch thick plywood, pressure treated (recommended), CDX grade.
2. Lumber, four (4) eight (8) foot, six (6) inch high, two (2) inch wide commercial grade lumber.
3. Wood glue
4. Wire clamps
5. Wood screws, 1 5/8 inch, self-tapping, star-drive, all-purpose, coated, countersunk, steel, flat head

The following figure shows a top internal view of the power cap.

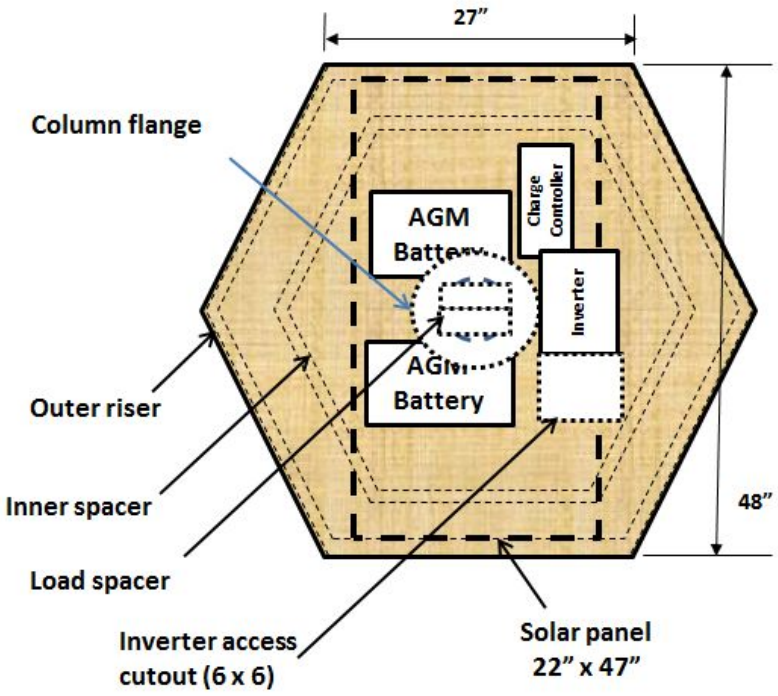


Figure 34 - Power Cap, Top Internal View

The following figure shows a cutaway side view of the power cap.

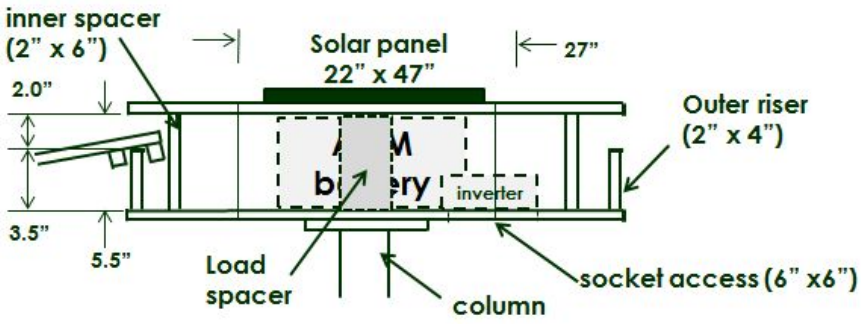


Figure 35 - Power Cap - Side View

TOOLS

1. Table saw, 10 amp, 10 inch, recommended
2. Radial arm saw, 10 inch, 3 HP recommended
3. Circular saw, 10 – 20 amp, 7 ¼ inch blade
4. Cordless electric power drill, 3/8 inch chuck
5. Star driver bit,

MEASURING AND CUTTING THE POWER CAP MATERIALS

MEASURING AND CUTTING THE PLYWOOD

DRILLING HOLES FOR THE LED LIGHTS

MEASURING AND CUTTING THE RISERS

MEASURING AND CUTTING THE SPACERS

ASSEMBLING THE POWER CAP

The power cap is assembled as follows:

STEP ONE

STEP TWO

STEP THREE

STEP FOUR

STEP FIVE

STEP SIX

STEP SEVEN

STEP EIGHT

RAISING THE POWER CAP

Once you have the walls up, then you can raise the Power Cap in the center of the HOME shelter as follows:

The steps to install the power cap are as follows.

