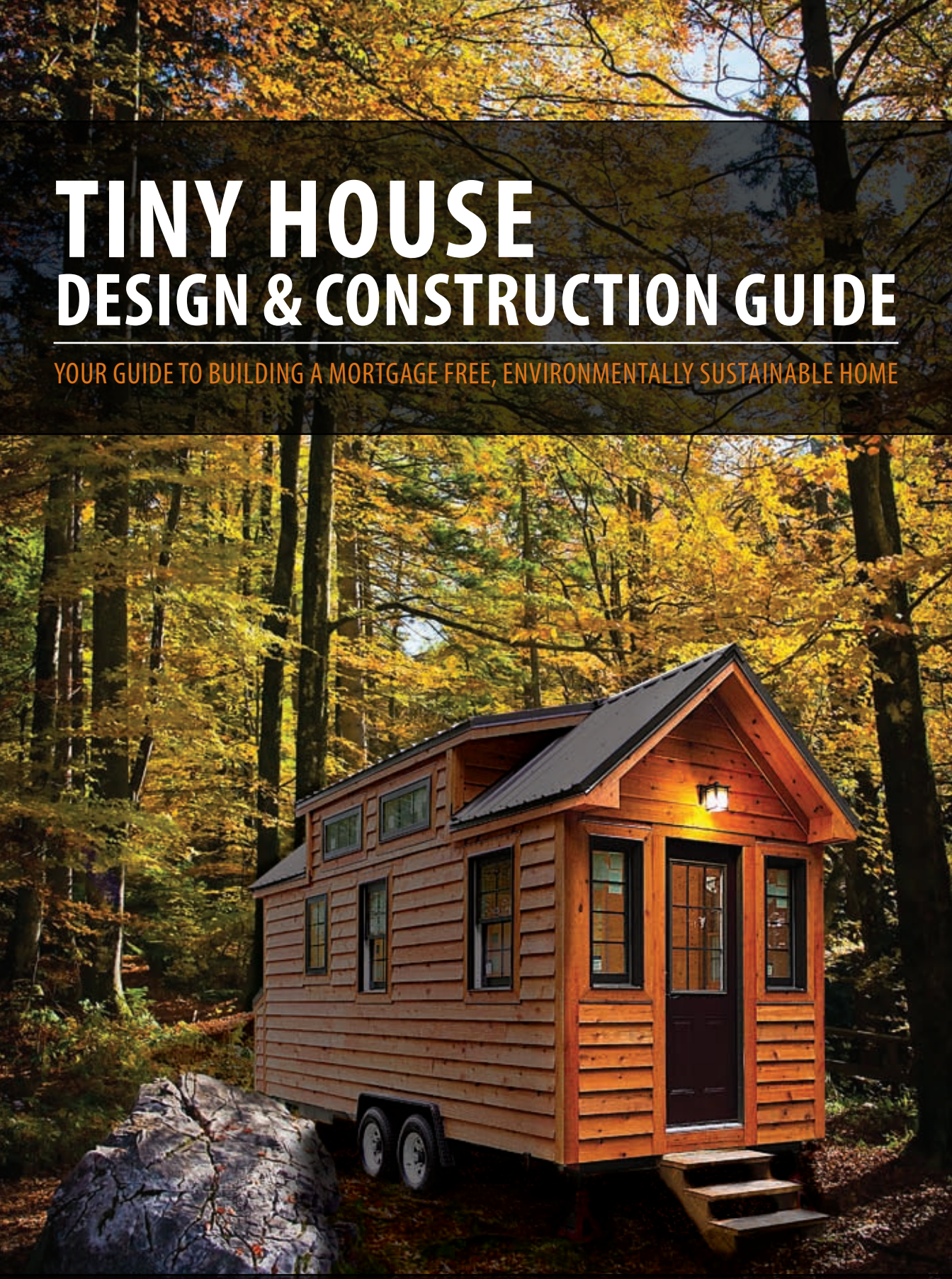
TINY HOUSE
DESIGN & CONSTRUCTION GUIDE

YOUR GUIDE TO BUILDING A MORTGAGE FREE, ENVIRONMENTALLY SUSTAINABLE HOME



DAN LOUCHE

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TINY HOME BUILDERS

http://tinyhomebuilders.com

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It is extremely important that while preforming any steps in this guide that you use the safest methods possible

BE SAFE!

Below are a few reminders while working on any project.

- Always use caution, good judgment, and common sense when following the procedures described in this guide or elsewhere.
- Read and follow any instructions or warning labels on both products and tools as they take precedence over any instructions in this guide.
- Special care should be taken when working with power tools. Only drill or cut small pieces of wood with a power tool if they are properly clamped in place. Keep your hands as far away from any blades as possible and do not wear loose fitting clothing.
- Always wear eye protection, especially when working with power tools or when using a striking tool like a framing hammer or sledge hammer.

The information contained in this book is intended to provide general guidance. Because tools, products, materials, techniques, building codes and local regulations are continually changing, Tiny Home Builders assumes no responsibility for the accuracy of the information contained herein and disclaims any liability for the omissions, errors or the outcome of any project. It is your responsibility to ensure compliance with all applicable laws, rules, codes and regulations for a project. You must always take proper safety precautions and exercise caution when taking on any project. If there is any question or doubt in regards to any element of a project, please consult with a licensed professional.

Building your own tiny house is an achievable dream!

INTRODUCTION

In August 2009 I received an unsettling call from my mother. The poorly constructed trailer home she was living in was beginning to deteriorate around her. Water lines had been leaking for some time, and now mold was growing rampant. Living under these conditions was causing her health to deteriorate, but neither she nor I had the money to purchase a conventional house or even a new trailer. So I started researching our options. I had always been interested in smaller homes, but up until this point, I had no idea there was an entire movement around tiny living. Once I discovered it, I was hooked. I began building my mother a tiny house of her own in September 2009.

After the house was complete and my mother had moved in I was amazed by the level of joy that it brought her. Her excitement was contagious as others who had previously been skeptical of tiny living were now genuinely considering the possibility of living in a tiny house themselves. When I saw this reaction I knew that I wanted to help others experience a similar level of happiness and independence and so I founded Tiny Home Builders.

I imagine since you are reading this book you too are excited about the possibilities that a tiny house can bring; the financial freedom of not having a mortgage, the freedom to move as you desire and to take your house with you, and finally the freedom of a simpler life. I hope you find answers and inspiration in these pages and realize that building your own tiny house is an achievable dream.

My Moms House

Before any construction can begin on your tiny house, you'll need to determine a design

DESIGN & PLANS

The design that you select for your house can either be your own design, an existing design, or a combination of the two.

CUSTOM DESIGN

Coming up with your own custom design allows you to create a house to your exact specification. The size restrictions imposed on tiny houses on wheels, generally a maximum of 8.5 feet wide and 13.5 feet tall, can be restrictive but can also actually make them easier to design. If someone were to give you a blank page and tell you to design your perfect house, that might be pretty intimidating. However, if instead you were given a specifically sized box and told to fit in it and arrange everything you need to live and be happy, that probably seems a lot less daunting. Sometimes having too many choices can be crippling.

The difficult part of designing your own house from scratch is that it requires a lot of knowledge that you may not already possess and that may take a lot of time to acquire. You'll need to know how to use the technology that can capture and document your design, proper framing and building techniques, and how to best take advantage of small spaces.

CAPTURING AND DOCUMENTING YOUR DESIGN

There are several different options to capture and document your design. These range in price from free to thousands of dollars. Since the free tools that are available are more than adequate for this job, I'll focus on them.

The most obvious of these options is a pencil and paper. When starting from scratch I highly recommend starting with a sketch. A sketch is great for quickly capturing your ideas and is very easy to make changes to unlike a more complicated model in a design program. The sketch can be nothing more than a floor plan that can be used to determine where the door(s), windows, bathroom, and kitchen should be. This information can then be used to help determine the external appearance.

While the entire design can be captured and built from hand drawings, there are significant advantages to using a design and modeling computer program to convert your sketches into plans. The program that we recommend and use ourselves at Tiny Home Builders is Trimble SketchUp (previously named Google SketchUp). This program has several different versions, and at the time this book was published, the basic version was free.

SketchUp is a 3D modeling program that is incredibly easy to learn. However, as with paper, if you open up the program and start with a blank canvas it can be intimidating. We recommend that you search for and download a sample model of a tiny house to get a feel for how the model should be constructed.

TinyHouseDesign.com has several tiny house models you can download for free. By using a program that models your house in 3D, you get a unique perspective and get to see how all the different components fit together. More importantly, you are able to instantly determine any measurement of any component in the house during construction.

FRAMING AND BUILDING TECHNIQUES

While understanding how to capture your design is important, you will also need to understand the proper way to frame a house so that what you design is structurally sound. While this can be extremely complicated in larger structures, it is much less difficult for a tiny house.

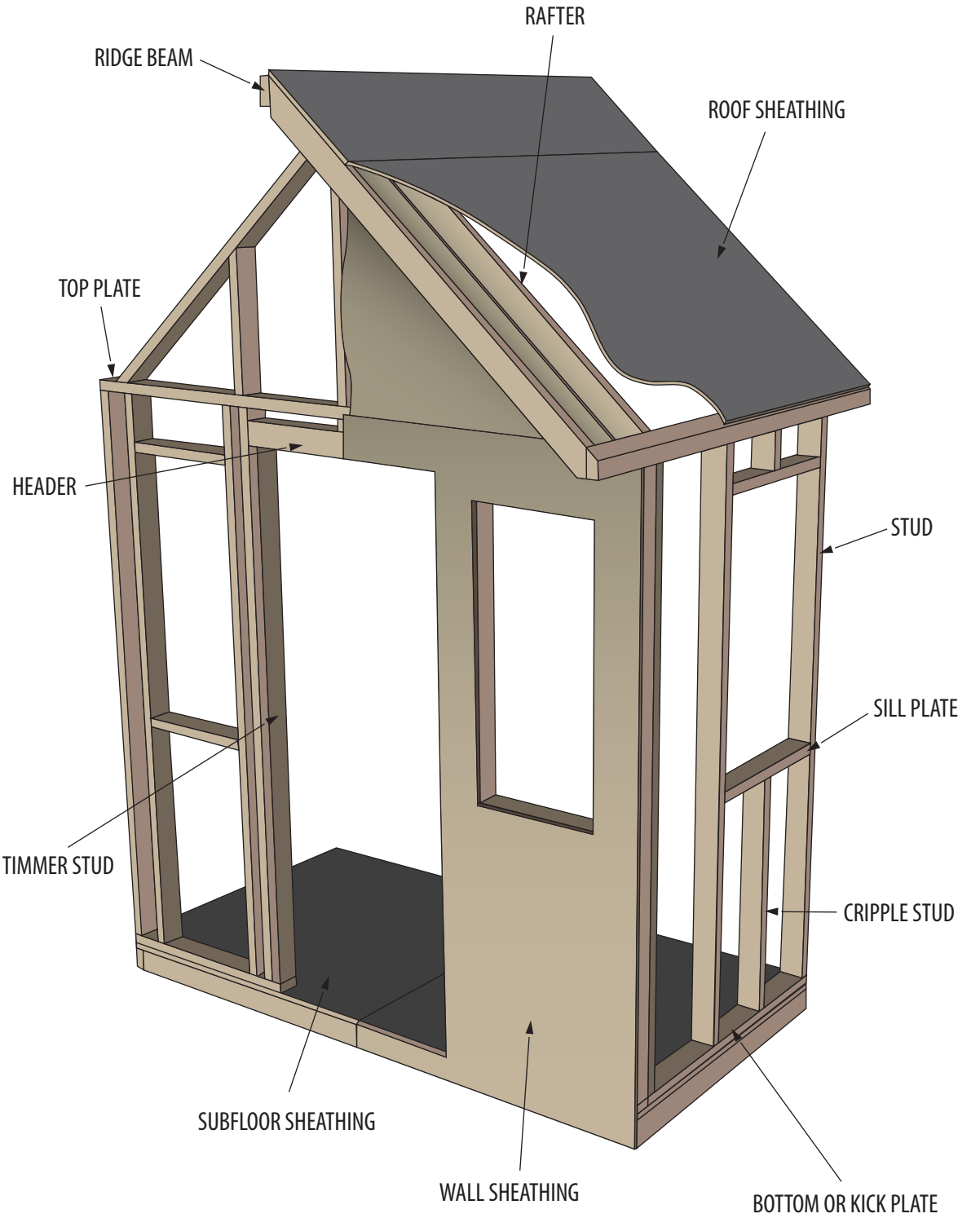
The first step is understanding the various components of a houses framing (see diagram).

Studs in a house are generally placed either 16 or 24 inches apart. Since the wood that studs are made of is not a good insulator, it is desirable to have the minimum number of them in your wall as possible while still providing sufficient support. For a smaller structure like a tiny house, 24 inches apart is usually adequate.

If possible, to reduce the number of studs and thus the amount of wood in the walls, windows should be positioned such that one side of them is against an existing stud. In load bearing walls (generally all four walls in a tiny house), if any windows or doors are large enough that they intersect a stud, a header will need to be placed above it to support the load from the cut stud. See the chapter on wall framing for more information on headers.

Older framing methods may suggest using two top plates in a house as well, but by lining up the rafter so that they make contact with the top plate at the same location that the studs make contact, the weight of the roof is transferred directly to the studs, and only a single top plate is required.

For additional information on proper building and framing standards, consult the International Building Code (IBC). For additional information on the most energy efficient framing techniques, search the internet for "advanced framing methods".



Anatomy of a House

DESIGNING FOR SMALL SPACES

The key to a successful interior design in a tiny house is having the room for all your belongings, while also having an open, roomy feel. Achieving those two conflicting goals in such a small space can be extremely challenging.

The first step, as I am sure you are aware, is to minimize your belongings. This will reduce the amount of storage and cabinets that will be required in the design. I have seen houses that were built by individuals that have failed this first step. In one case, when the front door was opened, the entire living area was filled with wall to wall cabinets. There was no sitting or common area to be had. While this allowed this person to keep more of their stuff, it also created an extremely unwelcoming space that I couldn't image living in.

On the other hand, we all require a minimum amount of belongings to live. For some this is only a toothbrush, but for others the list includes a washer and dryer. If you design a house that is so open that it has too little storage, you will either be disappointed because you miss the items you deem essential, or you will still have those things with no place to store them. Not having a place for everything will make your house feel smaller by giving it a cluttered feel.

HOUSE LAYOUT

One of the most significant decisions that is made when designing a tiny house is the location of the bathroom and the kitchen. While some choices concerning a house's layout can be changed after the house is built, like a cabinet's location or the need for an additional bookcase, the location of the bathroom and kitchen cannot. Below are two of the typical choices and a few pros and cons of each. While my observations will likely be biased since Tiny Home Builders primarily uses just one of these layouts in our designs, this should get you thinking about different aspects of this decision.

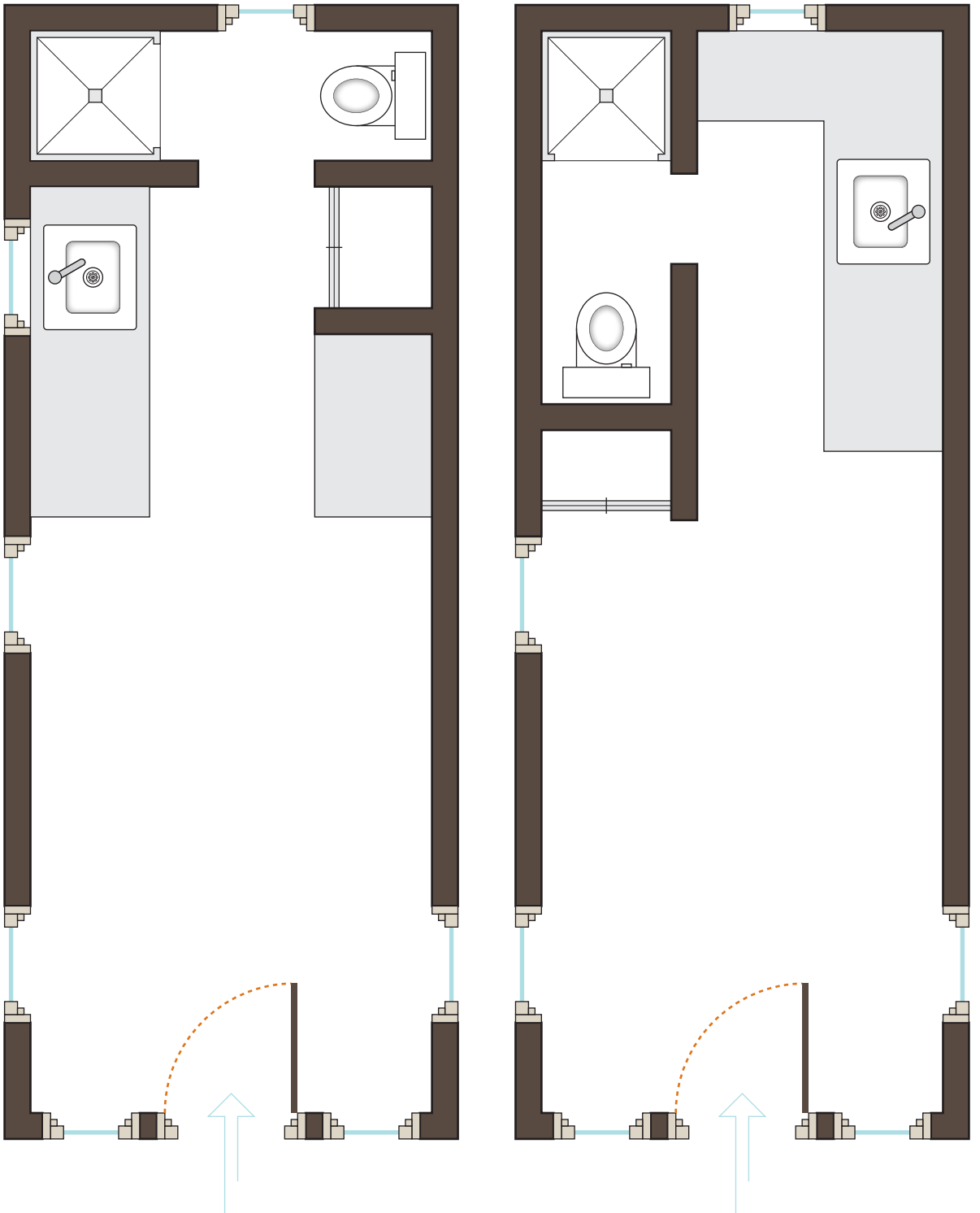
BATHROOM ALONG SHORT WALL

Pros
- House is perfect width to fit a shower and toilet in this orientation
- Kitchen and living area are opened up to each other, making both feel larger

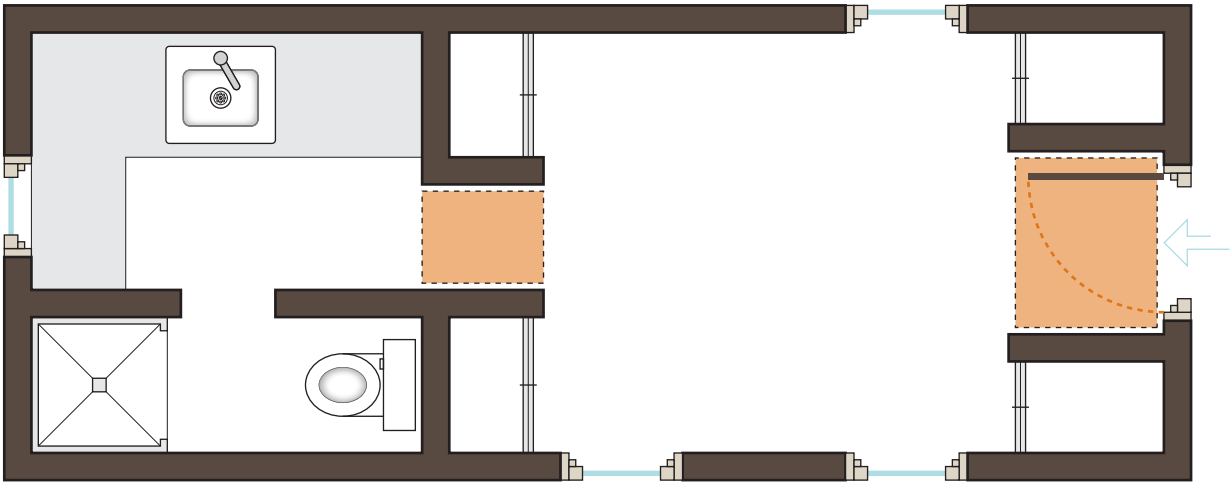
Cons
- Countertop is split between sides

BATHROOM ALONG LONG WALL

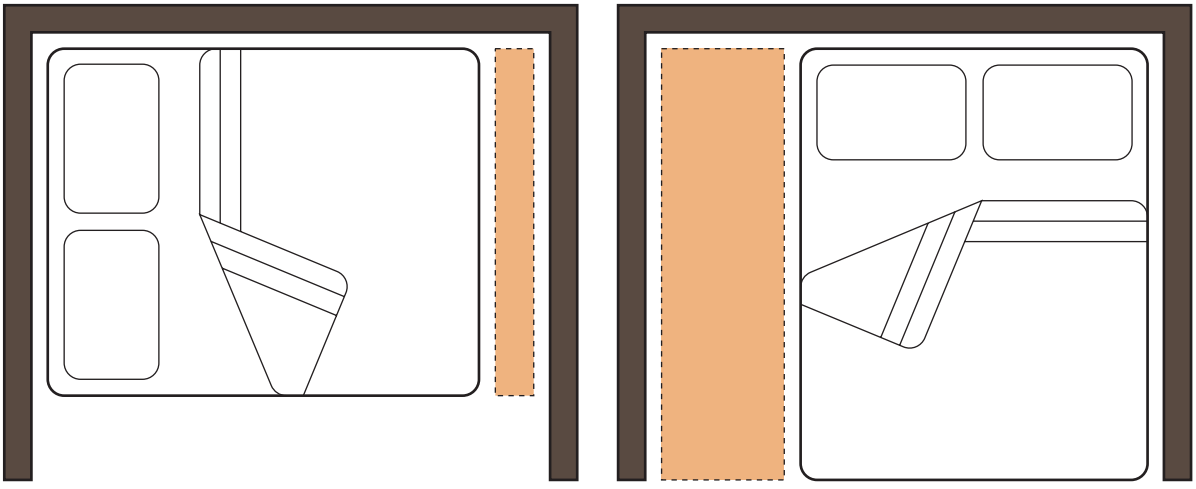
Pros
- Long, continuous countertop



Bathroom/Kitchen Layout



Micro Hallways in House Design



Efficient and Inefficient Furniture Placement

Cons

- Kitchen may have a tighter feel since it is between two solid walls
- Depending on the size of the trailer, the bathroom may overlap the wheel well, which may present some design challenges
- If the bathroom is to be under a loft, there may be a size mismatch (i.e. desired bathroom size is bigger than desired loft size)

Also, try to avoid creating micro hallways in your design. It is very easy to identify a hallway in a traditional house. It's an interior passage whose purpose is simply to provide a means of getting from one room of a house to another. A micro hallway is a little more difficult to spot. A micro hallway is any area of a house that would likely only ever be used to get from one part of a tiny house to another. It's essentially a hallway without the enclosure. You might be asking yourself, "who would put a hallway in a tiny house?", but they're a little more common than you might think. In some cases they are built into the design and structure of a house, and in other cases they are created by the placement of furniture. When designing your tiny house try to minimize any floor space that would likely only ever be stood in for a few moments.

The areas indicated on the diagrams to the left are examples of micro hallways.

EXISTING DESIGN

Because of the size constraints of a tiny house, the options for a tiny house's layout are limited. For instance, the front door can really only be placed on either the back of the trailer or on one of the sides. If it is placed on the side of the house it will most likely be off-center because of the wheel wells. If it's placed on the back of the house it will either be centered or along one of the edges. Because of these limitations, there are not nearly as many design combinations as can be found with traditional houses. So there is a good chance that a set of plans already exist for the design that you have in mind.

If you are able to settle on an existing design, even if there are a few items that you would like to change, this can be the easiest, least time consuming, and least expensive option. With existing plans there is no need to learn how to use a new design program or to be concerned if the house is properly framed (for example to support the load of the roof). All of that has already been done for you. Depending on how you value your time and the cost of the plans, this option can be significantly cheaper than designing a house yourself.

Another advantage to using an existing design, particularly if at least one house has been built from the design, is that many of the kinks have likely been worked out. Often a design may look good on paper, but once it is built, it may be discovered that it's not as practical or as functional as initially believed. For instance, the first house that was built by Tiny Home Builders included a storage

loft above the bathroom. Since it was small and would not carry a very large load, 2x4s were used instead of 2x6s. This ended up being a poor decision as no recessed lights or bathroom exhaust fans are designed to fit in a 3½ inch ceiling cavity. In this particular case the fix was not very difficult, but it still took time and would have gone undiscovered in the plans had the house not actually been built.

Another benefit to buying plans for a house that has already been built is that you get to see what it will look like when it is completed. Just as designs may not be as functional on paper, they may not look as good in real life either.

Finally, another benefit is that some plans come with additional valuable information like a materials list. As described in the Building Materials chapter, this can save a significant amount of money, essentially reducing or negating the cost of the plans.

The disadvantage of using an existing design is that it may not be exactly what you want, and depending on how easy it is to modify, compromises may need to be made.

CUSTOMIZING AN EXISTING DESIGN

If you're only able to find a design that is close to what you want, but not exact, you may be able to customize it to fit your exact needs. Most plans are primarily framing plans, so changes to the exterior, including window and door locations, will require the most rework. Interior changes on the other hand, assuming that they still work with the existing window and door placement, may not require any changes to the plans at all.

EXTERIOR CHANGES

Some minor framing and exterior customizations can be made to a design without making changes to the plans. Instead, these changes can be done during a house's construction and are usually referred to as 'site modifications'. An example of this type of change might be the removal of a window or even a slightly more difficult alteration like shifting the location of the wheel wells. While not having the plans exactly the way you want them before you begin construction is not optimal, with care and special attention they can still work.

If the plans that you purchase are provided to you in a format that can be easily changed, you will have a lot more flexibility as to the changes that you can make. For instance, the plans sold by Tiny Home Builders include not only a PDF version of the plans (that can't be easily changed), but also the Trimble SketchUp model (that can be easily changed). So if you plan to make alterations to a design, inquire about receiving the plans in a change friendly format.

INTERIOR CHANGES

The framing of a house is primarily linked to the layout of the house through the window and door placement. For instance, if a kitchen is anticipated to be in a certain location it will likely have a window positioned above where the sink is expected. If instead you were to decide to move the kitchen to another wall, you'll need to ensure that any windows on that wall will not interfere with the cabinets.

Having the right tools for a job is extremely important as they can save a considerable amount of time and frustration

TOOLS

The problem for tiny home builders is that they are usually trying to minimize their belongings and so the prospect of acquiring a bunch of tools is unappealing.

Some tools should be owned by every homeowner; however, others are large and would rarely be used (e.g. air compressor and pneumatic tools). While those tools can be rented, given the length of time that building a tiny house can take, an option to consider is buying them and then reselling them once you are finished.

Tools are often rented at a daily rate of between five and ten percent of their cost if new. That means that if a tool is rented for over twenty days, as much money or more will be spent than if it had been purchased new. However, if instead the tool was purchased new in the beginning, it could likely be sold at the end of the project for around fifty percent of the original cost. In this scenario the tool would be used longer and would cost only half as much as renting for the shorter length of time.

FREE 'RENTALS'

An even better option, if the required tools can be found in relatively good condition, is to buy used. A tool that is purchased used and only used for a few months adding little wear and tear could likely sell for near the same price that was originally paid, effectively allowing the use of the tool for free.

I was able to do this a few years ago with a refrigerator when I rented an apartment that didn't come with one. At that time I had the option to either rent one from the apartment complex for $10 per month ($120/year) or supply my own. After research I found that a new comparable model refrigerator cost $200, while a used one between one and two years old cost about $100. While the depreciation during the first year was significant, the depreciation during the second year was negligible. So I bought a one year old used refrigerator in near perfect condition for $100, then one year later when I moved out I was able to sell it for $100, thus paying nothing for the use of the refrigerator and saving myself $120 in rental fees. This same method can be used for tools.

A good place to look into buying and selling used tools is Craigslist.org and even eBay for smaller tools. There are also online retailers that are dedicated to selling refurbished tools.

TOOL LIST

Below is a list of the tools that I use and a description of how I use them when building tiny houses.

THE ESSENTIALS

HAMMER - This is one of the most commonly used tools. From hammering nails to knocking boards in place, a builder won't get far without one of these.

TAPE MEASURE - A quality, sturdy 25 foot tape measure is a must.

PENCIL - Carpenters have their own pencils for a reason, a thicker lead means less time sharpening and more strength while marking rough lumber.

UTILITY KNIFE & BLADES - A utility knife is used to cut the house wrap, tar paper, and even to score the metal roof panels.

CHALK LINE - This is used to mark a straight line over an extended length. It's essentially a string that is covered in chalk. The string is pulled tight before being pulled back and released to strike a surface where a mark is left behind. This tool is used most frequently while installing the exterior siding and flooring. While using this tool be careful that the chalk doesn't come in contact with any wood that will be visible when the house is complete as it can be very difficult to remove or cover up. Red chalk is the most difficult to remove and so blue chalk is recommended.

SCREW DRIVERS - Screw drivers are used for miscellaneous tasks throughout the project, particularly while installing the electrical outlets, switches, and plates.

DRILL - A drill is used to drill holes and to drive shorter screws. If the framing of the house is fastened with screws this tool will get a lot of use pre-drilling many of the framing boards

IMPACT DRIVER - Impact drivers are used primarily to drive screws (although they do make drill bit attachments). While this tool may be confused for a drill, it works in a different way to produce a lot more torque than a drill. While a standard drill might have a difficult time driving a 3½ inch screw (without striping it), this tool will do it with ease. The biggest drawback to this tool is that it is somewhat loud to operate.

CIRCULAR SAW - A circular saw is used to cut all of the sheathing and the occasional 2x4.

MITER SAW - A miter saw is essential to house framing. Behind the impact driver it is the most commonly used power tool. Almost every single board (except for the sheathing) used in your house will have an edge cut with this saw. While a 10 inch saw will do ninety-five percent of the cuts, a twelve inch version with a blade that pivots in both directions is the best option.

Carpenters Pencil, Screw Drivers, Hammer, Tape Measure, Chalk Line, and Utility Knife

Drill and Impact Driver

Circular Saw and Extension Cord

Miter Saw

PVC Pipe Cutter and Hole Saw

PVC PIPE CUTTER - A pipe cutter is an inexpensive tool that creates quick and clean cuts of PVC and CPVC. A hand or miter saw can also be used as a substitute for this tool but it is not nearly as convenient and will leave behind burs that will need to be removed before the pipes are attached to any fittings.

HOLE SAW - A hole saw is a blade that attaches to a conventional drill. This tool is used to make holes in the subfloor for the drainage plumbing as well as holes in the exterior walls for the bathroom vent and the plumbing exhaust.

LEVEL - A level is used often to verify that various surfaces are level.

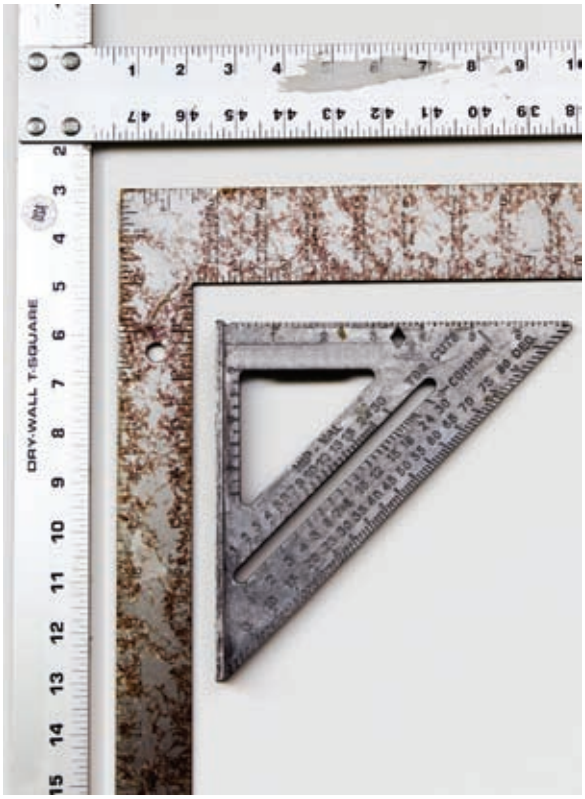
SQUARES - Squares come in various shapes and sizes. The most commonly used square is called a speed square because of its small size. Squares are used to assist in marking lines and making cuts that are 90 degrees.

PLIERS - Pliers aren't used that often except when installing the electrical. They are however an essential tool for any homeowner.

WIRE CUTTERS - Wire cutters are used while installing the electric lines. This is thick wire so the larger the cutters the better.

STEEL SNIPS - Steel snips are used to cut various metal components primarily while installing the metal roof. They come in straight cutting, left cutting, and

Level



Drywall T Square, Carpenters Square, Speed Square

Pliers, Tin Snips, Wire Cutters

Angle Grinder

right cutting versions that designate in which direction they can easily cut angles. These are discussed in more detail in the chapter on roofing.

GRINDER - A grinder is occasionally used on the metal roofing panels to cut sections where the snips or shears have a hard time reaching. These are discussed in more detail in the chapter on roofing.

ALMOST ESSENTIAL

TABLE SAW - A table saw is incredibly useful. It only made it to the 'almost essential' list because a circular saw can do a lot of what a table saw is used for (cutting boards lengthwise). But a table saw does it much more easily and with a lot more precision.

FLAT BAR - A flat bar isn't used that often but can be especially helpful with removing stubborn nails or adjusting sheathing and flooring. A straight claw hammer can often be used as a substitute.

COMPRESSOR AND PNEUMATIC TOOLS - Since a house can be framed by screwing together the boards, a compressor and pneumatic tools are not required. They can however speed up progress considerably and I wouldn't want to install interior plank paneling without a pneumatic brad nailer.

JIG SAW - A jig saw's small blade makes it unique in that it can easily make curved cuts. This tool is not used often but is really handy when cutting the sheathing and siding around the wheel wells. A hand coping saw can be used as a substitute.

POWER SHEARS - Power shears are used to make quick and clean cuts to a metal roof panel. A combination of snips and a grinder, or a utility knife can be used as a substitute.

Flat Bar

Air Compressor

Table Saw

Jig Saw

Electric Power Shears

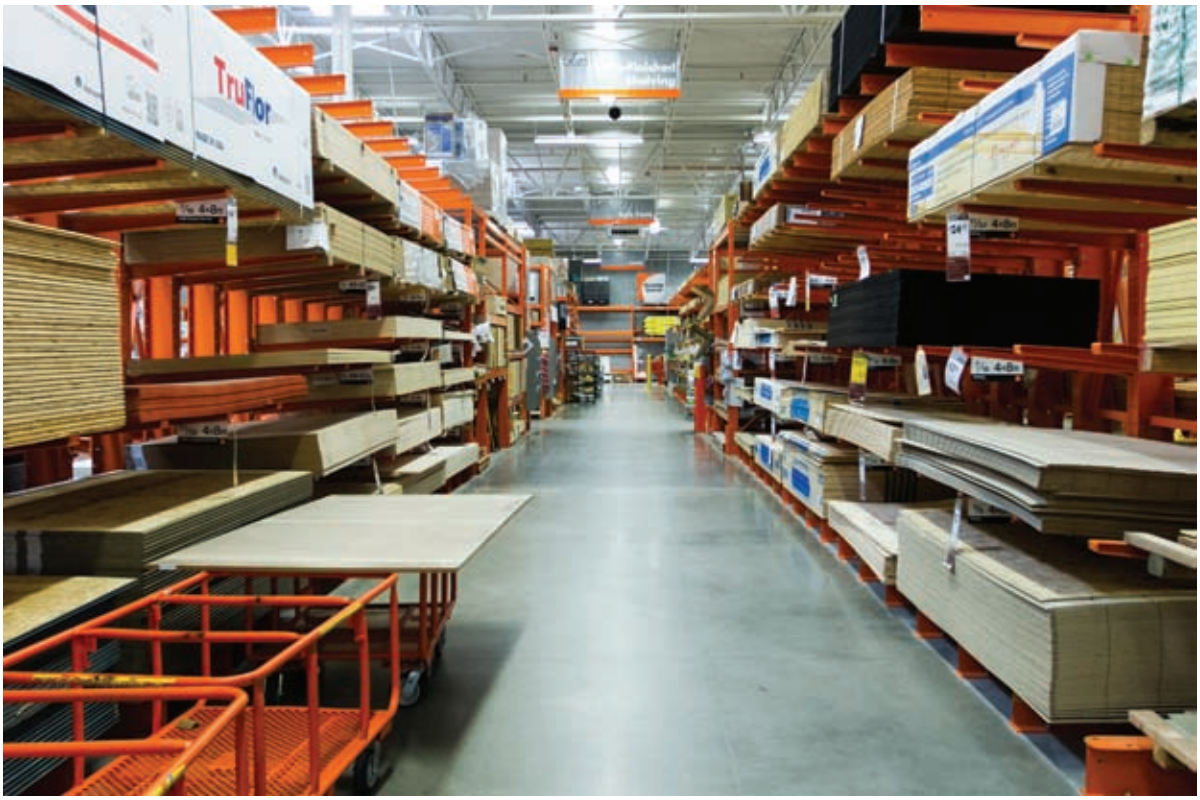
A comprehensive materials list is essential

BUILDING MATERIALS

Having a materials list can save a substantial amount of time by allowing you to purchase all of the materials in as few trips to the store as possible. Also, if a list is provided to one of the larger home improvement stores, they can 'pull' the order for you, thus saving hours of gathering up all the various items. The down side to a store pulling an order is that they are not going to be as careful as you might be in their selection process, so you can expect to get a few items that may have been tossed aside by other shoppers. However, having to exchange a few items will still require far less effort than pulling the order yourself so it's definitely worthwhile having the order pulled for you.

These stores will also often provide special pricing for larger orders with as much as a 60% discount on some items (although the overall discount will average out to be substantially less). For a home requiring $12,000-16,000 in materials, this translates to significant savings. To get the discount, orders need to be placed at the office or counter reserved for professionals, sometimes called the pro desk. Orders placed there usually have to be in excess of $2500 unless you have previously established a commercial account, so it is important to include as much as possible in the few orders that will be made there in order to maximize the savings.

If a materials list was not provided with the plans that you purchased or if you created your own plans, a list can be created by analyzing the plans. This can be done by mentally walking through each step of the construction process and



examining the plans in order to count how much of each item will be required to complete that step. For instance, by examining the plans one can count the number of studs and sheets of plywood that will be needed. The problem with this approach is that without detailed knowledge of the build process there are many items that will likely be overlooked. Despite this hurdle, an incomplete list can still be created and used as a starting point.

Below is a general list of materials that are often ordered by Tiny Home Builders for most of our tiny houses. If you are confused by some of the items, don't worry, they will be described in more detail in the later chapters. The quantities of each item will be determined by the design and size of the specific house being built. The items are grouped by the departments in which they are generally found in the store.

BUILDING MATERIALS

2X LUMBER - 2x (said "two by") lumber is lumber that has a 2 in the dimensions (e.g. 2x4, 2x6, etc.). Most of the framing is built with 2x4s. In conventional homes where trusses are not used, the rafters are usually 2x6s, but 2x4s are adequate for the small span of most tiny houses. Only where significant load from snow is expected would larger lumber need to be used for the rafters. Note that numbers in the dimensions are not the lumbers actual size. For instance, a 2x4's actual size is 1 ½ inches by 3 ½ inches.

This lumber also comes in varying lengths. Try to purchase lengths that will result in the least amount of waste. For instance, if your plans call for rafters that are 4.5 feet long, it is better to order a single 10 foot length than two 8 foot lengths.

PLYWOOD - At Tiny Home Builders we use plywood instead of OSB (orientated strand board). While plywood cost more, it is also more rigid, durable, and lighter than OSB. Also, when OSB gets wet it will swell up as it absorbs the water but then never returns to its original shape unlike plywood.

Plywood comes in 4 foot by 8 foot sheets of varying thicknesses. You will likely need two different thicknesses for your tiny house; 15⁄32 inch (sometimes called ½ inch) for the walls and roof, and 23⁄32 inch (sometimes called ¾ inch) tongue and groove for the subfloor. Note that tongue and groove sheets of plywood are also 4 feet wide, but since this includes the tongue that will overlap with any adjacent board's grooves, two sheets together will not equal 8 feet.

EXTERIOR SIDING AND TRIM - At Tiny Home Builders we use Cedar for the exterior siding. This is a product that is usually heavily discounted at the pro desk, so if you plan to finish the exterior of the house before the store's return period has elapsed, we suggest buying extra.

INTERIOR SIDING AND TRIM - Either slat paneling or sheet paneling is usually used for the interior siding because it is both lightweight and relatively durable. The types of trim include cove, casing, corner, and stop.

LOFT DECKING - For the loft decking inexpensive plywood can be used. A more attractive alternative is 1x6 pine tongue and groove.

TAR PAPER - 30 lb. tar paper is used for under the metal roof; 15 lb. tar paper can optionally be used as an underlayment under wood flooring.

STRAPPING - Strapping is metal pieces that are used to reinforce specific connections in a house. There is an entire chapter devoted to these.

FLASHING - Flashing is an impervious material used to prevent water from coming in contact with wood or from entering a wall cavity. There are various pieces of flashing that are used including 'Z' flashing that is used above and below the window and door trim, 3 inch roof edge flashing that is used to cover the wheel wells, and roll valley flashing that is used to protect the underside of the subfloor.

The flashing that is used as part of the roof is covered in the roofing section.

NAIL PLATES - Nail plates are attached to the studs wherever wires or plumbing go through the studs. These prevent the wires or pipes from accidentally being pierced by a nail or brad.

MILLWORK

FRONT DOOR - Front doors are generally made out of wood, steel, or fiberglass. Be wary of plans that call for a narrower, custom sized front door as this will likely be the only way to get furniture and appliances in and out of your house. You may not want to be stuck with the same refrigerator for the next 25+ years.

INTERIOR DOOR - The interior door will separate the bathroom from the living area of your house. If it is to be stained be sure to select one made from solid wood.

POCKET DOOR FRAME - The pocket door frame is built inside the wall cavity to contain a pocket door. These come either pre-assembled or in a kit. A pocket door is perfect for such a small interior as it is less likely to get in the way.