1. Tilt the power cap on edge.

2. Locate and mark the center of the hexagonal power cap.

3. Attach the metal pipe flange to the underside piece of plywood.

4. Thread the 3 inch diameter column pipe into the threaded flange.

5. Locate and mark the approximate center of the shelter.

6. Thread the 2 ½ inch diameter ground level stanchion onto the threaded flange in the center of the shelter.

7. Using three adults, tilt and raise the power cap up.

8. Now lift the power cap over and slide onto the short 2 ½ inch high stanchion on the ground.

9. Rotate the power cap so that one side is parallel to a wall panel.

10. One person slips a roof panel onto the wall panel.

10. Then lower the roof panel to slide it onto the power cap riser.

11. Rotate the power cap to align the roof panel.

11. Do the same for a roof panel exactly opposite of the first roof panel.

12. Continue attaching the pairs of roof panels and flat or cornered splines around the HOME Shelter.

Chapter

3

ELECTRICAL SUBSYSTEM

Insert a short explanation of the electrical system here.

Describe this solar power system and components like direct and analog power, battery (type), inverter, converter, switch, lights, and power socket.

Discuss some of the tradeoff issues like power output per square inch, weight, cost, availability, and reliability.

Describe where power system is located and why.

SCHEMATIC DIAGRAM

Discuss the schematic diagram here.

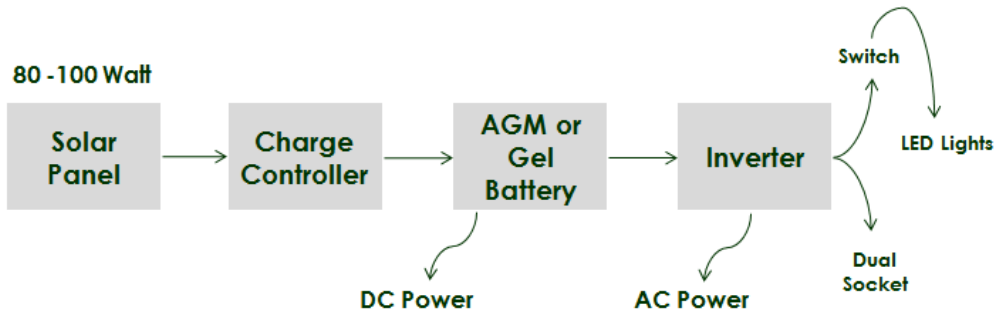


Figure 36 - Electrical schematic diagram

COMPONENTS

All components are commercially available or COTS (Commercial Off The Shelf).

SOLAR PANEL

Discuss the component specifications (performance, weight, etc.) here.

Discuss the recommended manufacturer here.

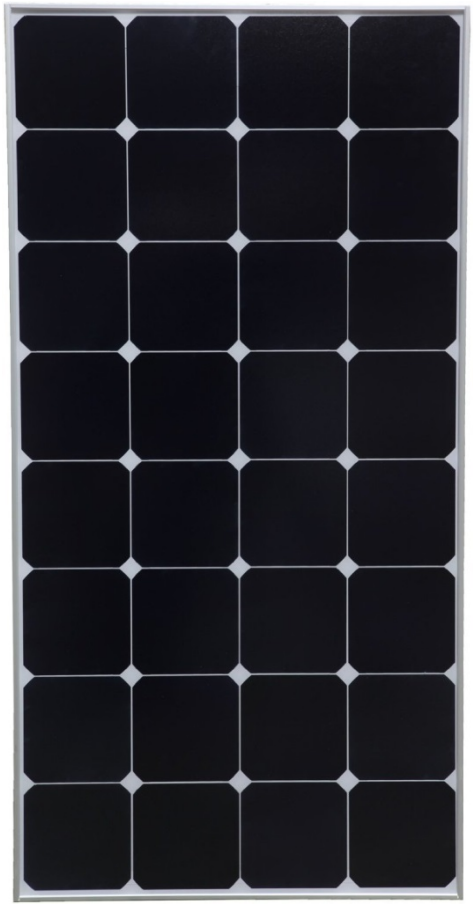


Figure 37 - Solar panel, typical.