WINDOWS - Windows can make up a very large portion of the material cost of your house (up to 20 percent). Tiny Home Builders uses aluminum clad wood windows. These have wood on the interior that can be stained but still have an extremely durable exterior. The least expensive windows are usually vinyl windows, but those are not available in all areas and generally only come in white.

SHIMS - Shims are tapered pieces of wood that are used while installing the windows and doors.

ELECTRICAL

LIGHTING - The lighting that is needed for the house will likely include a bathroom fan/light combo, a light over the shower, lighting for under the loft (recessed can lights), lighting for any open areas (ceiling fan/light combo), and any exterior lighting.

OUTLET BOXES - Outlet boxes are nailed directly to the studs and hold the switches and outlets. These come in different sizes depending on the number of outlets and switches (called 'gang') they will contain (e.g. 1 gang, 2 gang, etc.). These are also divided into 'new work' and 'old work'. For a new house you will choose 'new work'.

OUTLETS AND SWITCHES - Outlets and switches can normally be purchased in 'contractor packs' (10 per pack) to get a discount. Special switches (called 3-way switches) are required if you plan to operate a single light from two different switches.

SWITCH PLATES - Switch plates are installed on the outlet boxes to cover the switches and outlets.

WIRE - Residential sheathed wiring is run through the walls and provides power to the lights and outlets. See the chapter on electrical for additional details.

WIRE STAPLES - Wire staples are heavy duty staples that are installed with a hammer and hold the interior wiring against the studs. These are often used on the wires right before they enter an outlet box in order to keep them in place.

ELECTRICAL PANEL AND BREAKERS - The electrical panel will hold the breakers for the houses electrical. Additional information can be found in the chapter on electrical.

CABLE, NETWORK AND TELEPHONE WIRES - Any additional wires that you would like in the house will need to be purchased as well. At Tiny Home Builders we only install cable lines unless others are specifically requested.

FLOORING

HARDWOOD FLOORING - Hardwood flooring is used throughout the house with the exception of the bathroom.

VINYL TILES - Vinyl tiles can be attractive, easy to install, and durable. Tiny Home Builders uses vinyl tiles in the bathroom of each of our homes.

VINYL ADHESIVE - While vinyl tiles usually come with an adhesive pre-applied to the back of them, an additional layer is recommended.

FLOORING TRANSITION PIECE - The flooring transition piece covers the transition between different flooring types and thicknesses.

HARDWARE

EXTERIOR SCREWS - Exterior screws are used to attach all the sheathing and are an alternative to using nails for the framing.

WAFER HEAD SCREWS - Wafer head screws are screws that have a very low profile head. These are used to attach the strapping to the framing since they are less likely to interfere with the interior siding.

LAG SCREWS AND WASHERS - Lag screws are used to attach the subfloor to the trailers deck boards.

HARDWARE FOR ATTACHING THE HOUSE TO THE TRAILER - Additional hardware is required to attach the subfloor to the metal framing of the trailer. See the chapter on strapping for additional details.

EXTERIOR NAILS - Spiral shank exterior nails are used to attach the exterior siding.

PLASTI-CAP OR SIMPLEX NAILS - Plasti-cap or Simplex nails are nails that have a large flat plastic head. These are used to attach thin, less durable items like tar paper to the roof, or in some cases the house wrap.

STAPLES - Standard T50 staples are used to attach the metal valley flashing to the trailer before the subfloor is constructed. These don't have to be that strong since the subfloor will ultimately keep the flashing in place.

BRADS - Brads are small nails that have a very small head. They are often used on finishing products where a visible nail head is undesired (e.g. interior siding).

DOOR HARDWARE- Door hardware is required for both the front door and the interior door.

INSULATION

EXTRUDED POLYSTYRENE (STYROFOAM) BOARDS - Styrofoam boards are used to insulate the subfloor and possibly the wall and roof cavities. See the chapter on insulation for additional details.

SPRAY FOAM - Several cans of aerosol spray foam will be needed to fill the cracks around the wheel wells, windows and doors. This product comes in a couple different varieties based on how much it will expand. Be sure to use only minimally expansive foam around the windows and doors to avoid bending the jambs and preventing the windows or doors from operating correctly.

Significantly more of these canisters will be needed if Styrofoam boards will be used for the interior insulation. In this case we recommend finding a version, like that made by Hilti, which includes a rigid dispenser that will allow for one handed operation.

HOUSE WRAP AND TAPE - House wrap creates both a moisture and air barrier around a house. Not all house wraps are created equally. Tiny Home Builders recommends DuPont™ Tyvek®. A special tape is also required to seal any seams in the house wrap.

PAINT

PAINTS AND STAINS - Paints and/or stains are used for the exterior siding, the interior siding, and the front door.

CONSTRUCTION ADHESIVE - Construction adhesive (sometime referred to by the brand name Liquid Nails) is used when installing the sheathing and interior siding.

PLUMBING

FIBERGLASS SHOWER - Several different materials can be used to make a shower stall. At Tiny Home Builders we use a one piece, 36 inch shower. Because of its size it needs to be put in the house before all of the exterior walls are stood up. These showers also come in kits that can be installed later but they are generally flimsy and more difficult for the homeowner to clean because of the seams.

CPVC PIPES, FITTINGS AND PRIMER/CEMENT - CPVC pipes and fittings are used for the plumbing supply lines.

PVC PIPES, FITTINGS AND PRIMER/CEMENT - PVC pipes and fittings are used for the plumbing drain lines.

KITCHEN SINK AND FAUCET - A narrow, single well sink should be selected to preserve counter space. If a larger sink is used, a cutting board can be used to cover it up to temporarily regain some counter space.

SHOWER ASSEMBLY - The shower assembly includes the shower head and the controls for the water pressure and temperature.

Great Stuff Brand Spray Foam

Hilti Brand Spray Foam

TOILET - The available utilities at the location where you plan to park your house will determine the type of toilet you need. The options include a standard flushable toilet and a composting toilet.

WATER HEATER - For a tiny house, a tankless water heater is optimal. They have a smaller size and provide endless hot water. While there are several inexpensive options available, if your house will be located in an area that will often have cold weather, be sure to choose a heater that is or can be insulated.

DRYER VENT - A dryer vent is used for the bathroom fan and also to cover up the air inlet for the plumbing.

HANGER TAPE ROLL - Hanger tape is galvanized strips of metal used to add support to hanging pipes.

TRAILER MANUFACTURER

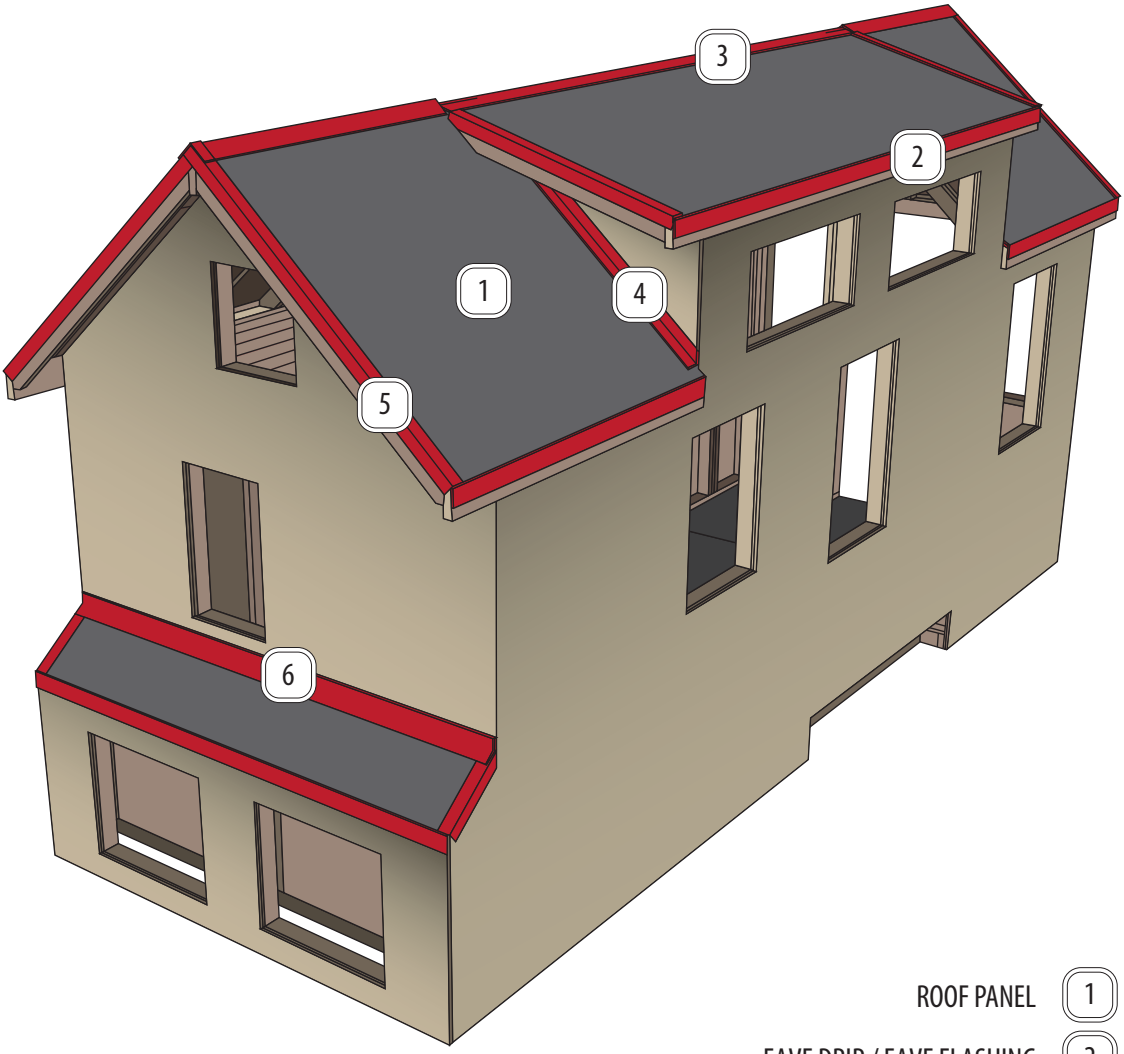
EQUIPMENT TRAILER - The trailer is the foundation of a house on wheels. See the chapter on trailers for additional details.

JACK STANDS - Jack stands are used to level the house during construction and to keep the house stable while it is lived in.

METAL ROOF

The metal roofing will likely need to be custom ordered as retailer's generally only carry basic parts that are more suitable for sheds. Metal roofing is made up of several different components. The complexity of your roofs design will dictate how many different components you will need to order.

The diagram to the right illustrates the most commonly used metal roofing components



ROOF PANEL 1

EAVE DRIP / EAVE FLASHING 2

RIDGE CAP 3

SIDE WALL FLASHING 4

GABLE RAKE / GABLE TRIM 5

END WALL FLASHING 6

Getting the right trailer for your design is important, as it is the foundation of your house

TRAILER

ACQUIRING A TRAILER

Trailers are generally categorized by what they will be used to haul. While there are no industry standards that define these categories you will often find trailers that are best suited for tiny houses referred to as either utility or equipment trailers.

A trailer for a tiny house can be purchased either new or used. For a used trailer I suggest checking Craigslist.org and local trailer dealers. In my experience, however, I have not found there to be a substantial price break in used trailers unless they required significant restoration work. And considering that the trailer is the foundation of the house, it is important that there are no issues with it. That coupled with the customizations that can be made to a new trailer, I recommend buying new.

Customizations to a trailer that make it most suitable for a tiny house include:

NO DOVETAIL

A dovetail, sometimes called a beavertail, is a slight decline at the end of a trailers deck. This feature facilitates loading equipment by reducing the incline angle of the trailer's ramps. However, since the trailer's deck supports the subfloor of a

Trailer Tongue

tiny house, a slant in the deck surface is undesirable. If you are required to use a trailer that has a dovetail, wooden supports can be constructed to negate the dovetail's angle, but since a tiny house's siding doesn't generally extend below the trailers deck, this will likely be visible when the house is complete and may look unattractive.

NO TOP RAIL AND UPRIGHTS (SIDEWALLS)

Since the subfloor of the home is likely to extend beyond the width of the trailer bed, sidewalls should be avoided. If necessary, steel sidewalls can be removed by a welder at a metal shop.

NO FRONT GUARD

A front guard helps to prevent equipment from pushing past the front of a trailer into the tow vehicle. This is undesirable but can be built around if necessary.

Note that the trailer in some of the pictures has a front guard.

HEAVY DUTY AXLES (5000 - 5200 LBS. EACH)

On shorter trailers less heavy duty axles may be sufficient. However, on longer trailers the larger axles are recommended.

Trailer

NO RAMPS

Ramps are generally installed on equipment trailers for the loading and unloading of equipment. They are designed to be raised and lowered and are thus attached to the trailer with a large pin. While the ramps themselves won't be welded to the trailer, the pin may be. If purchasing a trailer from a dealer, have them remove the ramps. Otherwise, you can attempt to hammer out the pin, but be sure not to damage the trailer. If the pin does not slide out, you will need to take the trailer to a metal shop to have the ramps removed.

ADDITIONAL STEEL FLANGE ALONG THE SIDES

To assist in securing the houses foundation to the trailer and to reduce the amount that the subfloor overhangs the trailer's edge, a piece of angle iron can be welded to the sides of the trailer so that it is even with the top of the trailer deck. Individually attached brackets can also be substituted for this and are covered in the chapter on strapping.

Trailer

LEVELING THE TRAILER

The trailer needs to be leveled before any construction can begin. To assist with this I recommend using adjustable 6 ton SUV jack stands as supports (which can also be used when the house is completed to stabilize it) and an SUV jack. The adjustment granularity on the jack stands is not very fine so boards of various thicknesses may also need to be placed under the stands to make minor adjustments. Regardless of the type of supports selected be sure that they are strong enough to not only support the weight of your trailer, but also the completed house. Try to begin on a relatively level area as this will greatly simplify this process.

To begin, place supports under each of the four corners of the trailer. Be sure to place the supports on a firm or reinforced surface. If the house is to be built on grass or soil some settling may occur over time or as weight is added to the house requiring the house to be re-leveled. This can be reduced if the supports are placed on a platform such as a piece of pressure treated 2x6 or concrete pavers.

Identify and start at the highest corner of the trailer and use a jack to bring the remaining corners up to that level, adjusting the supports as you go. The jack that is built into the trailer can also be used to adjust the height at the front of the trailer. When checking if a side is level, only place the level on the metal framing of the trailer to reduce inaccurate measurements due to irregularities in the trailer's deck boards.

This process will likely require adjusting each side or corner multiple times and can be time consuming, but it is important to take the time to complete it correctly before moving on.

Trailer with Jack and Support

Trailer Being Leveled

Trailer Being Leveled

The subfloor of a tiny house is a composite of the metal trailer and the wood constructed subfloor

SUBFLOOR FRAMING & INSULATION

In a conventional shed or house, the subfloor framing is generally constructed of 2x6 or larger lumber. In a tiny house however, since the subfloor will be resting and getting support from the metal framing of the trailer, 2x4 lumber can be used. While thicker lumber can still be used, which is usually only considered to create a larger cavity for additional insulation, the thinner lumber allows for more room in the interior of the house since the overall height of the house is restricted.

Before installing the subfloor, every other board from the trailer deck can be removed. This is done since these boards will not be bearing much weight compared to the subfloor framing boards that will run perpendicular to the decking, which will be constructed and added later. Removing these boards will also reduce the total weight of the house and can optionally be used later in the framing of the house. It is important to verify that none of the trailers electrical wiring is attached to any of the boards before removing them.

Next, aluminum flashing is installed over the entire trailer surface to protect the underside of the house, specifically the exposed insulation that will be added later. A hand stapler (using T50 staples) or roofing nails can be used to attach the flashing to the wood. The flashing should overlap by at least 4 inches.

Next, if your trailer has curved wheel wells, create a template that will be used later when cutting the sheathing. This template can then be laid on the

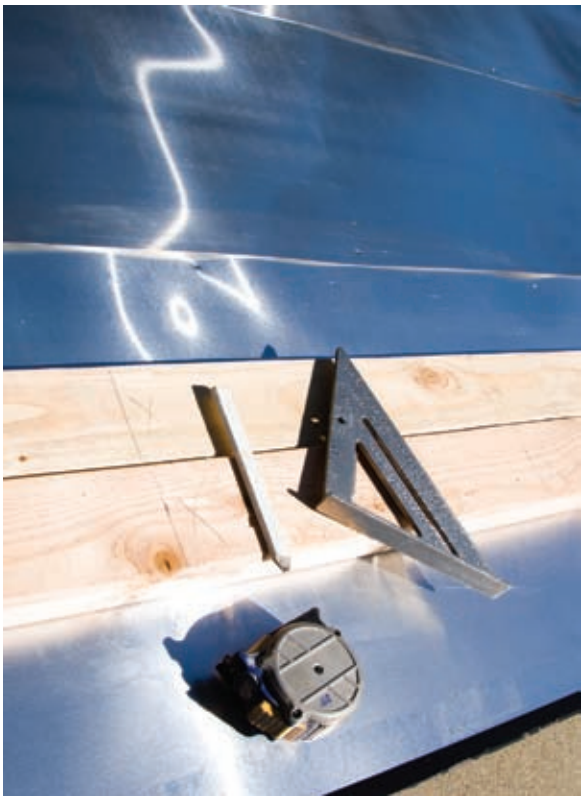
Trailer with Boards Removed

Trailer with Flashing Installed

sheathing to replicate that curve when it needs to be cut in a later step. This is accomplished by holding a board up behind the wheel well and drawing a line that matches the curve of the wheel well. A jig saw is then used to cut along the line to create the template.

To build the subfloor framing, verify the measurements of the plans with those from the trailer and cut all the boards for a section. The subfloor can be divided into three sections; in front of the wheel wells, behind the wheel wells, and between the wheel wells. When constructing the subfloor or wall framing it is easiest to mark the kick plate and the top plate at the same time which also ensures that all the boards will be properly aligned.

Note: Before constructing the subfloor, ensure that the boards are not lined up with the metal support beams under the trailers decking. If they are, the subfloor framing will need to be shifted so that the subfloor can be properly attached to the trailer. Later on, lag bolts will be drilled up through the decking and into the subfloor and metal supports should not be in the way.



Top Plate and Kick Plate Marked

Top Plate Pre-Drilled

Subfloor Framing

Subfloor Framing

FRAMING FASTENERS

Either screws or specialized nails can be used to join the pieces of wood for the framing.

SCREWS

If screws are to be used, the first board that the screw is to pass through will need to be pre-drilled; otherwise the boards will not bind together as the screws are tightened. For this job I recommend using a 3½ inch exterior screw. Driving a 3½ inch screw requires a large amount of torque, and a standard powered screwdriver will likely only strip the head of the screw. To avoid this use an impact driver. These are very effective but also fairly loud.

NAILS

If nails are to be used, use either ring shank or spiral shank nails. Ring shank nails have small rings or ridges around them which makes them more difficult to remove. Spiral shank nails (sometimes called screw nails) are twisted so that they rotate as they are driven, also to make them more difficult to remove. Both of these nails sometimes also come with an adhesive on them to further hinder their removal. Nails are not as strong as screws but they are strong enough,

Pre-Drilled Hole in Trailer Decking

Galvanized Lag Screws and Washers

especially considering the additional support the wall will receive from the sheathing that will be screwed and glued to the framing. The primary benefit of using nails is that a pneumatic framing nail gun can be used to drive the nails which can significantly speed up the build process.

ATTACHING THE SUBFLOOR TO THE TRAILER

After each subfloor framing section is constructed and put in place, mark the location of the joists that go across the trailer on to the aluminum flashing. Then move the section and predrill ⅜ inch holes into the trailer deck for the lag screws that will later screw into the center of the subfloor joists from below the trailer. There should be about 2 holes per joist that are offset from the two holes on any adjacent joists.

Once all the holes have been predrilled, place the subfloor sections in their proper location and attach them together. It may also be helpful to attach the sections to the trailer decking itself with a few nails to prevent the sections from moving while working under the trailer later.

After the subfloor framing is complete, it needs to be attached to the trailer. From below the trailer, using a 3⁄16 inch drill bit and the previously drilled holes as guides, drill a pilot hole into the subfloor joist. Then, using an impact driver

Subfloor Framing Completed

or ratchet, screw ⅜ x 3½ inch hex-head galvanized lag screws with ⅜ inch galvanized washers into the subfloor boards. Ensure that the screws are tight enough so that there are no gaps between the subfloor boards and the trailer decking.

SUBFLOOR INSULATION

The next step is to add the subfloor insulation. Since there are no wires or plumbing in the subfloor it is best to fill as much of this cavity as possible. Use a 2 inch and two ¾ inch foam sheets stacked together, for a total of 3 ½ inches of insulation. Any gaps between the insulation and the subfloor framing should be filled with spray foam insulation.

Lag Screws Under the Trailer

Subfloor Insulation

Subfloor Framing Attached to Trailer

Subfloor Insulation Being Installed

The subfloor sheathing is a thicker material to support the weight of all the items and occupants in the home

SUBFLOOR SHEATHING

The subfloor sheathing is 23⁄32 inch tongue and groove (TNG) plywood. The sheets are placed so that the grain is perpendicular to the floor joists and are attached to the subfloor framing with a construction adhesive and 2 inch exterior screws. The construction adhesive is applied directly to the joist with care being taken to not to let the adhesive come in contact with the insulation as some brands will dissolve it.