BATTERIES

The batteries (2) selected is the sealed acid, AGM type battery manufactured by Universal Battery. Model number - UB12180. The following table lists the physical specifications.

Product Type:	Universal Battery
Model No:	UB12180
Chemistry:	Sealed Lead Acid / AGM

PHYSICAL SPECIFICATIONS	
Length (in.):	7.13
Width (in.):	3.00
Height (in.):	6.57
Weight (lb.):	13.10
ELECTRICAL SPECIFICATIONS	
Nominal Voltage:	12
Terminal:	B1
20 hr @ 0.9A	18A

Discuss the component specifications (performance, etc.) here.

Discuss the recommended manufacturer here.

Figure 38 - Battery, storage, typical

INVERTER

Discuss the component specifications (performance, etc.) here.

Discuss the recommended manufacturer here.

Figure 39 - Xantrex PROwatt SW inverter

CHARGE CONTROLLER

Discuss the component specifications (performance, etc.) here.

Discuss the recommended manufacturer here.

Figure 40 - Charge controller, typical

WIRING

Discuss the component specifications (performance, etc.) here.

Discuss the recommended manufacturer here.

Insert a photo here

LED STRING LIGHTS

Discuss the component specifications (performance, etc.) here.

Discuss the recommended manufacturer here.

MAKING THE ELECTRICAL SUBSYSTEM – SEE MAKING THE POWER CAP

Since the electrical subsystem is housed inside the power cap, it makes sense to describe the assembly process in the power cap section.

TOOLS

MATERIALS

PREFERRED PARTS LIST

WATER SUBSYSTEM

DESCRIPTION AND FUNCTION

MATERIALS

TOOLS

MAKING THE COREX DRAIN SYSTEM

DOWNSPOUT

COREX WRAP AROUND FLEXAPIPE

COREX SUMP AND LINER

FILTRATION

PERSONAL SANITATION SUBSYSTEM

DESCRIPTION AND FUNCTION

MATERIALS

PAILS

VALVES

SEAT

PVC PIPE

TOOLS

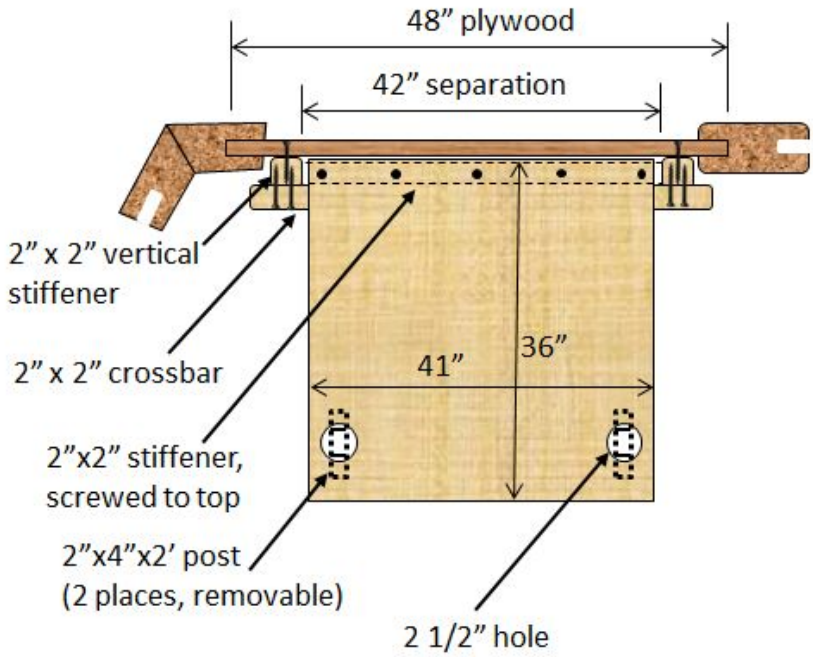
MAKING THE PERSONAL SANITATION SUBSYSTEM