Avoid placing screws along any edge that will have another piece of sheathing placed against it until that other piece is in place. Screws can sometimes pinch or splinter the sheathing making it difficult to properly place another board tight up against it.

A sledge hammer can also be used to tighten two pieces of sheathing together along the tongue and groove side. If a sledge hammer is used, try not to strike the sheathing directly, and instead hold up another piece of board against the board you intend to move and strike it. This will reduce the chance that you will damage the board you intend to adjust.

Subfloor Sheathing Half Installed

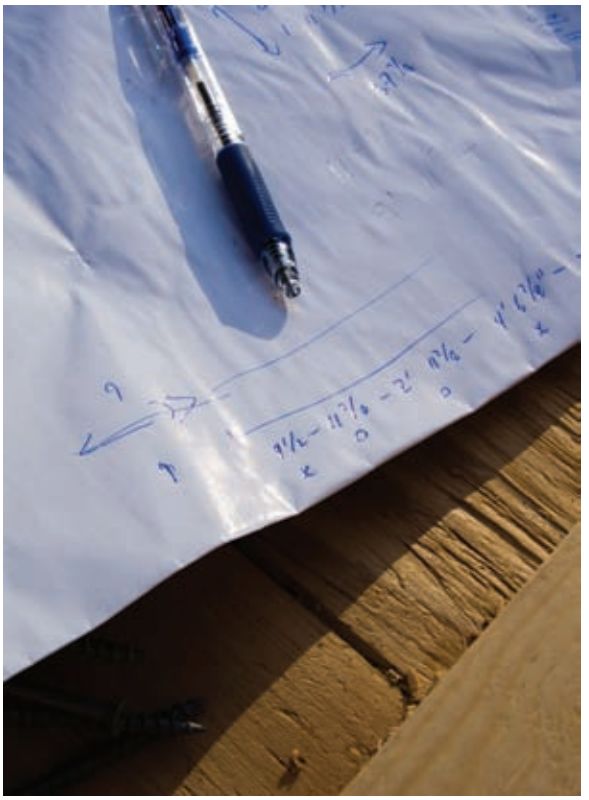
The walls are constructed in the same way as the subfloor

WALL FRAMING

Before beginning, verify the measurements from the plans with the physical measurements. This is particularly important for the walls that run along the sides of the trailer since the wheel wells may be in a different location than those in the plans.

Cut all of the boards needed to complete one section of the wall and mark both the top plate and the kick plate at the same time.

Now is also a good time to mark the top of the top plate for the rafters while it is on the ground since doing so later will require a ladder.



Notes

Top and Kick Plate Marked

Each wall section is constructed laying down and stood up only after it is assembled.

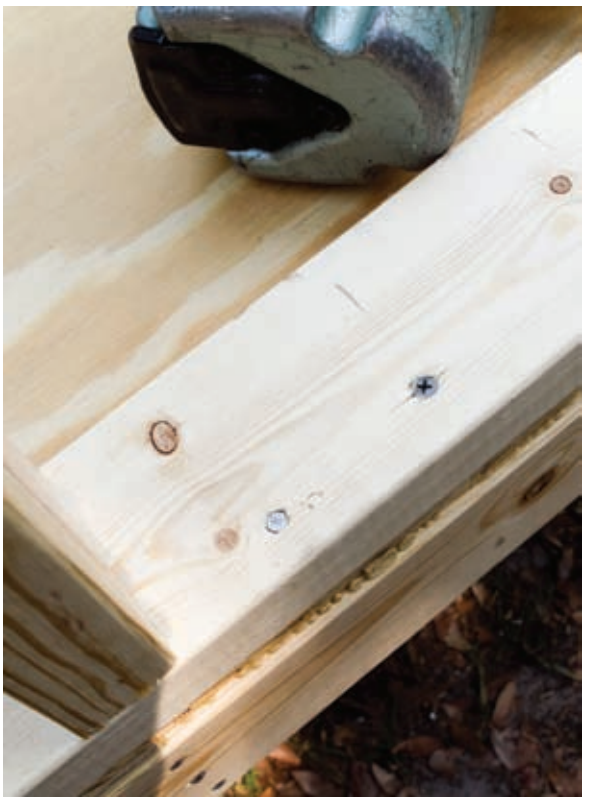
Attach some temporary stops along the edge of the subfloor that will prevent the wall from sliding off the floor and ensure that it is properly lined up with the edge once it is stood up.

Once the wall is stood up and in the proper location, screw the kick plate down every twelve inches with 3½ inch screws. After the wall is up it may require some temporary bracing to ensure that it won't fall over until it can be properly secured to an adjoining wall. If an adjoining wall is going to be stood up immediately, and it is not windy outside, supports may not be necessary.

Next, work on an adjoining wall so that it can be used to provide stability to the first wall section. The walls should only be attached to each other with a minimal amount of screws since they may need to be removed when the walls are squared and leveled.

Wall Partially Completed

Temporary Bracing at Subfloor Edge



Wall Nailed and Screwed In Place

Wall Stood Up and Braced

Adjoining Walls Stood Up

Header Components

Header Assembled

Upper Wall Section Parts

HEADERS

Some wall sections may require a header. A header is a section of the wall framing that is designed to bare weight, usually found over a door or window wide enough to intersect at least one load bearing stud.

A header is composed of two 2x (e.g. 2x4, 2x6, etc.) pieces of lumber with a ½ inch piece of plywood sandwiched in the center, all cut to the proper length. These are then nailed or screwed together.

When a header is installed be sure the orientation is such that the plywood edge is visible from the top and bottom.

As with the other sections of the wall framing, if the plans call for any higher level walls like those found on a dormer, those too can be constructed on the ground and then lifted into place.

Upper Wall Section Assembled

Wall sheathing is attached to the outside of the studs to provide support to the framing and a base for the siding

WALL SHEATHING

The wall sheathing material is 15⁄32 inch plywood and is attached with construction adhesive and 2 inch screws. Exterior wall sheathing should be installed vertically. This orientation provides the most strength since there are no unsupported or unscrewed seams.

To attach the sheathing begin in a corner of the house and cut a sheet to the correct size and with any openings required. Mark the stud locations on the sheathing to assist with screw placement later. Add construction adhesive to the studs, top plate and kick plate in the area where the sheet is to be attached. Attach a few temporary support pieces under the subfloor overhang to rest the plywood on. This will save your back and ensures that the sheathing is level with the bottom of the subfloor once stood up.

A sheet of sheathing can be expected to be very square (all four corners are 90 degrees) so if it is level with the bottom of the subfloor (which should be level with the ground) and even with the outside edge of the wall, the wall should be square and level in that direction.

Walls Sheathed

End Wall Sheathed

Temporary Bracing Under Subfloor

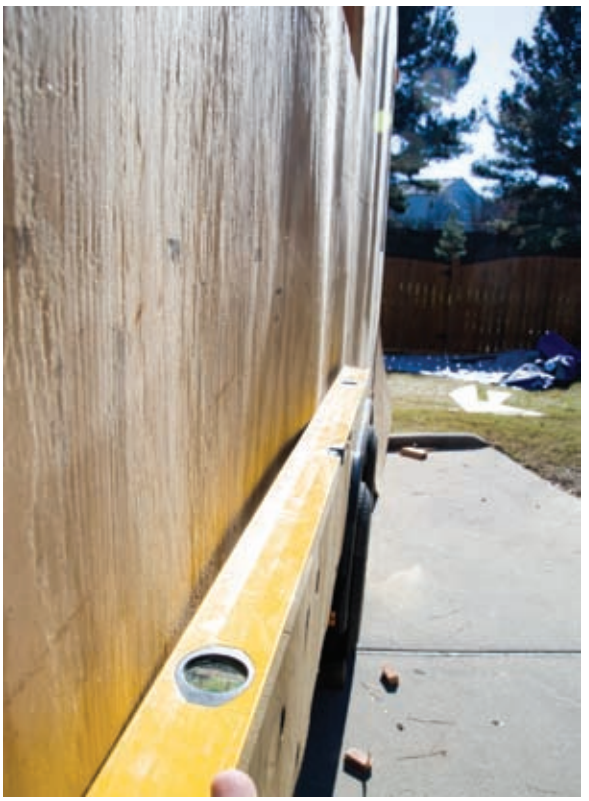
Verify this with a level and make any fine adjustments as necessary before screwing it. On the outside edges the screws should be approximately 6 inches apart and 12 inches apart on the inside studs. Offset the screws along the seams of adjoining pieces of sheathing.

FIXING WARPED PLYWOOD

If the sheathing of the house gets wet before you have a chance to protect it with the house wrap, it may warp. If the wood warps such that it protrudes into the wall cavity, it won't interfere with the installation of the siding; however, it will reduce the amount of insulation that can be used in that section of the wall. In this case, correcting the warped material is optional.

On the other hand, if the wood warps out from the wall then fixing it will be required, and it will likely be easier to repair than to replace.

To repair, set the blade depth of a circular saw to approximately half the thickness of the sheathing.



Warped Sheathing

Warped Sheathing

Set Blade Depth

Expansion Cuts

Wall Braced on the Inside

Wall Screwed from the Outside

Then cut several “expansion” slots into the sheathing on the side where the sheathing is expanding into. Then put a 2x4 on the inside that can be screwed into.

Then screw into the 2x4 from the outside. In this example, as the 2x4 was screwed into, it was pulled tight against the sheathing and thus straightened it out.

Wall No Longer Warped

Before beginning work on the roof the walls should be braced to ensure that they do not push out while installing the rafters

ROOF FRAMING

Bracing can be accomplished by screwing a small section of 2x4 to the floor, and then attaching a longer piece of 2x4 to the floor piece and about three quarters up on a stud. Before the piece is connected to the stud the wall should be made level.

This should be repeated in several locations depending on the length of the house. The walls can also be braced to each other by nailing a board across the top plates of the walls to ensure that they don't spread apart.

Next, cut the rafters. Before cutting all of the rafters for the entire roof, double check your cuts and angles on just a few pieces. A quick check can be accomplished by holding two rafters in place either on the top plate or someplace similar like the sill plate of two adjacent windows (that is if your design has two windows of equal height across from each other).

Rafters Being Installed

Rafters Nailed

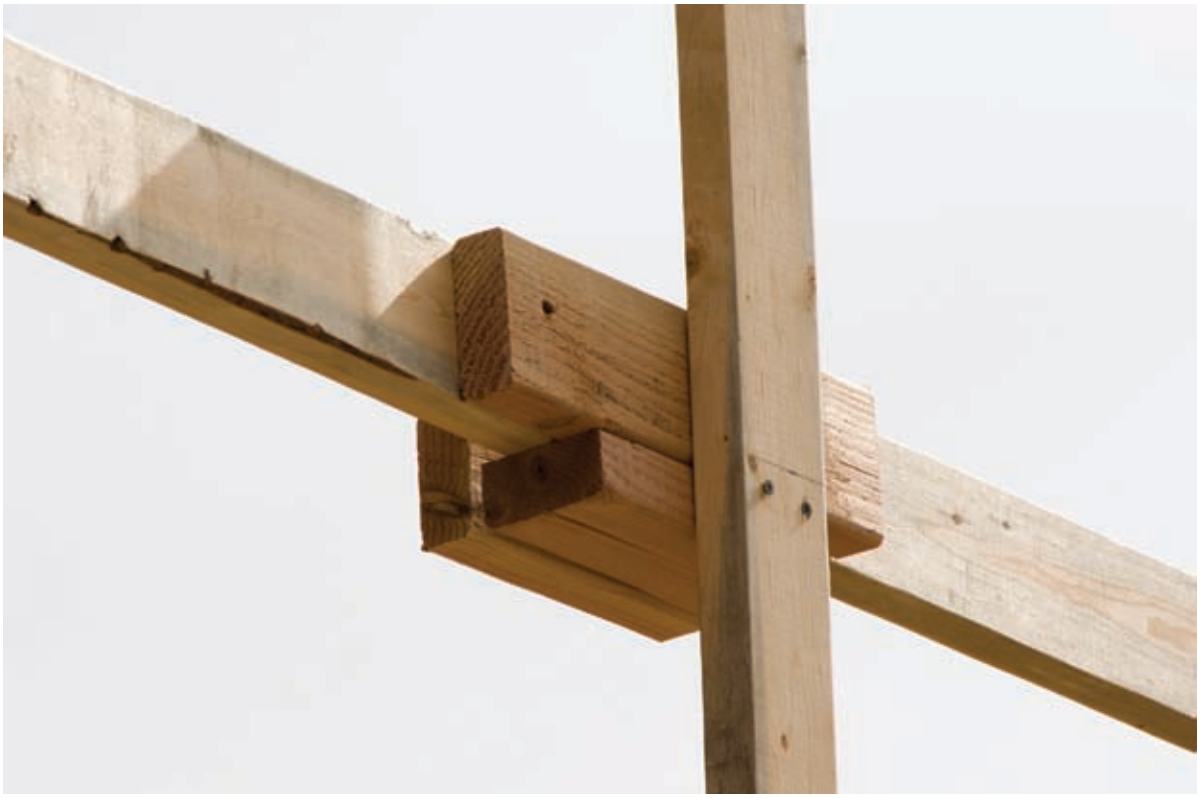
Mark both sides of the ridge beam for the rafter locations. The ridge beam should then be lifted up into place and the rafters nailed to both it and the top plate of the walls. It will likely be necessary to either have multiple people hold the ridge beam or build a temporary support for it while it is being nailed.

Because of the length of most tiny houses, the ridge beam will likely need to be two pieces of wood that will be joined together by a third shorter piece called a scab. However, if a solid piece can be used it is preferred.

Assuming that the walls are level and evenly spaced across the entire length of the trailer, and that the rafters are all cut to the same size, each rafter should meet up with the ridge beam at the same place. But because the ridge beam is such a long piece of wood, it will likely not be perfectly straight. So it should be pulled into the correct position as needed to consistently line up with each rafter, as opposed to cutting the rafters to fit. The point is to not let a curved piece of wood determine your ridge.

Note: A technique often used by contractors, especially when working with angled pieces of wood like those found around the roof, is scribing. When there is a piece of wood that needs to have an angled cut, it can often be difficult to replicate that angle on the piece of wood in order to cut it to fit. Scribing is when you hold a piece of wood as close as possible to where it needs to go, and then you trace the angle or pattern that you need to have cut onto the wood. They make a special tool to aid with scribing (called a scribing or marking gauge) but for most of my cuts I am able to use my hand to get good enough results.

An internet search for "scribe technique" can provide additional details.



Temporary Support for Ridge Beam

Rafters at Ridge Beam

Strapping is metal pieces that are used to reinforce specific connections in a house

STRAPPING

To ensure a secure linkage between the various layers of a houses framing, strapping is added in various locations.

Strapping comes in many different varieties for different applications but can most easily be thought of as a metal strap that is screwed to two (or more) pieces of wood to reinforce their linkage.

For strapping to be effective the screws in the strap should be perpendicular to the shear line that can be created by an anticipated force (e.g. high winds).

For example, when wind hits the side of a house, in addition to applying direct pressure to that side, it also travels up the wall and puts upward pressure on the overhang. Since the rafter boards are nailed down into the top plate of the wall, the nails are aligned with the force of the wind and thus need only to be pulled out to free the rafter. This is why many older homes not equipped with hurricane straps lose their roofs in hurricanes.

However, by adding a strap, the screws of the strap are perpendicular to this force and would thus need to be sheered for the rafter to be freed. Sheering a nail or screw is much more difficult than simply pulling it out.

To attach any straps, use 1¼ inch wafer head screws that are designed for straps. Wafer head screws have a low profile head and thus are less likely to interfere with other building materials like the interior siding.

STRAPPING TYPES

Let's examine the various layers of the houses framing and their linkages to identify the need for strapping and the strapping types:

TRAILERS METAL FRAME TO TRAILERS WOOD DECKING

This linkage in most trailers is heavy duty screws that are added at the time the trailer is manufactured. The designed purpose of these screws is to keep the trailer decking in place while carrying a heavy load (like a piece of heavy equipment), not to sustain the upward force that can be exerted by the attached house while driving and rounding a corner or while encountering strong winds. Since this is not a very strong link in this direction we cannot rely on just securing the house to the decking boards.

While the house will be attached to the decking boards it will also need to be directly attached to the metal framing of the trailer.

Additional screws or bolts can also be added between the decking and the metal framing to increase this linkages strength.

TRAILERS WOOD DECKING TO HOUSE SUBFLOOR

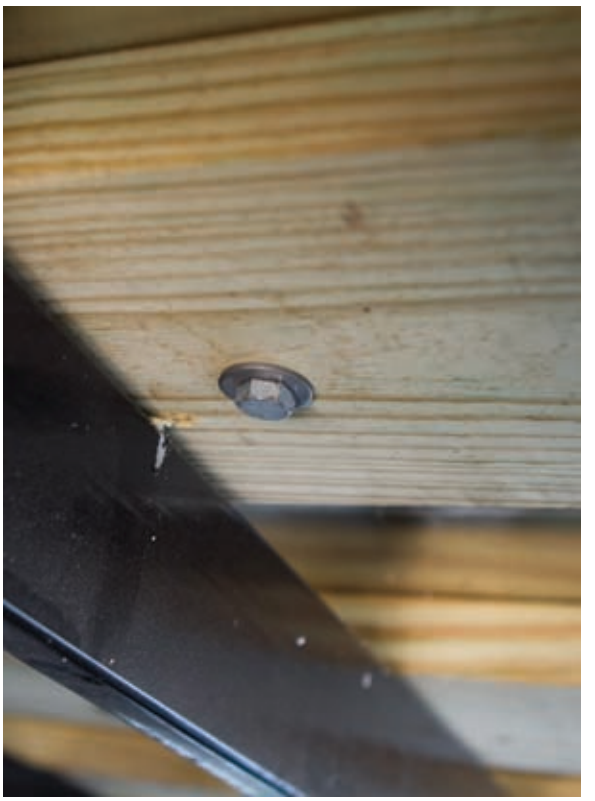
This linkage is made by approximately 30-50 (depending on the length of your house) 3½ inch lag screws screwed from beneth the trailer through the decking boards into the subfloor framing.

TRAILER METAL FRAME TO HOUSE SUBFLOOR

There are several different methods to create this linkage. One option is to have the trailer manufacturer weld a piece of angle iron along the sides of the trailer that is flush with the deck to create a flange that can be screwed up through and into the subfloor framing. A lighter, less expensive alternative is to use angle brackets that are bolted to the trailer framing to achive the same goal. These brackets would only be attached to the trailer at the locations where the joists extend beyond the edges thus using substantially less metal.

HOUSE SUBFLOOR TO HOUSE WALLS

The walls are secured to the subfloor using two methods. First, 3½ inch screws are driven through the kick plate into the subfloor at 12 inch intervals. Second, a much stronger linkage is created by the wall sheathing. The wall sheathing covers the entire wall and also extends down to overlap the edges of the subfloor. Since the sheathing is secured with 2 inch screws and construction adhesive, it creates a very strong linkage.



Lag Screw Under Trailer

Bracket Attaching Subfloor Framing to the Trailer

Brackets After Being Painted

Strapping for Upper Walls

Hurricane Strap

Strap Connecting Rafters

HOUSE WALLS TO UPPER HOUSE WALLS

Upper walls are any wall portions that sit on top of a lower wall's top plate, for instance, the walls found in dormers. If possible, the sheathing seams should not be lined up with the framing seams between these two layers as the sheathing can be used to reinforce this linkage. Since it may not be possible to avoid lining up these seems, or the overlap may not be substantial, it is also recommended to add metal strapping across these layers.

HOUSE WALLS TO ROOF RAFTERS

A specialized type of strapping called hurricane straps are used for this linkage. These straps have a bend in them to fascilitate attaching them to both the top plate of a wall and a rafter.

RAFTERS TO RIDGE BEAM

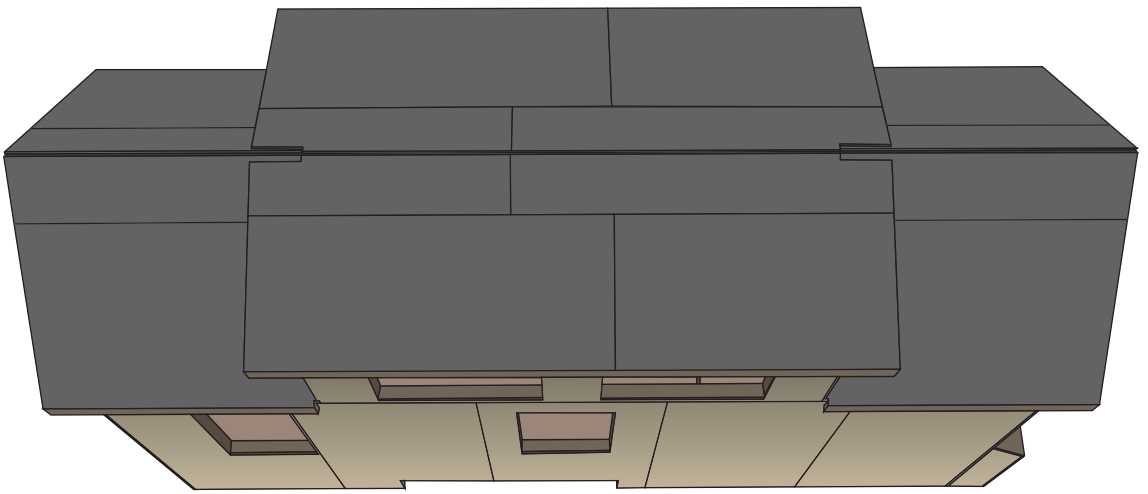
Strapping is suggested here as well. There are various options available but a single 12 inch strap that wraps from one rafter over the ridge beam to the other rafter should provide adaquate support. This strap is intended to prevent the rafters from being pulled away from the ridge beam. Collar ties can also be used which are pieces of wood that run underneath the ridge beam and connect the two rafters together.