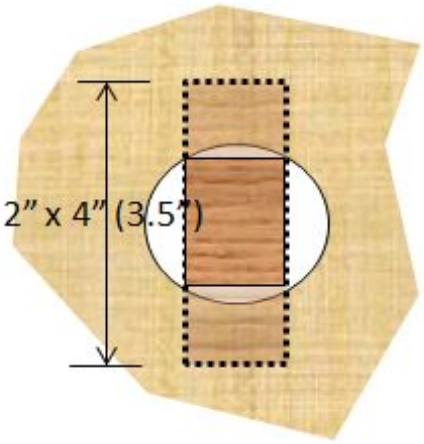
ASSEMBLY

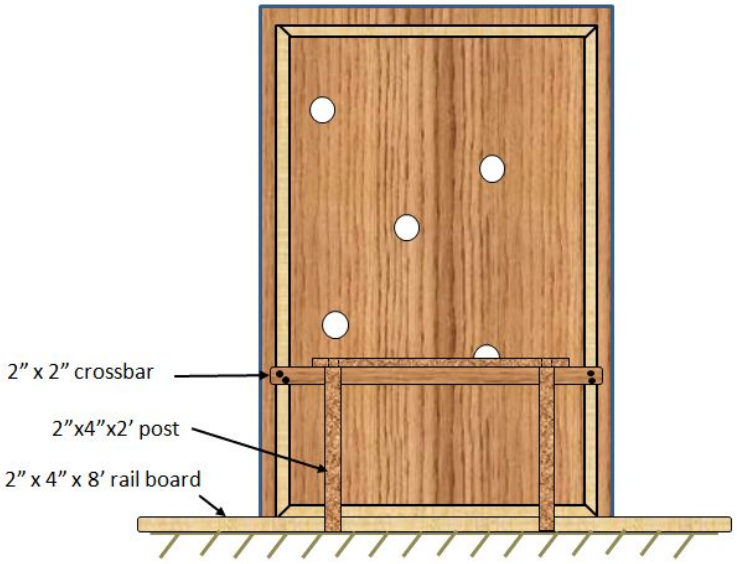
INTERIOR DESIGN AND ACCOMMODATIONS

TRANSFORMING FURNITURE

STOWAWAY TABLE TOP

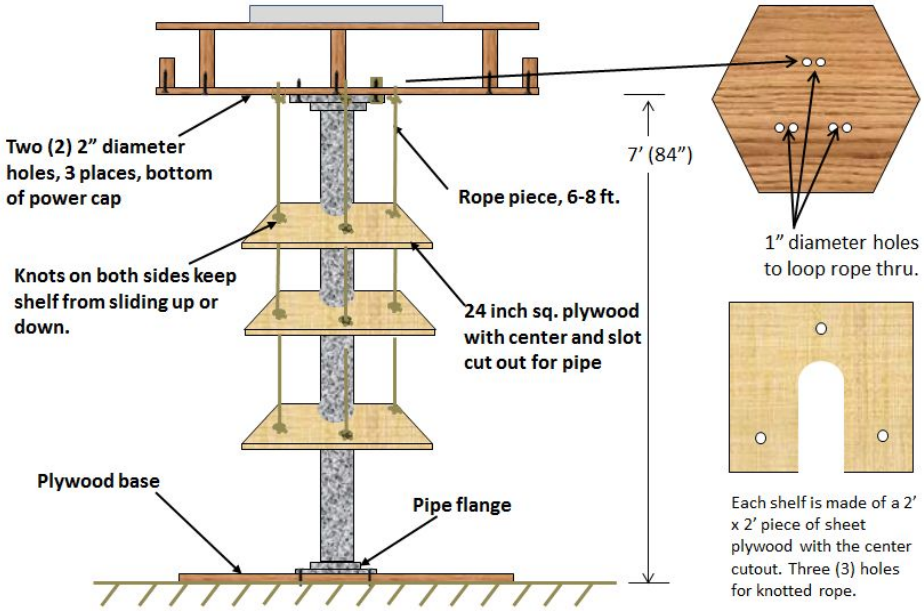

48” plywood
42” separation
2” x 2” vertical stiffener
2” x 2” crossbar
2”x2” stiffener, screwed to top
2”x4”x2’ post (2 places, removable)
41”
36”
2 1/2” hole


2” x 4” (3.5”)



HANGING SHELVES

The hanging shelves are made from the lids of sump liners or similar flat, rigid plastic lids (approximately 18 - 24 inches in diameter), three (3) ten foot pieces of rope, and three (3) screws.



CHAIR / STOOL / TABLE

The chair/stool/table is one of the multifunctional pieces of furniture in the HOME Shelter System. It's constructed of plywood, 2x2 lumber and locking hinges. The 'normal' position is the chair. When the back is folded over the front of the chair, it becomes a 3-step stool or shelf. In the half-way position (seen in the far right photo, the chair is a table when the fold-down legs are extended (not seen in this photo).

Figure 41 - The 3 Stages of the Chair / Stool / Table

MATERIALS

TOOLS

MAKING THE INTERIOR DESIGN THINGS.

MAKING THE SHELVES

The shelves are suspended from the underside of the power cap by 3 pieces of knotted rope. The shelves are made of heavy duty COREX sump liner lids. The lids are split and a 3 inch diameter cutout made in the center.

AGRICULTURAL SUBSYSTEM

FUNCTION AND DESCRIPTION

MATERIALS

1. One (1) gallon HDPE plastic planter
2. One (1) metal clothes hanger
3. One (1) 2 ½ inch diameter plastic water bottle

TOOLS

1. Small sharp knife to cut off the bottom of the plastic bottle

MAKING THE PLANTERS

HEATING AND COOLING

FUNCTION AND DESCRIPTION

INDEX

APPENDIX

LUMBER – ACTUAL SIZES AND WEIGHTS

Nominal Size (in x in)	Actual Size		
	(in x in)	(mm x mm)	Weight (lb/ft)
2 x 2	1 1/2 x 1 1/2	38 x 38	0.55
2 x 4	1 1/2 x 3 1/2	38 x 89	1.28
2 x 6	1 1/2 x 5 1/2	38 × 140	2.00
2 x 8	1 1/2 x 7 1/4	38 x 184	2.64
2 x 10	1 1/2 x 9 1/4	38 x 235	3.37

KILN DRIED LUMBER WEIGHT PER BOARD

	8	10	12	16	20
2 X 4	11	13	16	21	27
2 X 6	16	20	24	32	40
2 X 8	21	27	32	43	53
2 X 10	27	33	40	53	67
2 X 12	32	40	48	64	80

PRESSURE TREATED LUMBER WEIGHT PER BOARD

	8	10	12	16	20
2 X 4	17	21	26	34	43
2 X 6	26	32	38	51	64
2 X 8	35	44	53	70	88
2 X 10	44	55	66	88	110
2 X 12	53	66	79	106	132
4 X 4	38	48	58	77	96
4 X 6	56	70	84	112	140
4 X 8	75	93	112	149	187
4 X 10	93	117	140	187	233
4 X 12	112	140	168	224	280

GREEN LUMBER WEIGHT PER BOARD

	8	10	12	16	20
2 X 4	13	17	20	27	33
4 X 4	29	36	43	58	72
4 X 6	43	54	65	86	108
4 X 8	58	72	86	115	144
4 X 10	72	90	108	144	180
4 X 12	86	108	130	173	216
6 X 6	65	81	97	130	162

- *1 lb/ft = 1.48 kg/m*
- *1 in (inch) = 25.4 mm*