The roof sheathing is installed very similarly
to the wall sheathing

ROOF SHEATHING

The roof sheathing material is 15⁄32 inch plywood and is attached with construction adhesive and 2 inch exterior screws. If the rafters are 24 inches apart, plywood clips (also known as H clips) should be placed between the horizontal seams of any two adjoining sheets, centered in the area between the rafters. The grains of the plywood sheets should be perpendicular to the rafters (long side of the sheet is parallel to the ground) for strength. Stagger the seams so that a lower sheets seam does not line up with any adjoining upper sheet's seam on the same rafter.

Install temporary blocks along the bottom edge of the roof to prevent the plywood sheets from sliding off the roof when initially put in place. These also ensure that the plywood will be even with the bottom edge of the roof. These blocks can be made of scrap material including small pieces of plywood or 2x4s. They should only extend above the edge of the roof about one to two inches; otherwise they may get in the way and make it more difficult to lift the sheathing into place. Cut a sheet of plywood to the size required and mark the rafter locations to assist with screw placement later. Apply the construction adhesive on the rafters that the sheathing is to lay on and then put the sheet in place. If any construction adhesive gets on any part of a rafter that will not get covered by sheathing in a relatively short period of time, be sure to clean it off before it hardens. Removing hardened adhesive is considerably more difficult than removing it when it is fresh and wet.



Sheathing Seams Offset

Also, if working alone, consider using smaller pieces of sheathing. Smaller pieces will often result in more waste but are also a lot easier and safer to move, especially while on a ladder.

A technique to get larger pieces of sheathing up on a roof is to use an extension ladder. The ladder is positioned such that it is leaned against the roof at a relatively gentle angle. The sheathing is placed at the bottom of the ladder and is then slid up as you walk up the ladder until it slides off the top and on to the rafters. If this technique is used, care should be taken so that the base of the ladder does not lift off of the ground when the sheathing gets to the top as this can result in the ladder sliding and falling.

Once the sheet is in the proper location, attach it with 2 inch exterior screws. On the outside edges, the screws should be approximately 6 inches apart and 12 inches apart on the inside rafters. Offset the screws along the seams of adjoining pieces of sheathing.

Thirty pound (30#) tar paper (often called felt) is then added and attached to the roof with plastic cap (also called simplex) nails. The installation of the tar paper should begin on the lowest part of the roof with the next highest section added afterwards. This ensures that the higher sections overlap the lower sections and thus reduce the chance of rain water getting under the paper. Each section of tar paper should overlap the lower section by about six inches.

Roof Sheathing Ready to be Slid In Place

Roof Sheathing In Place

Tar Paper Installed

House wrap creates both a moisture and air barrier around a house

HOUSE WRAP

The purpose of house wrap is to prevent moisture from coming in contact with the wall sheathing and/or entering the wall cavity, while at the same time allowing moisture to escape. If properly sealed, house wrap can also act as an air barrier that improves the energy efficiency of your home by reducing drafts.

There are several different types and brands of house wrap on the market, and they are not created equal. Some are woven and/or perforated while others are continuous. These different characteristics impact how strong the material is and how effective it is at keeping out moisture. Based on our experience we strongly recommend using DuPont™ Tyvek®.

House wrap is lightweight and comes in a long roll that makes it easier to install than tar paper. The fasteners used to attach the house wrap to the sheathing vary based on the brand or type of house wrap. Generally, woven type house wrap requires the use of plastic cap or simplex nails, which are the same as those used to attach the tar paper to the roof. With stronger house wraps, staples can be used which can significantly speed up the installation. Read the instructions for your particular brand of house wrap to verify you are using the correct fastener and fastener spacing.

The house wrap should be installed on the lower portions of the house first with the upper portions installed afterwards. This ensures that the upper portions overlap the lower portions, thus reducing the chance that water will get behind the house wrap. Once all the house wrap has been attached, the seams will then need to be sealed using a specialty tape made specifically for house wrap.

House Wrap Installed

Installing the windows and doors properly is very important since they are some of the more likely places for water to enter and damage a house

WINDOWS & DOORS

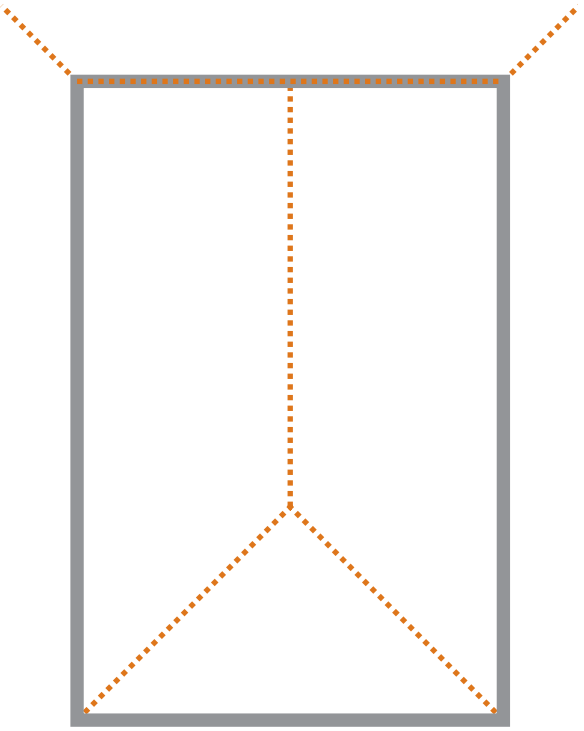
FLASHING

Flashing is an impervious material used to prevent water from coming in contact with wood or from entering a wall cavity. Flashing around windows and doors is generally a flexible, thicker material that has adhesive on one side to facilitate installation. Proper flashing is extremely important since if it is done incorrectly, water will be able to penetrate the house and potentially cause extensive damage. Flashing can also be extremely difficult to fix if done incorrectly since various layers of building material are added on top of it.

FLASHING AND INSTALLING WINDOWS

The first step to flashing and installing a window is to cut the house wrap for the window opening. This cut is in the shape of an upside-down champagne glass so that the house wrap can be wrapped around to the inside of the window opening on the sides and bottom. The top edge does not have a flap so that any water that might happen to run down the sheathing cannot get trapped in the house wrap.

Since any water that is to get behind the window would most likely come to rest on a horizontal surface, the window sill is the most vulnerable spot in a window opening. To reduce the chance that water will come to rest on the sill, cut a thin



Cut Pattern for House Wrap Over a Window

House Wrap Cut for Window

piece of lap siding the same size as the sill and attach it with the thinnest edge facing out. This will effectively slant the sill reducing the chance that water will pool at this location.

The house wrap flaps along the sides and bottom can then be wrapped around and attached on the inside of the house with staples.

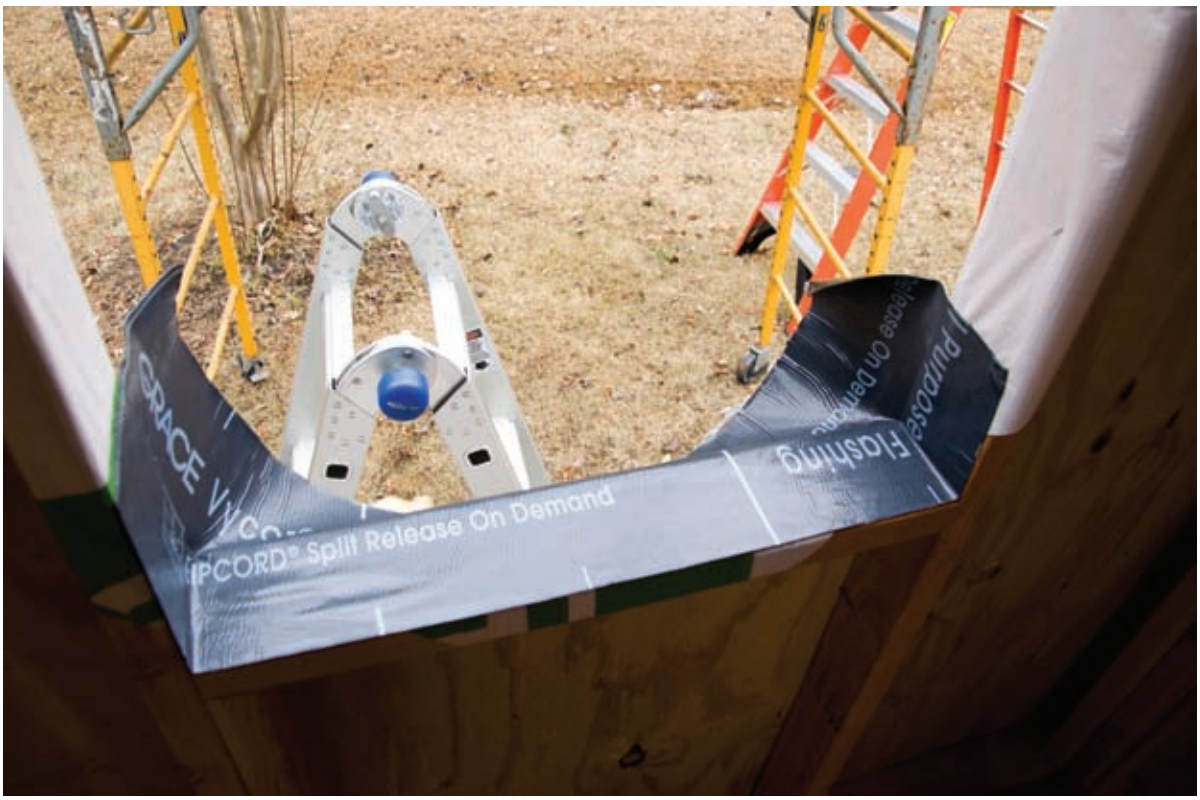
Next, make two diagonal cuts in the house wrap, approximately 6 inches long at 45 degree angles away from the window starting in the two top corners. This will form a flap that will overlap the top strip of flashing once installed. Temporarily tape this flap up and out of the way.

Since material higher up on the house should be overlapping lower materials, flashing is installed at the bottom first with subsequent layers added directly above the last piece.

Next, flexible flashing is cut to the size of the window sill with an additional 12 inches so that it can be run up each side of the opening 6 inches. The flashing backing is then removed to reveal the adhesive and it is put into place so that the flashing's edge is even with the inside edge of the window framing.

Cut Siding for Window Sill

Flexible Flashing Laid Out



Flashing Partially Attached to Sill Plate

Flashing Attached to Sill Plate

Slits are then cut in the flashing so that the flashing can be wrapped around the exterior of the house.

Note: Some products don't require slits to be cut and the flashing can instead just be stretched into position against the exterior.

Next, the window is inserted into the opening and a single screw is added to the top right to hold it in place. Be sure that the flap made in the house wrap earlier is clear of the window flange. Adjust the window until it is square and plum and attach the remaining screws to secure the window. Verify that the window operates properly. If it does not, the window is likely not square and will need to be corrected before proceeding.

Finally, flexible flashing is added to the outside of the window. First, it is applied to the sides of the window, extending beyond the top and the bottom by about 6 inches. Next, it is added to the top of the window under the house wrap flap, also extending beyond the edges by about 6 inches on either side. The flap edges should then be taped down over the flashing with house wrap tape.

No additional flashing is to be added to the bottom since that could inhibit the escape of water if it does make its way down to the sill.

Flashing Attached to Sill Plate

INSTALLING THE DOOR

The same technique that was used to create a sill for the windows is also used for the door. The only difference is that instead of using a tapered piece of wood on the sill, a ½ inch piece of plywood is used. On the windows, the function of the tapered piece was to angle the sill so as to encourage water runoff. With the door however, an angled piece of wood is undesirable since the threshold of the door must be placed on a flat surface to evenly distribute any weight it might bear.

The purpose of the plywood is to elevate the door a small amount to ensure that there is enough room under the door for the flooring and any rugs that might be placed on it.

Once the sill is flashed, the door is stood up in the opening and attached as per the doors specific instructions.

OTHER FLASHING

A piece of metal flashing is also nailed above the wheel well. This piece may need to be contoured if the fender is rounded which can be accomplished by cutting several small slits at the spots where a bend is needed.

Flashing Over Wheel Well

There are several different options for exterior siding on a tiny house. Our preferred material is cedar lap siding which is lightweight, durable, and attractive

EXTERIOR SIDING

Most current residential applications of lap siding in the southeast use HardiePlank which is made with a concrete material. HardiePlank is not suitable for a tiny house due to its heavier weight and somewhat brittle nature.

The trim and siding should be painted or stained on both sides prior to installing. This will increase the durability of the material by protecting the back side in the event that water gets behind it, and will also prevent unstained/ unpainted portions of the boards from being exposed when the wood expands or contracts.

Next, the walls are marked with horizontal lines which will be used to line up with the top edge of each piece of siding. These lines are made by measuring up from the bottom edge of the house at the corners and then using a 'chalk line' to connect the measured points. It is important that each line be measured and marked from the same starting point (i. e. the bottom edge of the house) and not from a previous line or from the top edge of a previously installed piece of siding. If the measurements are not taken from the same starting point, it is possible for slight imperfections in the measuring process or in the wood to compound so that by the time you get to the top of a wall the difference between the measurements on two different ends of the house is significant.

By measuring from the same point for all of the boards, a slight mistake in the placement of the guide line for one board will not be carried over to the next.

Trim and Siding Completed

Vertical lines are then marked on the exterior of the walls to indicate the location of each of the stud centers for nail placement. An easy way to make this mark is to take a measurement from the inside of the house to determine a stud's location. Then adjust the measurement to account for the thickness of the sheathing material on the end of the house from which the measurement was made and use that measurement to mark on the exterior of the wall. A level can then be used to extend that mark up the side of the house.

I find that a sharpie works best for making these lines on the house wrap.

TRIM BOARDS

Next, install the trim boards around the doors, windows, and on the edges (corners) of the house. Trim boards are generally not larger than 1x4 inches; however, larger boards may be needed to prevent small, unworkable gaps between trim pieces. For instance, if a window is 8 inches from the edge of the house, using 1x4 trim (which is 3½ inches wide) along the edge of the house and around the window would result in a one inch gap between the two trim pieces. It is difficult to fill such a small gap with siding as siding that is cut that narrow is hard to properly attach without it breaking or splitting. In a case like this it may be better to use a wider piece of trim along the edge of the house to avoid the gap or to fill the gap with a cut piece of trim.

Trim Installed and Starting on the Siding

Any horizontal trim boards, like those above and below a window, should also have a piece of Z flashing installed along with them. This prevents water from resting on the horizontal surface or from working its way behind the siding. For the trim on the top of a window the Z flashing is installed above the trim, and for the trim below a window the Z flashing is installed below the trim.

The trim and siding is attached using 8D (2½ inches) spiral shank galvanized or stainless steel nails.

SIDING BOARDS

Once the trim is complete, the siding is then installed from the bottom up. The nails used to attach the siding should be driven into the studs as indicated by the vertical lines made previously. In some cases holes may need to be predrilled in the siding so as to minimize cracking or splitting. This is usually done near the ends or on smaller pieces. The siding boards should fit snuggly up against the trim pieces. Each edge of the siding will need to be cut to properly square it, as cedar lap siding from the mill will rarely come with squared ends.

If the length of a wall is too long to use a single piece of siding, multiple pieces can be butted together. The end of any board that will butt up to another board should be cut at a 45 degree angle. This allows the boards to overlap so that the sheathing and house wrap behind the joints aren't visible if the siding were to contract.

Hand Made Tool to Help Install Siding

If working alone, it may be difficult to both hold a long piece of siding and nail it at the same time. To provide an extra 'set of hands' a platform for the siding can be created from a few pieces of wood and a painters extension pole. One end of the siding can then rest on this platform while the other end is nailed.

FASCIA BOARDS

The next pieces of trim to be installed are the fascia boards. Fascia boards are 1x6 inch cedar that is attached to the edge of the roof overhang. When installing the fascia boards be sure that no part of the board extends above the plane created by the top surface of the roof sheathing. An easy way to ensure the proper placement of these boards it to take a 2x4 and temporarily lay it on the roof sheathing so that it extends over the edge of the roof. The fascia board can then be placed so that it is snug up against the 2x4 thus ensuring that it is not installed too high and will not interfere with the metal roofing later.

Siding Installed on the Side of the House

Siding Installed on Gable End

While metal roofs are not as commonly used on traditional houses, they provide the best durability for the high winds experienced by tiny houses

ROOFING

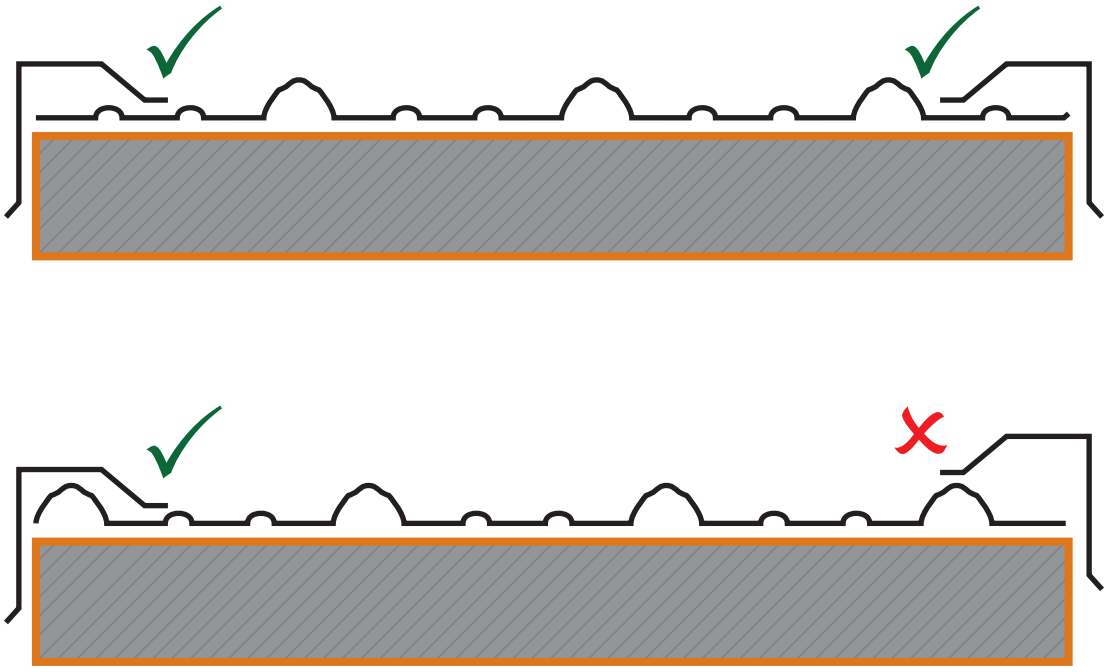
The first component of a metal roof that is installed is the drip edge. Drip edge is a painted piece of metal that overlaps the bottom edges of the roof and covers the top portion of the fascia boards. It generally has a small bend at its base to allow water to fall off away from the house. The drip edge is cut to size with steel snips and attached with roofing nails (using either a hammer or a pneumatic roofing nail gun). Drip edge should be wrapped around any edges of the fascia board by a few inches. This helps to keep water from getting behind it as well as to more strongly secure it to the house.

Once the drip edge is in place, the roof panels can be installed. The roof panels often need to be cut to fit properly. Before cutting any panels though, it is very important that you verify that where you plan to place your panels, the humps or raised portions of those panels will not interfere with the trim pieces that will be installed later. For instance, gable trim flashing, depending on the profile, may need to make contact with the flat portion of a panel at 5 to 6 inches from the edge of the roof. If a hump or raised portion of the panel happens to be within this range, the panel (and all attached panels) will need to be shifted over. This can be a very time consuming and frustrating mistake.

CUTTING METAL ROOF PANELS

There are four different tools that we use to cut metal roof panels, each with

Drip Edge



Roof Panel Properly Aligned, Roof Panel Improperly Aligned

Roof Panel Trimmed to Fit

their own advantages and disadvantages. Often using a combination of the tools is required.

UTILITY KNIFE

Surprisingly a utility knife can be used to help cut panels lengthwise. Use the blade to score the panel as many as eight to ten times and then bend the panel back and forth until it snaps. This can produce a very clean cut. While scoring the panel it can be helpful to clamp on a straight edge to ensure the blade is run over the same line each time. Be sure to clamp the straight edge to the side of the panel that will not be used in the event that doing so scratches the panel.

STEEL SNIPS

Steel snips work great for smaller cuts on thinner metal. They can also be used to make fine adjustments and curved cuts. However, steel snips do not perform as well for longer cuts on thicker metal. This is because unlike some of the other tools, snips do not remove any metal as they cut to make room for the tool itself. With thinner metal this usually isn't a problem since the metal can be twisted or pushed out of the way to make room. However, on thicker metal like that used for roof panels, it can be difficult to make room for the snips and the user's hand once the tool cuts in more than several inches.

To get around this limitation a rough cut can be made a small distance from where the final cut is to be made. A second, more fine/exact cut can then be made on a second pass using the snips. Since a majority of the unwanted metal will be removed on the first pass, during the second pass the last bit of metal can easily be pulled out of the way as the cut is made. An effective tool to use for the first pass of this technique is a grinder (described below).

ELECTRIC SHEARS

Electric shears are used to cut thicker metal for long lengths. Shears cut somewhat similarly to snips with the exception that they remove about 3⁄16 inch of metal as they cut to make room for the tool. Electric shears can cut along flat surfaces very quickly and cleanly, however, it can be difficult to use them to cut over the humps found in panels. Thus they are usually only used to modify the width of a panel and not the length.

ELECTRIC GRINDER

An electric grinder is the most destructive of the tools listed here. Instead of simply cutting the metal this tool grinds away a section of it. This process throws off quite a bit of sparks and requires a firm grip to keep the tool in place. Safety equipment should also be used including eye and hand protection. The cut edge that it leaves behind is generally pretty rough but since this tool is primarily

used to adjust the length of a panel, the cut edge should always be hidden by a piece of flashing or more likely the ridge cap. With a grinder, multiple panels can be cut at the same time. When cutting a panel be sure to have someone hold the panel in place, or use clamps to secure it. Also be sure to remove any metal filings that may be clinging to the panel as they will quickly rust and stain the panel.

Once the panels are cut, predrill the holes for the screws. See your roofing manufacturer for the suggested screw placement and spacing. We put screws on both sides of each hump on the panel along the bottom edge, then on both sides of alternating humps (beginning with the hump at the seam) spaced approximately 18 inches apart. Also check with the panel manufacturer to determine the minimum amount of overhang of the panels to determine how high up from the edge that the first row of screws should be placed. The recommended amount of overhang for the panels used by Tiny Home Builders is 1 inch, so we drill our first line of holes 2 inches up from the bottom edge. If a standing seam roof is used, special brackets are used instead of drilling through the panel itself. See your manufacturer for instructions.

Finally, butyl tape is placed on the inside of any humps that will overlap with another panel to make a seam. This step is often not required by the manufacturer unless the pitch of the roof falls within a certain shallow range (since water stays on a gently sloped roof longer), but since roofs on tiny houses are so small we recommend this small amount of additional effort regardless of the pitch.

Once a panel has been prepared (cut, drilled and taped), it can be put in place and attached. Care should be taken since a panel can act as a sail on a windy day and pull or push someone off of a roof or ladder. Also ensure that no one is standing below or around the installer while a panel is being mounted since a panel can easily slide off of the roof before it is screwed.

When putting the panel in place, try to avoid sliding it as this can easily scratch other panels and/or the drip edge. Also, ensure that the panel is square with the roof and that the amount of overhang across the entire panel is consistent. Since all the panels will be connected, a small difference on the first panel may end up being a considerable difference by the time the last panel is installed.

The roof panels are attached with color matched screws that have a butyl washer backing to eliminate leaking around the screw hole. Since the screws are painted to match the panels they should be obtained from the roofing manufacturer. Be careful not to over tighten the screws as doing so will weaken the seal and dent the panel. A good method to prevent over tightening is to adjust the drill tension so that the drill will stop driving the screw once it gets to the proper tightness.

Installed Roof Panel

Roof Panel Being Installed

Side Wall Flashing Being Installed

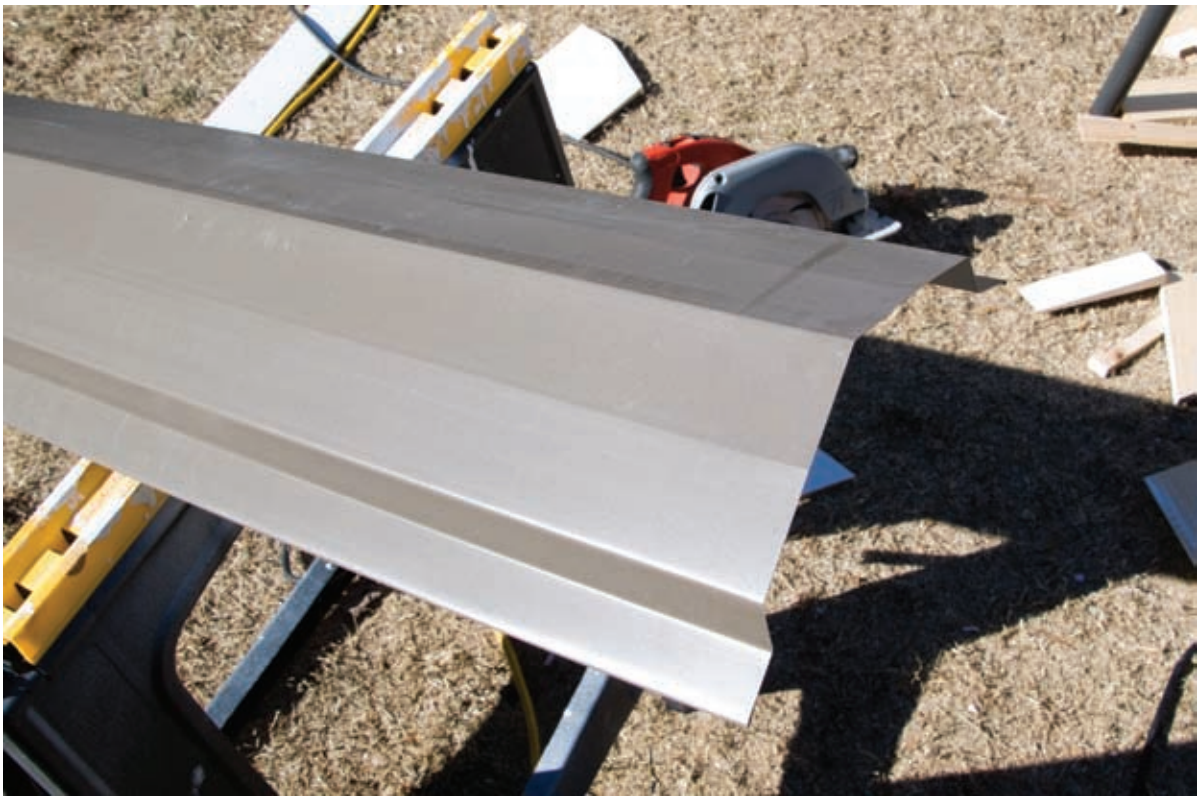
Ladder with Padding

Finally the roof trim pieces including the gable rake/trim, side wall flashing, end wall flashing, ridge cap, etc. are installed. These pieces can generally be cut using just steel snips. Occasionally, to cover longer lengths individual pieces of trim may need to be overlapped. In these cases the pieces should overlap by at least 6 inches. As with the other components, check with the roofing manufactures for installation details including fastener spacing.

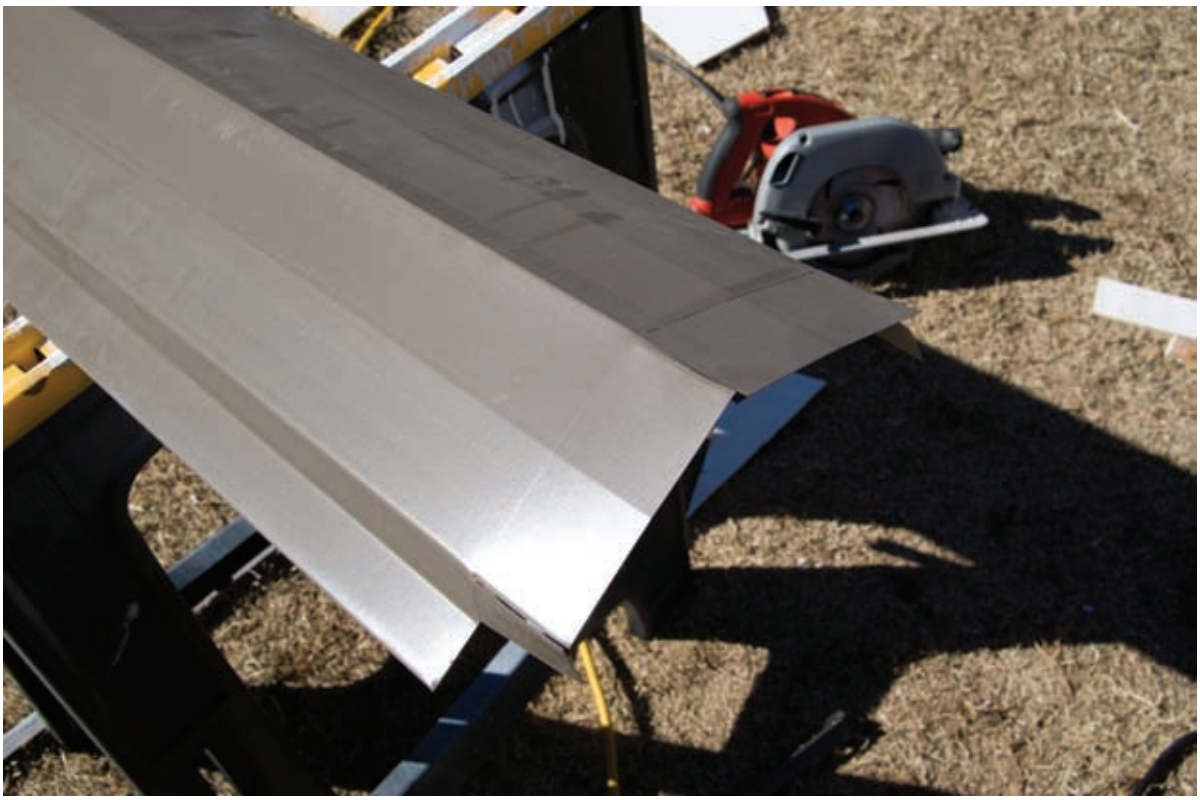
Note that depending on the complexity of your roof, some pieces may need to be installed out of order. For instance, if you have a dormer it may be easier to work on the trim under the dormer overhang before installing the last rafter on that overhang. Without that rafter being installed you will not be able to install the panels above the dormer. So in that case, some of the roofing trim work will be completed before all the panels are in place.

If scaffolding is not available while installing the roof, add padding or guards to any ladders to prevent scratching the metal panels.

The pictures below illustrate the steps to finish off the ridge cap ends.



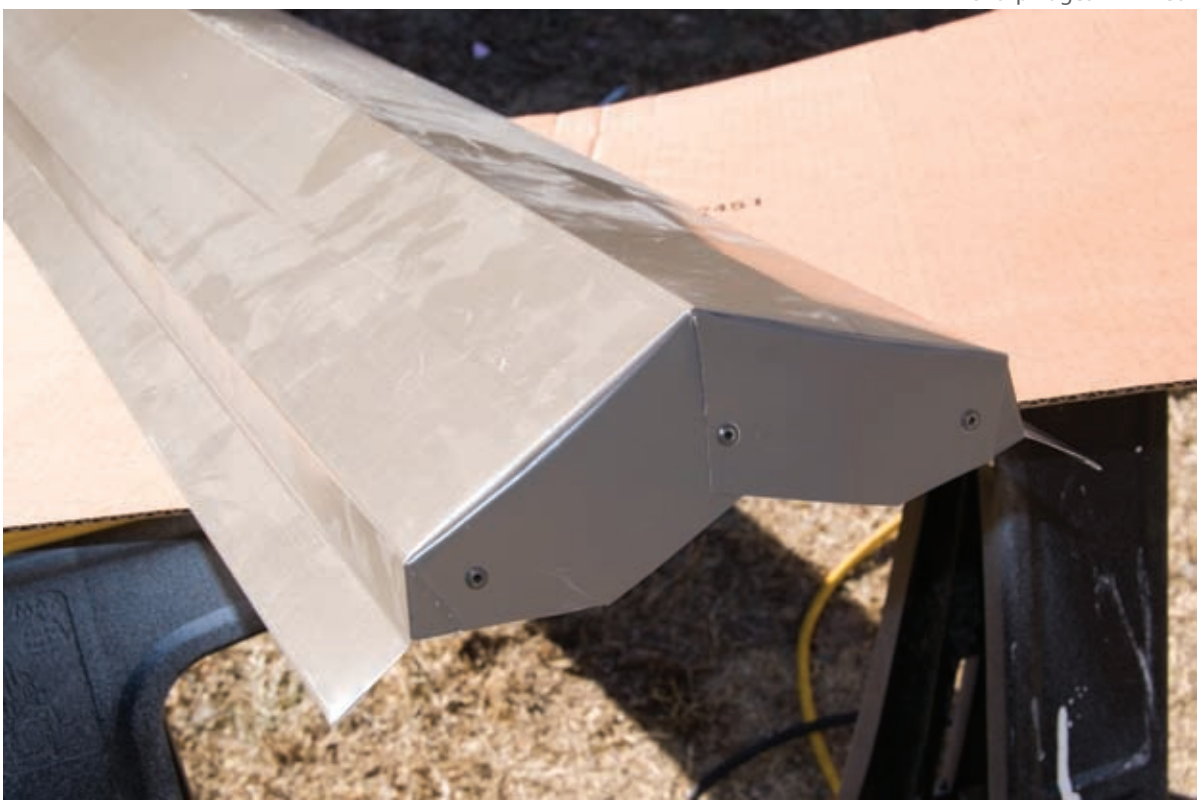
End Marked



End Cut

End Cut and Folded Down

Sharp Edges Trimmed



Flaps Riveted Together

Plumbing is usually worked on at two different times during the construction of a home. The first time, called the rough in, is when the pipes are installed within the walls and their ends are just left extending out of the wall cavity a few inches. The second time is when the plumbing is finished off and all the valves and faucets are connected

PLUMBING

The plumbing rough in usually only involves installing pipes and fittings. Fittings are the components that allow multiple pieces of pipe to be connected and come in many different varieties.

Plumbing is divided into two categories, supply lines and drain (or waste) lines.

SUPPLY LINES

The supply lines, sometimes called distribution lines, bring fresh water into a house. For supply line plumbing there are several different options including CPVC, PEX, and copper.

CPVC (CHLORINATED POLY(VINYL) CHLORIDE)

This is the pipe material used by Tiny Home Builders for the supply line plumbing in our houses. We use ½ inch pipes, which for CPVC, is measured from the outside edges of the pipe. CPVC is inexpensive, somewhat flexible, won't corrode, can stand up to higher temperatures, and is extremely easy to work with.

CPVC piping is cut to the desired length using a specialized tool called a PVC or CPVC pipe cutter (see the chapter on tools). A hack saw or miter saw can

Plumbing Parts

also be used but these tools frequently leave behind burs that will need to be removed before the pipe is put into a fitting. A pocket knife or a specialized sanding tool can be used to accomplish this.

Next, a primer is applied to both the exterior end of the pipe and the interior of the fitting that you plan to attach to the pipe. The primer will help soften the pipe to help seat it within the fitting. Next apply CPVC cement on top of the primer on both the pipe and the fitting. The primer and cement are applied using a dauber that is built into the cap of both products. Be sure that the primer and cement selected are specific to CPVC, as they are not interchangeable.

Next, firmly press the pipe into the fitting. Once the pipe is pressed all the way in, turn the pipe a quarter of a turn to help spread the cement evenly across the entire connection. The primer and cement will react with each other and melt the pipe and fitting together for a permanent bond. Hold the pipe and fitting together for 30 seconds to ensure that the heat from this reaction does not push the connection apart.

For brass threaded connections like those found on the shower assembly, a threaded CPVC adapter is used. First, the threads of the adapter are covered with a Teflon (or similar) tape. The adapter is then screwed into the shower assembly. This adapter then provides a small stub of CPVC that a pipe can then be glued directly to as described above.

Hot and Cold Pipes for Kitchen Sink

Supply Entry and Shower Hookup

These steps are repeated until all the hot and cold water lines are installed.

PEX

PEX is highly flexible tubing that in a conventional home can allow for fewer connections resulting in better water flow and easier installation. However, in a tiny house these benefits are not as great, if at all, due to the limited amount of product used. PEX is also more expensive than CPVC and requires a specialized tool that costs approximately $70 to make any connections. While PEX is marginally easier to work with than CPVC, we don't feel the higher cost is justified for a small application like a tiny house.

COPPER

Copper is the most expensive of the materials listed (which can make it prone to theft). It is also inflexible, can corrode depending on the quality of the raw material used, and requires the most skill to connect the pipes to the fittings. While copper has been in use for a very long time, for us, the negatives outweigh the positives of using it for plumbing.

Supply Entry Into House

Cold Pipe for Toilet

Hot Water Heater

Drainage Pipes Under Trailer

Drainage Pipes Under Trailer

DRAIN LINES

For drain (or waste) lines, 2 and 3 inch PVC piping is used. For PVC pipes, this measurement is taken from the inside edges of the pipe. At any single drain source 2 inch pipe is used and 3 inch pipe is used only after multiple 2 inch pipes are merged. PVC pipe is connected together much like CPVC except a different primer and cement is used. The most significant difference is that the PVC pipes will likely need to be cut with either a hack saw or a miter saw, as a smaller PVC cutter will not accommodate the large pipes. Also, as with the CPVC piping, any burs resulting from the cutting process will need to be removed.

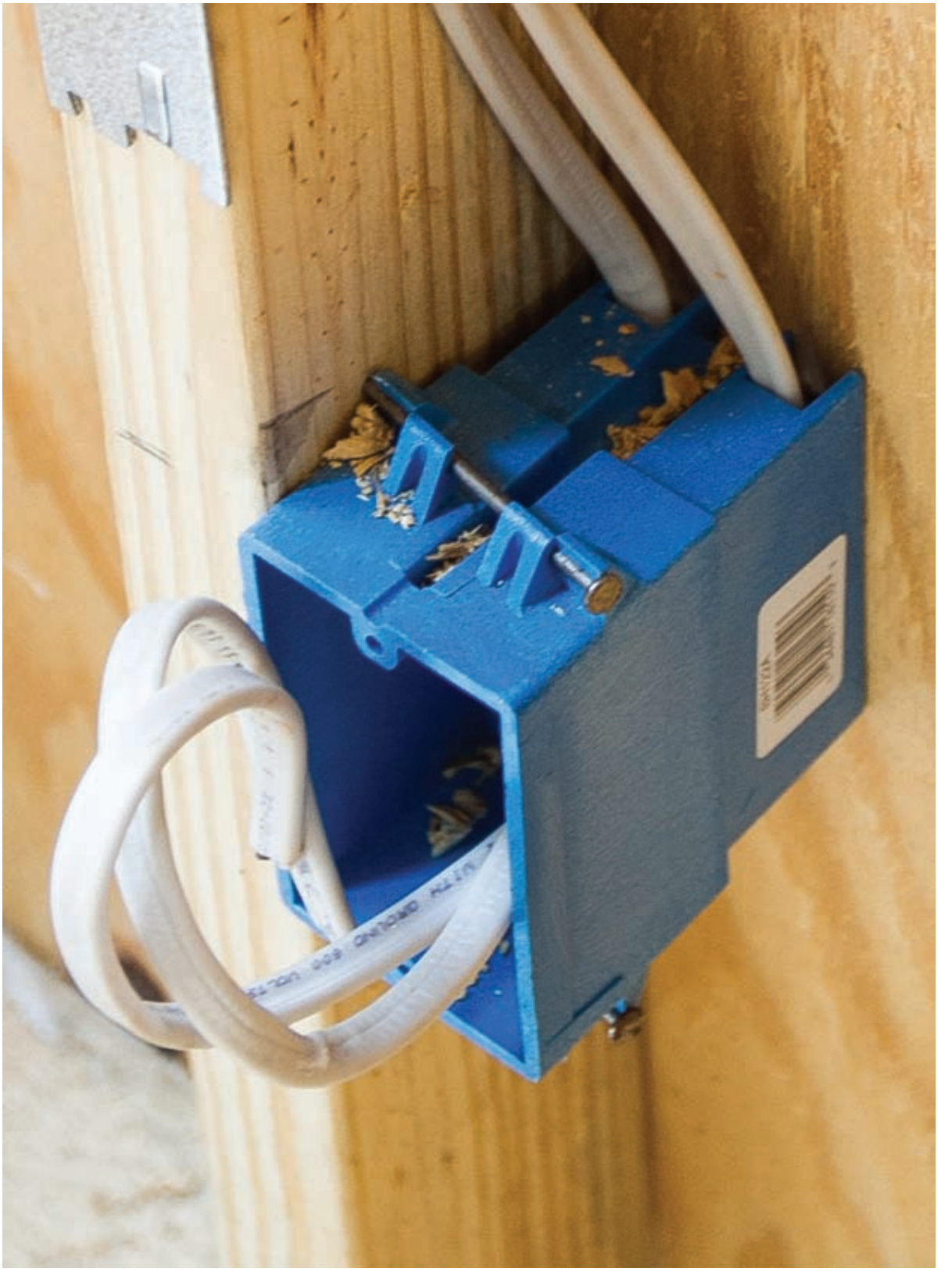
Drainage or waste pipes need to run downhill and thus need to drop slightly from their origin to where they will be hooked up to the external waste lines (e.g. city sewer lines, drainage tank, etc.). Each drain source also needs to have a trap. A trap is an area where water is trapped that prevents sewage gas from entering back into the house. The kitchen sink will have its trap directly below it in the kitchen cabinet. The toilet has its trap built in. The shower however does not have room to have the trap in the house and thus it needs to be added into the waste plumbing under the house.

An air inlet line must also be included in the waste system. When waste travels out of the system it can create a vacuum. An air inlet prevents this vacuum. The inlet is usually vented to the outdoors high up since the inlet cannot have a trap and thus sewer gasses may escape from it. In a conventional house the air inlet line usually extends through the attic and exits the roof and is easily identifiable as not having a cover or valve to prevent rainwater from entering it. In a tiny house it may be difficult to vent the drainage lines through the roof. Instead, this line can be run up within a wall and vented out the side of the house.

At Tiny Home Builders we run our inlet up inside the interior wall behind the pocket door and vent it out the side of the house. The vent is then covered with a dryer vent cover to make it more aesthetically pleasing and deter birds from making it a home.

Electrical work is not very complicated or difficult, however, if done incorrectly it can be both dangerous and expensive to correct

ELECTRICAL



Outlet Roughed In

Since the electrical wiring won't be tested until the wall sheathing is installed and the switches and outlets are connected, fixing fundamental wiring mistakes will likely require removing the wall sheathing. This can be time consuming and expensive. Incorrectly installed wiring can also be a fire hazard.

Residential sheathed wiring (often called by the brand name Romex) comes in different gauges (or wire diameters). In residential construction the gauges used range from 10 gauge (for items with a large electric load like a standard electric dryer) to 14 gauge (for most outlets and lighting). Since the electrical load for a tiny house is expected to be smaller, we use 14 gauge wire throughout. The product packaging for the wire will indicate the gauge and the number of wires within the sheathing, not counting the ground wire (e.g. '14/2' or 14 gauge with 2 wires). Standard outlets and switches require only 2 wires while 3-way switches require 3 wires (between the switches).

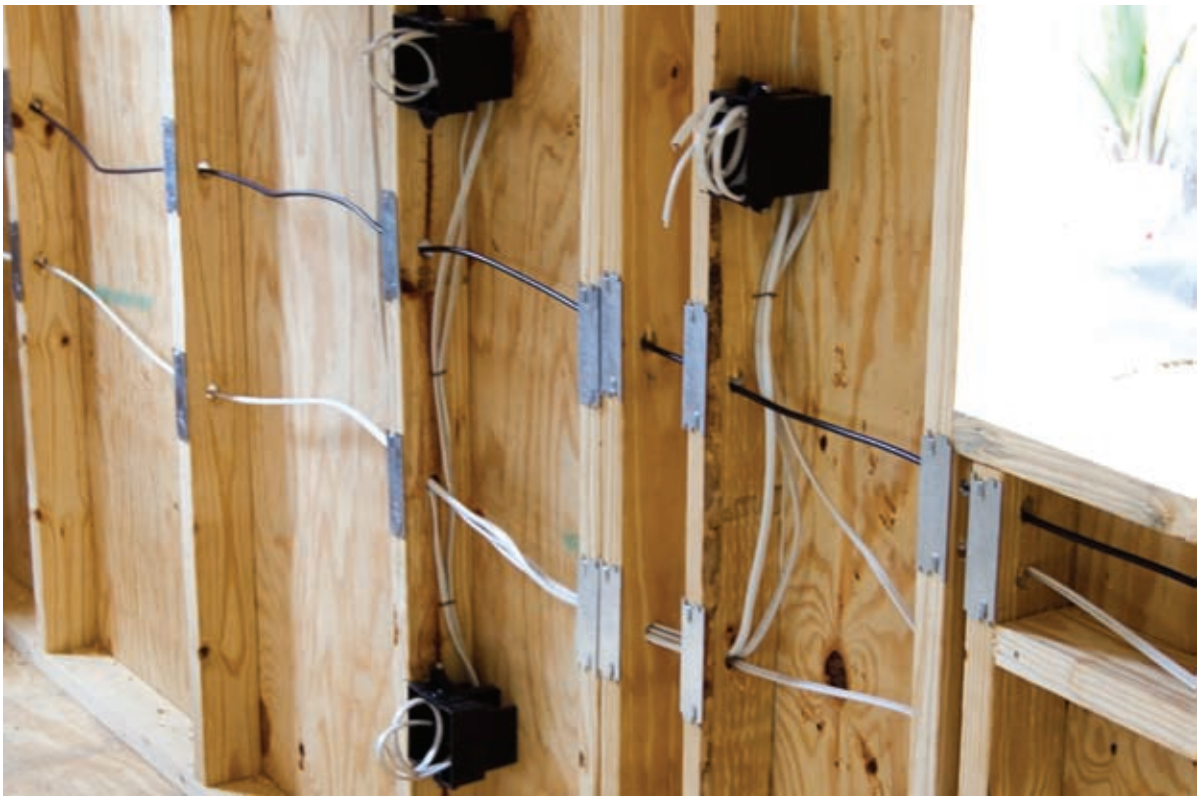
The house's electrical should be divided among multiple 15 amp breakers with larger loads like an air conditioner having a dedicated run and breaker. In the 20 foot homes designed by Tiny Home Builders we use 3 breakers, one for the left side of the house, one for the right side of the house, and a dedicated breaker for the air conditioner. These three breakers then share a single source that is either permanently wired into the electrical panel, or supplied by a heavy duty extension cord. If an extension cord is to be used, a three foot cord is wired into the electrical panel that has a male connector at the end which is plugged into

Dedicated Line for the Air Conditioner

the extension cord. If a single supply line is determined not to supply adequate amperage to the house, the individual breakers can be broken out into multiple electrical panels, each with their own supply; however, we are unaware of any cases where this has been necessary.
When running the power lines start by installing the switch and outlet boxes at the desired locations. These come with small raised 'tabs' on their sides that allow for them to easily be offset so that they extend ½ inch beyond the edge of the studs. If a thinner interior siding material is to be used these raised sections should be removed using a utility knife. When installed, the boxes should not extend out beyond the stud farther than the siding material to be used.

There are no standards as to the height that the outlet and switch boxes should be placed, but we place our switches 48 inches from the subfloor to the top of the switch box, and our outlets 16 inches from the subfloor to the top of the outlet box.

Next, map the route of the wires starting at the location where the breaker box will be installed. Be sure that the wires path will not interfere with the plumbing and that the electrical wiring is run separately from other wires (i. e. cable and telephone lines). If slat siding is to be used in the interior, it is recommended that the wires be run at an angle through the walls instead of horizontally. Since metal protective plates will be installed on the studs at the locations of the wires, if the wires were to be run horizontally, these metal plates would line



Switches and Outlets

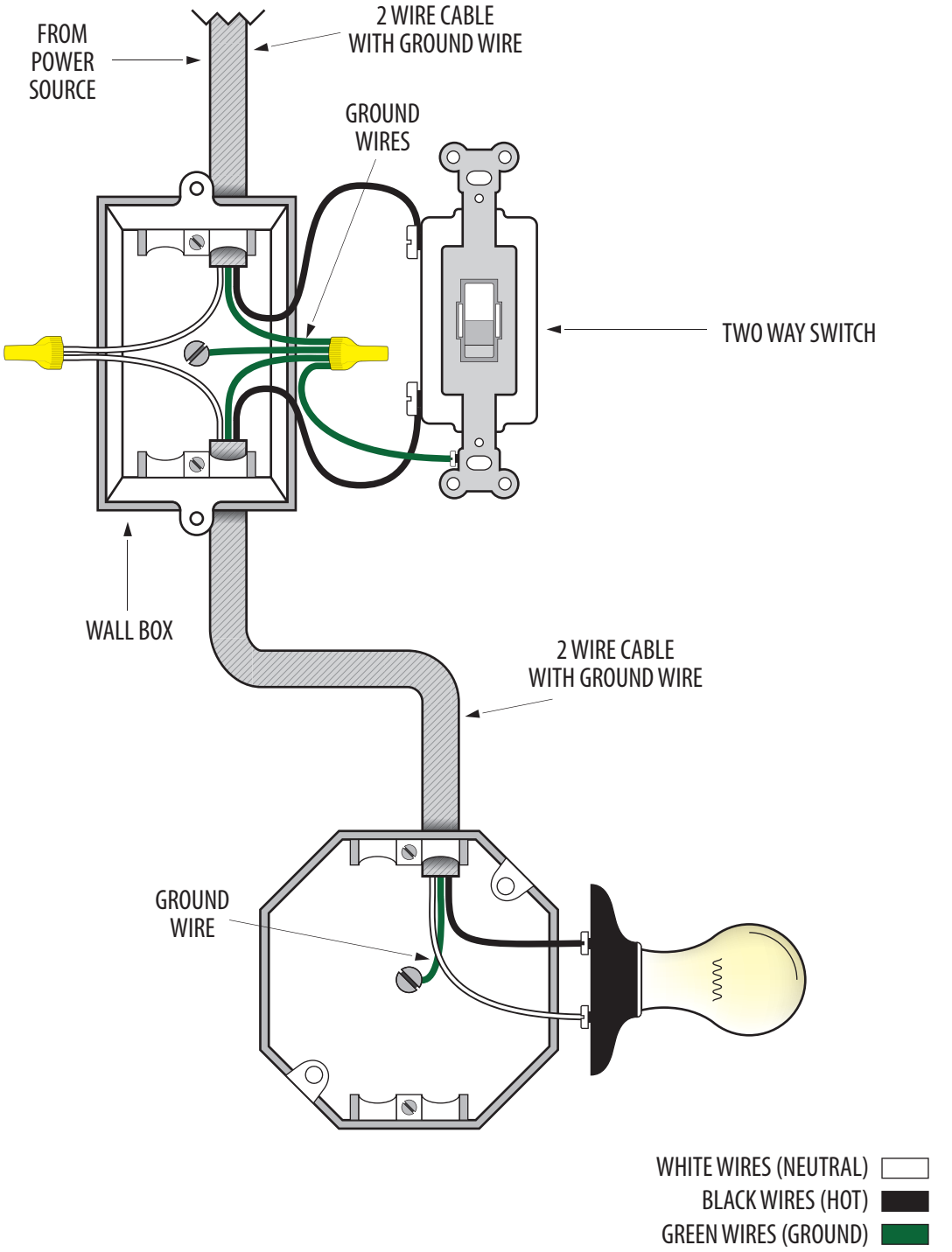
up to prevent a single piece of slat siding from being nailed to the wall. This can result in that row of the siding buckling or bowing.

Drill a ¾ inch hole in the studs to run the wires through. A metal nail plate, as mentioned earlier, should be attached to the outside of the studs directly over where the holes are drilled to prevent accidentally driving a nail into the wire later when installing the interior siding or while hanging a picture, etc..

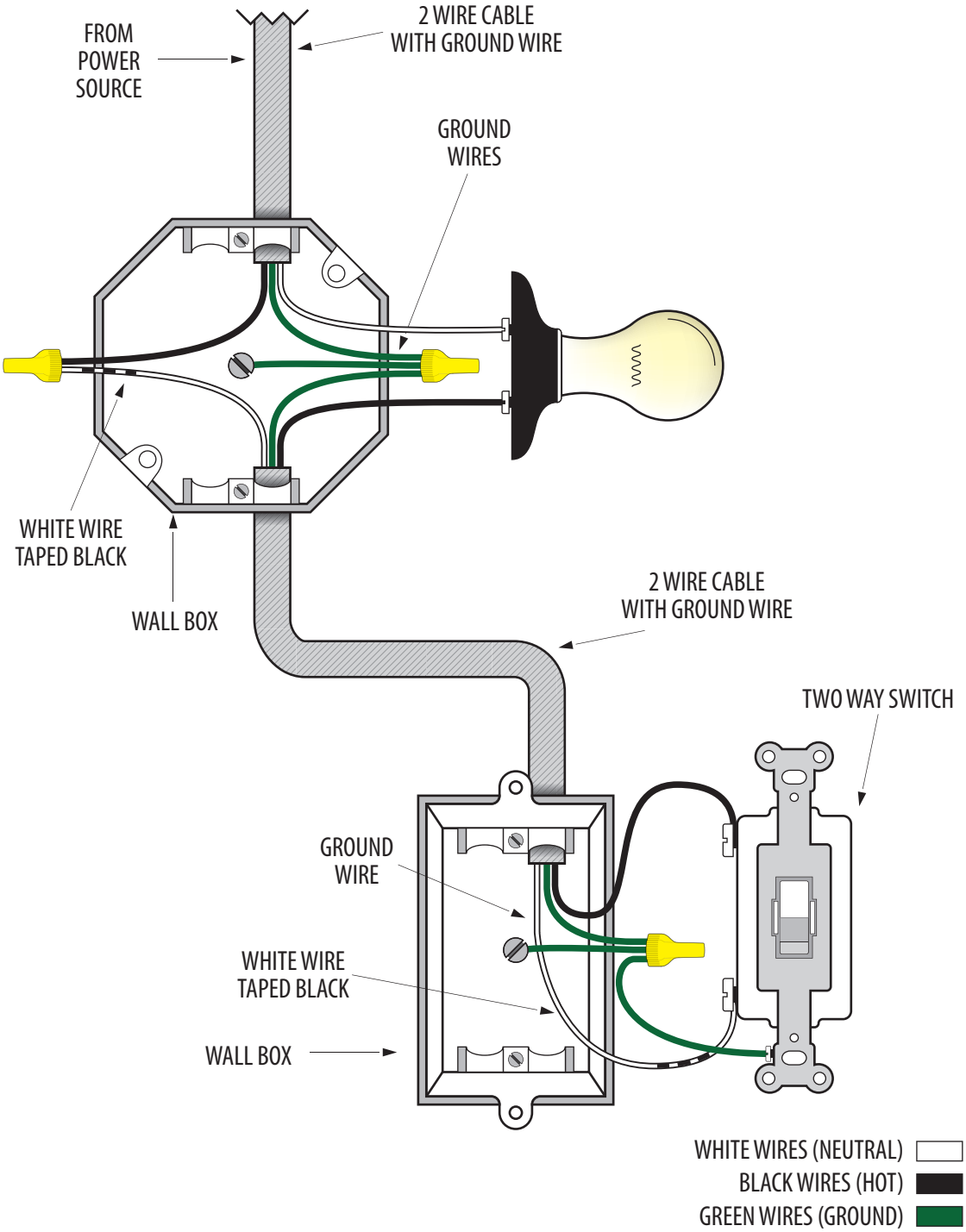
The wires are then run from box to box and are connected to each other by the switch or outlet that will be installed in each box. There can be no breaks in the wire other than those within the boxes. It is a fire hazard and against all electrical codes to have breaks in and/or connections between wires within the wall cavity. Outlets have connections on either side of them to facilitate this 'bridging' of the wires. The wire coming into the box is connected to one side of the outlet, while the wire leaving is connected to the other side. Try to limit the number of wires coming into a single box as it is difficult to fit the outlet or switch if there are too many wires.

Below are a few diagrams to illustrate how to run the wires for various switch configurations.

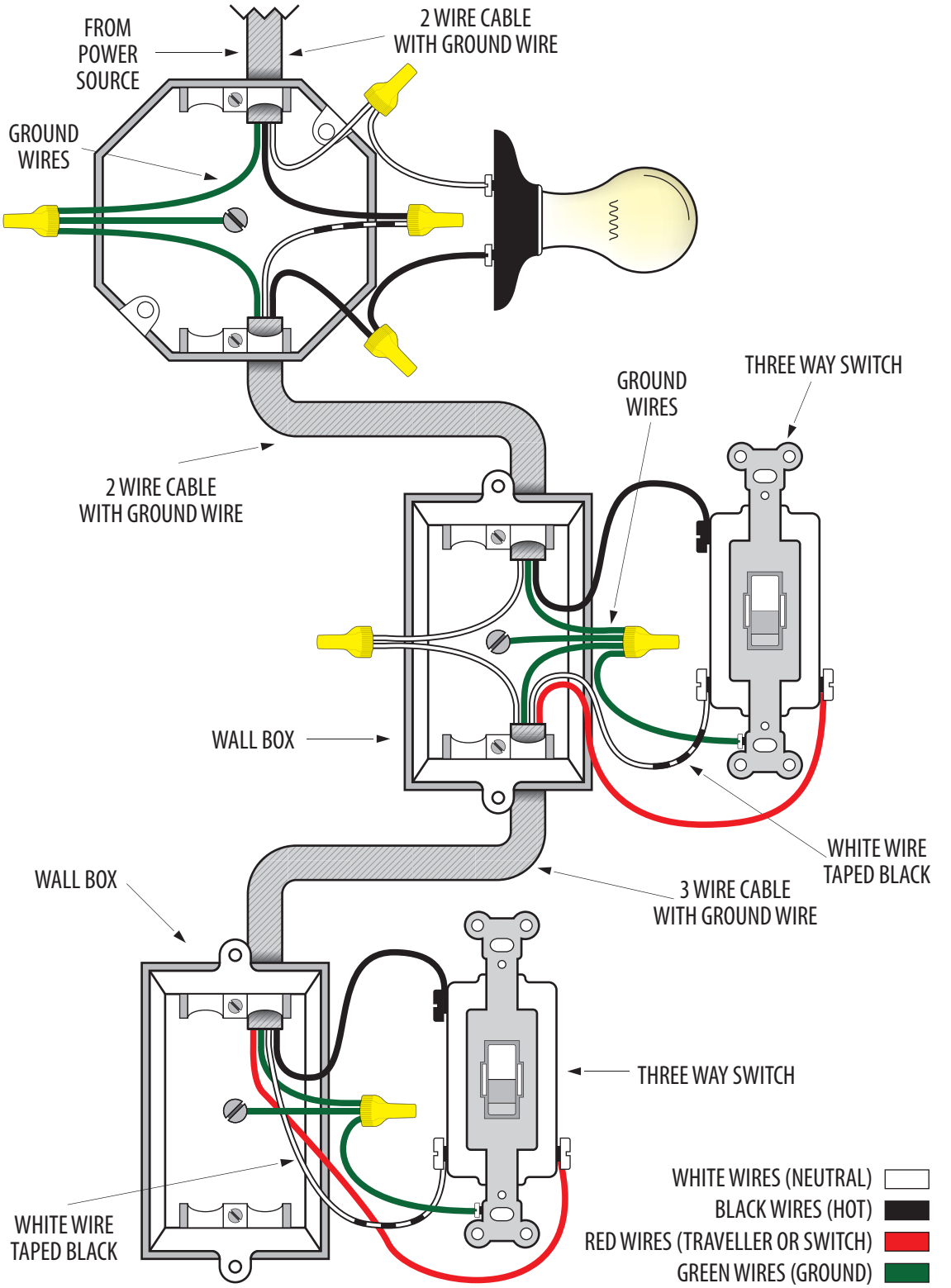
Because of the importance of the wiring I encourage additional research and/or consulting with a licensed professional if you are uncertain about the correct way it should be installed.



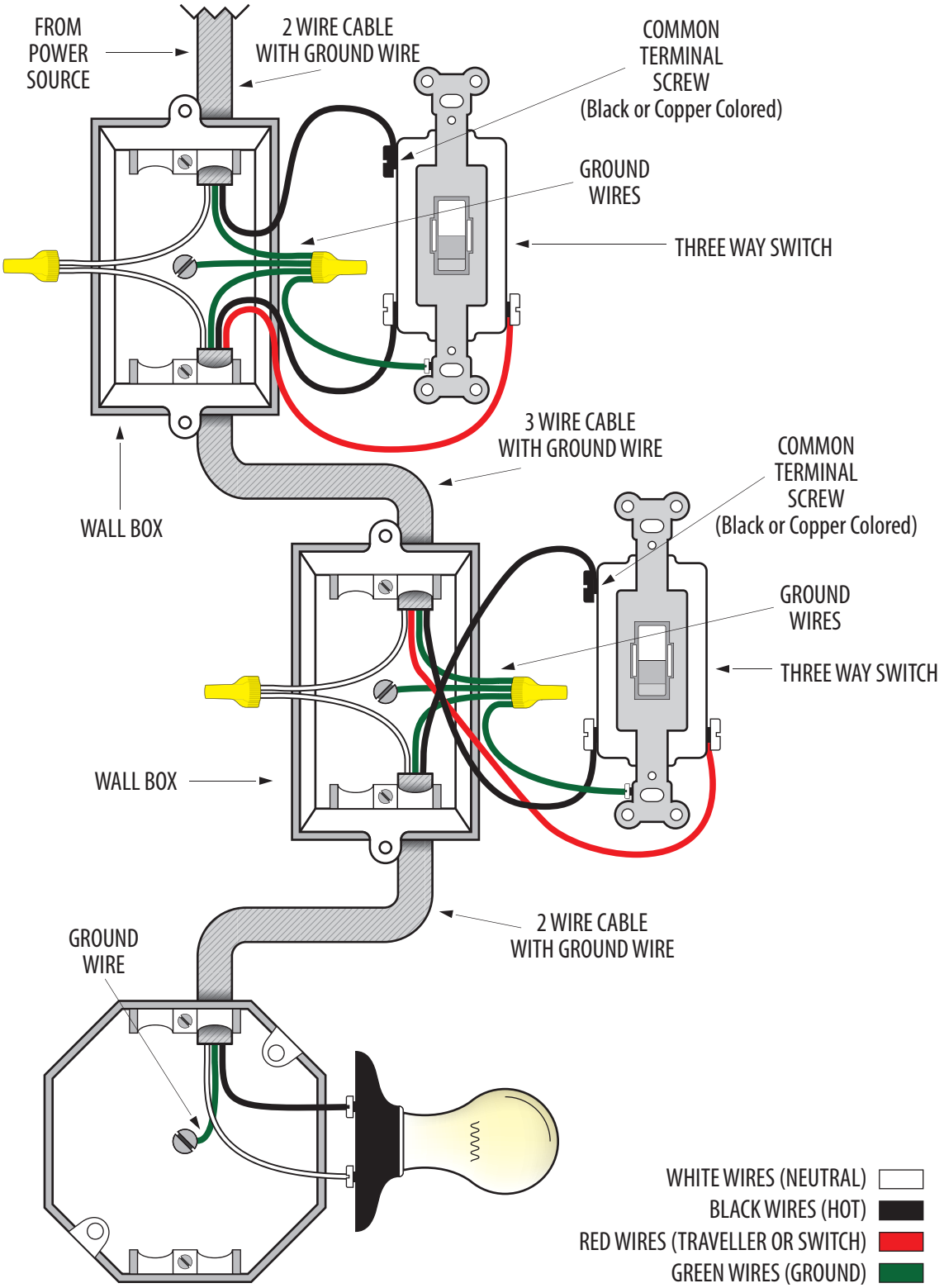
Standard Switch - Power Through Switch



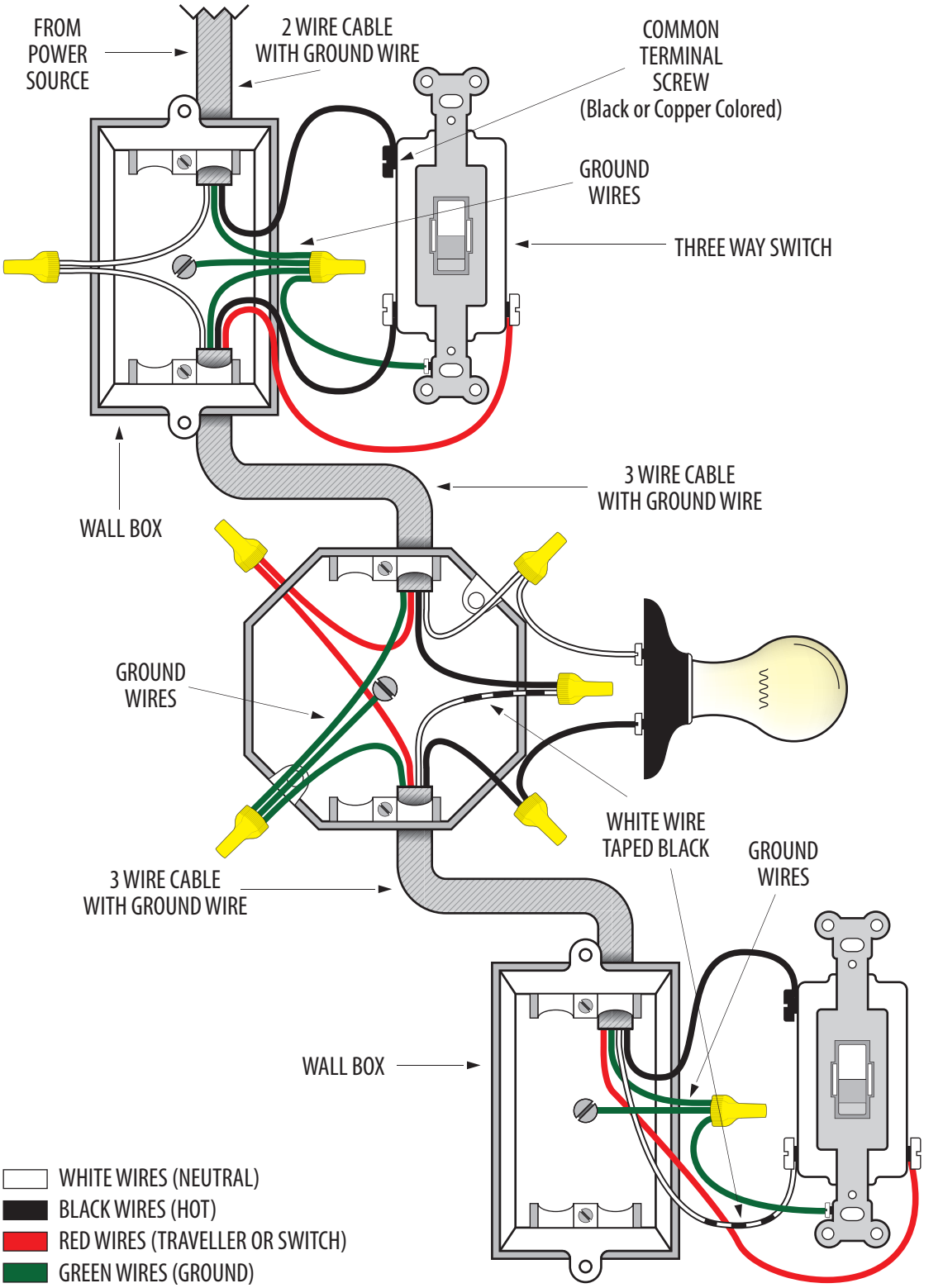
Standard Switch - Power Through Light



3 Way Switch - Power Through Light



3 Way Switch - Power Through Switch



3 Way Switch - Light Between Switches

Insulation provides a thermal barrier between the living quarters of the house and the outdoors

INSULATION

INSULATION TYPES

There are several different types of insulation that are often considered for a tiny house. The most common are closed cell spray foam (CCSF), extruded polystyrene panels, and fiberglass insulation.

CLOSED CELL SPRAY FOAM (CCSF)

CCSF is a great option for a tiny house and is the material we use for the houses built by Tiny Home Builders. CCSF has one of the highest R-values of any insulating material at approximately 6.25R per inch. In addition to having a high R-value, CCSF is also very resistant to air leakage through the wall and roof cavity since it is sprayed in and expands to fill the area in which it is applied. This cuts down on drafts and improves the energy efficiency of the home. It also acts as a vapor barrier when applied to a minimum thickness of 2 inches. Finally, CCSF also becomes extremely ridged after it expands and dries, which can contribute to the structural strength of a tiny house.

The biggest disadvantage of CCSF is that it is expensive. CCSF is typically 3 times the cost of fiberglass insulation installed, or even more if the homeowner were to install the alternative themself. The second disadvantage is that spray foam is not very do-it-yourself (DIY) friendly. While there are DIY kits, they can

Closed Cell Spray Foam

sometimes be more expensive than professional installation. These kits may also require expensive protective equipment that would only be used once. Also, unlike the temperature regulated rigs of the professionals, DIY kits can only be used within somewhat strict temperature ranges. If it is applied at the wrong temperature or incorrectly (e.g. two thick on a single pass), spray foam can outgas far after it has hardened. Unless there are no CCSF installation contractors in your area, we recommend hiring a professional to do this job.

EXTRUDED POLYSTYRENE (STYROFOAM) BOARDS (EPB) SUPPLEMENTED WITH SPRAY FOAM

EPBs are a good alternative to CCSF. They provide a relatively high R-value of approximately 5R per inch. They are considerably less expensive than CCSF, and if an aerosol foam product is used to fill the gaps between any adjoining boards and around the board edges, they still provide a relatively good air barrier. They are also readily available at many home improvement retailers.

A disadvantage of EPBs is that they can be somewhat difficult to install. Each board must be cut to the exact size of the cavity (i. e. the distance between the studs or rafters) that needs to be filled. Cutting these boards is a little more difficult than cutting wood since they aren't as rigid and friction from tools like a circular saw can melt the product. Also, If multiple layers of boards are used these cuts will need to be made multiple times for each cavity. Multiple EPBs are used when there isn't a single EPB made in the thickness of the amount of the cavity that you want to fill. Common thicknesses of EPBs are 2 inches and ¾ inch. Since it may be desirable to have more than 2 inches of foam in the wall cavity, a combination of a 2 inch and a ¾ inch board can be used. We don't recommend using a combination of EPBs that will exactly match the depth of a wall cavity. For instance, 3½ inches of EPBs for a wall constructed of 2x4s. This is because EPBs are very difficult to compress and if there are any size irregularities in the lumber (which is common) or any obstructions in the cavity itself, the EPBs may extend out of the cavity and make it difficult to install the interior siding later.

If EPBs are to be used, we recommend using a circular saw and/or hand saw to cut the thicker sheets. For thinner sheets, a utility knife can be used to score the sheet allowing for it to be easily and cleanly broken. Note that the blade of the knife will need to be replaced frequently.

FIBERGLASS

Fiberglass is the most common type of insulation used in residential construction. This is primarily driven by its low cost and easy installation. However, there are significant and numerous disadvantages to using fiberglass insulation. These include:

- Relatively low R-value of 3. 4R when optimally installed
- Diminished R-value if the insulation is pinched, becomes wet, or settles
- Ineffective against radiant heat transfer
- Does not tightly seal wall cavity against the flow of air
- Depending on climate, may require an additional moisture barrier.
- Requires protective equipment (e.g. mask, gloves) while installing

Because of these disadvantages we recommend against using fiberglass insulation in a tiny house.

OTHER INSULATION MATERIAL

There may be other insulation materials available depending on your location. These include effective natural options like cotton, sheep's wool, straw, and hemp. Since these are more obscure with limited availability I will not discuss them in this guide but I encourage additional research.

EPB Insulation

Wheel Well Partially Filled With Foam

The interior siding can set the tone and style of a tiny house

INTERIOR SIDING & TRIM

In typical residential construction the most common type of interior siding is drywall. For a tiny house though, drywall isn't recommended since it is both heavy and relatively brittle, especially at the joints. A more suitable material is either solid sheet paneling or tongue and groove (TNG) slat paneling. Solid sheet paneling is the easier of the two to install, however some varieties can have a dated look and the solid sheets can have unattractive seams. Slat paneling on the other hand is more difficult and time consuming to install but is considered by some to be more attractive.

The downside to using paneling over drywall is that some adjustments may need to be made in various places to compensate for the differences in the thickness of the two materials. Most notably these adjustments including changing electrical junction boxes so that they stand out beyond the studs only ¼ inch instead of ½ inch, and adding ¼ inch of filler behind the window trim (since the window jamb also extends beyond the studs ½ inch).

Before any interior siding can be installed there needs to be two pieces of framing wood in every corner that the siding can be nailed to. Often these boards will already be there as a result of the framing, but in some cases they will need to be added. These added boards are called either "nailers" or "deadwood" as they are only there to provide a surface to nail to and provide no structural support.

The siding should be unwrapped and given time to acclimate to the environment

Deadwood Installed in Ceiling Corner

Interior Pine Slat Siding

Interior Pine Slat Siding

Trim Around Kitchen Window

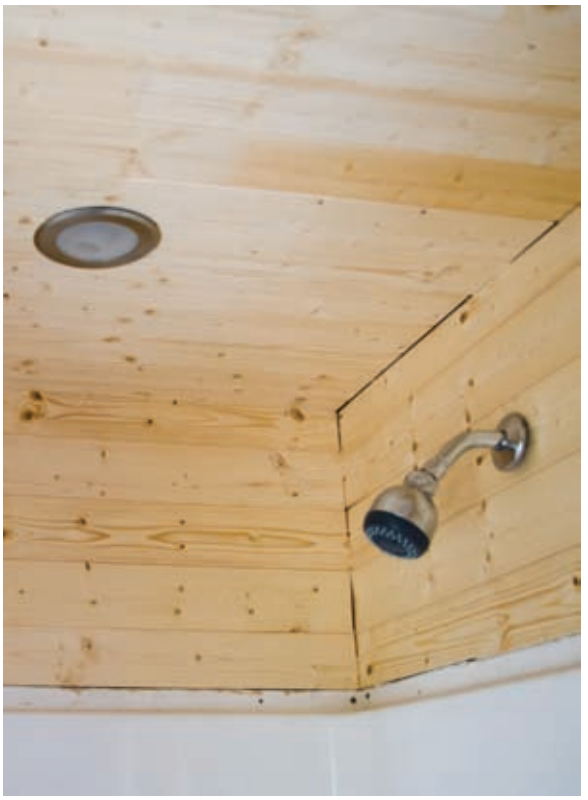
Trim Around Dormer Windows

before being installed. The amount of time it takes can vary based on the specific product but a minimum of 72 hours is recommended.

To attach the siding use a pneumatic brad nail gun and construction adhesive. Adhesive can be applied to all the studs in a small area where the siding will be installed within approximately 10-15 minutes (this does not apply to fast drying/bonding adhesive). This avoids the need to have to stop and apply glue for each board. Be sure that the boards are tight against the studs wherever adhesive is used since the boards will not be able to be made tighter after the adhesive dries.

The boards closest to the floor should be installed first with the upper boards following. The first (bottom) board should be raised off the floor by ½ inch to allow for expansion. This gap will not be visible later as it will be hidden by the flooring and trim. The end of any board that will butt up to another board not in a corner should be cut at a 45 degree angle as was done with the exterior siding. This allows the boards to overlap so that the studs behind the joints aren't visible if the siding were to contract.

Trim is then added around the windows, door, and in all the corners (both inside and outside corners). Cove or quarter round molding is used on the inside corners, corner molding is used on the outside corners, and casing is used around the windows and doors.



Untrimmed Interior Siding Above Shower

Siding Around Switch

A durable, attractive material should be chosen for the flooring

FLOORING

Hardwood Flooring

There are many different types of flooring that can be selected for a tiny house.

Tiny Home Builders generally uses solid or engineered hardwood flooring in the living area of the house and vinyl tiles in the bathroom.

Hardwood flooring is attractive, durable, and can flex with the trailer as required when the house is being towed. While hardwood flooring can be a more expensive option, because of the limited amount of material required, this cost difference may not be that significant. Substantial deals can also often be found at flooring centers for such small quantities since frequently materials are left over from larger jobs, and product lines are occasionally discontinued with some stock remaining.

Engineered hardwood flooring has the same appearance as solid hardwood and is real wood flooring, but is more stable than solid wood and is less susceptible to shrinking and expanding with changes in temperatures and humidity. Instead of being solid it is layered much like plywood with the top layer having the desired appearance.

The downside to engineered hardwood flooring is that it cannot be refinished as many times as solid wood.

Blind Nail

INSTALLING HARDWOOD FLOORING

Different flooring materials have different installation instruction so see the manufacturer for their specific directions.

ACCLIMATE THE WOOD

As was done with the interior siding, allow the hardwoods to acclimate to the environment where they will be installed. The length of time that is recommended can vary from 72 hours to 14 days, so check with the manufacturer for your specific product. Be sure that the boxes containing the flooring are not sealed and avoid stacking them. Engineered wood generally has a much less recommended acclimation time.

INSTALLING THE FIRST ROW

The first row of hardwood flooring installed is the most important as all subsequent boards will be based off of it. If this row is installed improperly the entire floor will likely not look right.

The first decision when preparing to install the flooring is deciding on the direction of the boards. In a tiny house the boards can be installed so that they run parallel with the longer side of the house, parallel with the shorter side of the house, or at an angle. Tiny Home Builders installs our hardwoods parallel to the longer side of the house since this is perpendicular to the joists, which adds strength to the floor, and we believe is more visually appealing since it makes the room look larger.

Optionally an underlayment can be stapled to the subfloor sheathing before installing any boards. This is not required but can help reduce squeaks and act as a moisture barrier.

The first line of boards should start at the edge of the floor and be spaced approximately ½ inch away from the wall. This gap is to allow for expansion of the wood and will be hidden later by the wall trim. Measure and mark a line using a chalk line for the first row of boards. If the framing around the wheel well is in the way of the chalk line, mark the closest line that can be continuous, and then measure for the shorter lines on either side of the wheel well from the continuous line.

Also double check your measurements and the line placement by verifying that the distance from the line to the opposite wall is the same on each end of the room. If it is not the same then one of the walls may be slightly out of square and you may need to adjust your line.

Attach the first row of boards by using a pneumatic nail gun to drive a nail at a 45 degree angle through the base of the tongue on the board. The nail should be driven in far enough so that it will not get in the way of the tongue and groove joining while installing the next row of boards. This process is referred to as blind nailing since the nail will not be visible when the next row is installed. Be sure that the boards do not shift during this process. Additional nails can be driven into the top of the board as long as they are close enough to the edge so that they will be covered by trim later.

INSTALLING MOST OF THE REMAINING BOARDS

To install the next row of boards, place a piece of scrap flooring on the ground against the boards in the new row and lightly hammer it to get a tight bond between the two rows. Be sure that the first row of boards does not move during this process. As additional rows are added, the chance of the existing boards moving reduces. Either use a hardwood flooring stapler or continue to blind nail the boards to the subfloor. Continue this process until all the boards are installed. Be sure to stager the seams between boards in a natural pattern.

INSTALLING THE LAST ROW

Since there will not be room for a piece of scrap wood or a hammer, use a flat bar placed against the wall to get a tight bond on the last row of boards. Top nail the last row to attach it. As with the first row, a ½ gap should be left between the wall and the last row of flooring boards.

INSTALLING VINYL TILES

Hardwood flooring is not a good option in the bathroom because of the higher moisture levels normally found there. For this space we recommend hard vinyl tiles because they are lightweight, strong, and inexpensive. When installing vinyl tiles be sure that the arrows printed on the underside of the tiles all face in the same direction. These markings are added by the manufacturer to ensure the tiles fit together correctly despite the possibility of slight differences between the lengths of the sides.

Hard vinyl tiles can be cut by using a utility knife to score a line and then bending them until they snap. If a portion of a tile needs to be cut out, run the utility knife over the same area several times until it cuts all the way through the tile.

These tiles usually come with their underside already coated in an adhesive,

but we recommend adding an additional layer of adhesive to the floor before installing the tiles. A trowel is used to apply the adhesive.

TRANSITION PIECES

An additional piece of wood is added to cover the transition between the two different flooring types, in this case the vinyl tiles and the hardwood flooring. Since these different types of flooring have different thicknesses, the transition piece has to be a different thickness on each side so that it rests flat when installed. The retailer/supplier that provided the flooring should also carry transition pieces with a matching finish to the hardwood floor. This piece is attached by top nailing it.

Installing the cabinets and any shelving is one of the last steps in building a tiny house

CABINETS & SHELVING

Pre-built Cabinets Installed

Your choice for cabinets and their placement can heavily influence whether you are happy or disappointed with your house. They will determine how much storage you have, and to some degree how roomy your house feels. It is important to have a place for each of your belongings in order for your house to stay organized and to not feel cramped or messy.

For the cabinets in your house you can either purchase pre-built cabinets, custom order them, or build your own.

PRE-BUILT CABINETS

Pre-built cabinets can be purchased from most of the home improvement stores. They are relatively cheap and come in an assortment of sizes. They are easy to install and can be used to complete an entire kitchen in just a few hours.

The problem with pre-built cabinets is that while they do come in an assortment of sizes, they may not have the right size for a tiny house. This is not as much of a concern for the lower cabinets since you would not want to deviate from the standard height (which is comfortable to stand at) or the standard depth (which will properly fit a sink). In the event that a shallower cabinet is required, the back of a pre-built cabinet that does not contain any drawers can be trimmed down. The types of cabinets that you are more likely to have issues with the size are upper cabinets or floor to ceiling cabinets.

The other issue that may come up with pre-built cabinets is the selection of the materials and finishes of the fronts and doors. This is usually fairly limited since the stores need to keep in stock so many sizes of each style variation. If you have an IKEA in your area you may find a wider selection there.

To install pre-built cabinets you will first need to join together any adjacent cabinets. This is done by lining up the framing on the face of the cabinets and clamping them together. Holes are then pre-drilled in the framing and the cabinets are screwed together. Once the cabinets are joined they are then screwed to the studs in the walls through the thicker pieces of wood on the back of the cabinets. Care should be taken to ensure that the cabinets are level when they are attached.

CUSTOM ORDER CABINETS

There are two different classifications of custom cabinets. There are those that are truly custom, which are constructed to the exact measurement for where they will be installed. And then there are those that are selected from a catalog of available sizes and then made for you. This second type is what is more commonly found at the home improvement stores. Either way, custom order cabinets offer a much greater selection of sizes and styles. The downside though is the cost. Custom order cabinets are considerably more expensive than any of the other options.

The home improvement stores generally offer free estimates for custom cabinets that include a 3D drawing of what the cabinets would look like installed. Even if you don't plan to purchase the cabinets, laying out the design with a professional who has designed many kitchens can be an educational exercise.

BUILD YOU OWN

Building your own cabinets is the most economical choice, and will also result in cabinets that are perfectly sized for your needs. The challenge is that cabinets can be the most difficult item to construct in a tiny house. The techniques to construct cabinets and furniture are very different than those used in house construction. Cabinet construction also uses a different set of tools aimed primarily at joining wood without using visible nails or staples.

CONCLUSION

There are many steps involved in building a tiny house. And while many of these steps may take a long time to complete, they are generally not that difficult. I believe anyone willing to research, learn and try can build themselves a tiny house.

For each chapter in this guide, there exist many books dedicated to the subject as well as an endless supply of articles on the Internet. If you get to a part that is unclear, simply take your time and do some additional research. The answers are out there. If there is something you are just not comfortable doing yourself (like the plumbing or electrical) you can always hire someone to complete a specific task for you.

Starting a project like building an entire home from scratch can be very intimidating. While it may seem overwhelming, keep in mind that it is nothing more than a bunch of individual tasks that can be learned and mastered one at a time.

If you read this book because you are considering building a tiny house, I hope that I have given you a little more knowledge, as well as a little more confidence to start your very own tiny house project.

TINY HOME BUILDERS

http://tinyhomebuilders.com