How to Build Shipping Container Homes

With Plans













John Davidson
7ing House Series

JD-Biz Publishing

How to Build Shipping Container Homes With Plans



Plan Book Series

John Davidson

Mendon Cottage Books



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Chapter One Introduction to Shipping Container Homes

Shipping container homes are houses that are built using shipping containers. The strength, durability, availability, and the cost effectiveness of containers as building material has made these types of homes popular in recent years. When you buy a container, it might appear as hollow boxes with no windows or openings. However, these boxes are highly customizable; they can be stacked and welded together to create beautiful yet economical homes. The next section is about the pros and cons of living in a shipping container home.



Advantages of Shipping Container Homes:

- 1. The first advantage, is of course the cost; the cost involved in constructing a container home is much less than the cost of building a conventional home (for the same space and storage).
- 2. Container homes are eco friendly and support minimalist living; you will be using containers that are no longer used in the shipping industry, thereby helping to recycle them.
- 3. These containers are used for shipping heavy loads and thus are built to be durable and strong.

- 4. These homes can withstand extreme weather conditions (hurricanes) due to their structural strength.
- 5. Containers can be stacked horizontally and vertically to create multistoried buildings.

Disadvantages of Shipping Container Homes:

- 1. The material used in the construction of containers conduct heat very well. Thus temperatures drop and raise very steeply within the containers
- 2. Due to the above reason, it is important to insulate the containers and control the temperature.
- 3. Containers are also used to carry toxic and harmful substances. Thus, before buying a container, it is important to get it tested.
- 4. Most of the containers that are sold are fit for scrapping; this leads to the issue of tackling rust.
- 5. It is possible that solvents and harmful paints were used inside the containers, which if inhaled for long duration (living in the container) can be fatal.
- 6. Applying and obtaining a building permit for container can be a major hurdle, as container homes are usually not allowed in residential zoning areas.

Container Sizes and Specifications:

Shipping containers come in two sizes: 20 feet and 40 feet.

The dimensions of a 20' container are: 20' (length) x 8' (Width) x 8'6" (Height).

The dimensions of a 40' container are: 40' (length) x 8' (Width) x 8'6" (Height).

From the above dimensions, the only variable is the length and choosing a 20' or 40' container depends on your needs and the number of people living with you. If you are planning to build a compact tiny house, a 20' container will suffice. You can also stack the containers vertically to create more

space and privacy. However, if you plan to stack two 20' containers horizontally, think again – a 40' container is a better alternative, as you will save money and effort used for welding two 20' containers.



New or Used Container:

Once the size of the container is set, the next step is to decide on buying a new or used container.

While buying new containers defeat the very purpose of minimalist living and add to your expenses, but they offer you peace of mind, as they have never been used before for carrying cargo. You can also get customized containers delivered to your location – talk to the container dealer about the delivery charges. You can negotiate the container prices by allowing a one-time cargo shipment using your container.

Buying a used container is more economical and environmental friendly. Before buying a used container, get it tested for toxic substances. It is always important to walk through the container to get a feel of the place you will be living in. Ask your dealer if it has a watertight seal and if it was ever damaged (however small it was). Talk to your dealer about the warranty, compare prices of different sizes, and ask about the delivery charges of the unit to your place.

Permits and Regulations:

Even though you are building a container house, you must still submit your plans to the local building/planning authorities and get a permit. Your local

authorities will be the ones to inspect your building and issue permits. It is a good idea to talk to the local authorities before you proceed with the construction. When you talk to them, inform that you are planning to build a house with modular steel sections and mention the use of containers in passing. Prepare a list of questions that you want to ask; following are some pointers:

- a. Find out about zoning restrictions
- b. Ask about the footage area requirements and restrictions (minimum and maximum area that is allowed)
- c. Find out about the maximum height allowed
- d. Collect details about the list of drawings and documents to be submitted for obtaining the permit
- e. Check out the local building department website for relevant information



Student Housing Complex

Chapter Two Foundation for Shipping Container Homes

Foundation is the most important part of your entire structure. Thus it is advisable to seek professional help in designing your foundation. Foundations can be broadly classified into 4 types:

- 1. Full basement
- 2. Submerged crawl space
- 3. Flush crawl space
- 4. Slab-on-grade

For each of the above foundation types, various construction methods can be used. Some of the methods are:

- a. Treated wood foundation
- b. Precast concrete foundation
- c. Cast in place concrete
- d. Concrete block foundation

Before choosing your foundation type, you must consider the structural load of your building along with the following factors:

Site Conditions:

This plays a vital role in selecting the type of foundation for your building. The main factors to consider here are the water table, soil conditions, and the topography. It is important to observe and determine the ground water conditions. If your site has a water table within 8ft depth from the surface, a basement foundation will leave your basement flooded. The only option here is to build a slab-on-grade or crawl space foundation.

The type of soil on your property is an extremely important factor in determining the type of foundation. If you have clay soil, the foundation requires reinforcements and soil testing to address the soil settlement issues. Usually pile foundation is used for clay soil, which extends till the bedrock.

Climate:

The impact of frost depth on foundation design plays a vital role in selecting the foundation type. Generally, the foundation must be placed at greater depths at colder places, as water expands when it freezes. When it expands under your foundation, the pressure exerted will force the foundation to move upwards. However, you can use shallow foundations in cold climates with proper insulation.

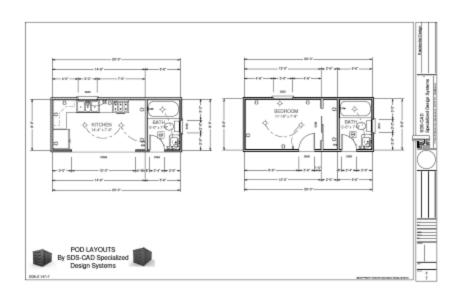
Market Factors:

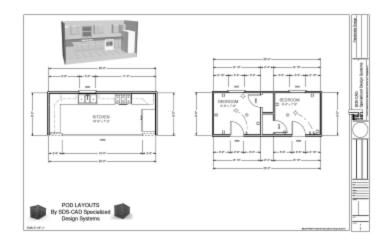
The local and regional markets in your area determine the type of foundation that can be built. Even though it is possible to build any kind of foundation at any location in the United States, the costs will definitely vary depending on the availability of materials and labor. For example: if the contractors in your area specialize in masonry foundation, the cost to install a prefabricated foundation will be higher.

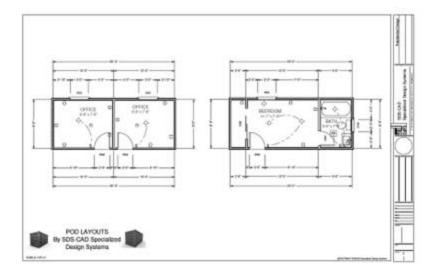
Building Design:

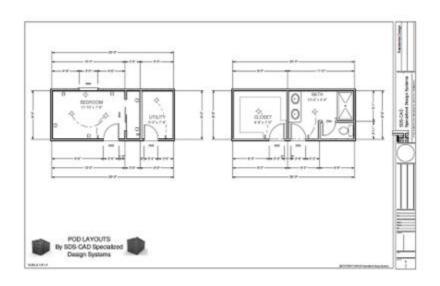
If you are planning to add aesthetic value to your building through a raised foundation, mention it to the engineer/contractor beforehand. Following are some of the building plans to consider:

You can design your house using several containers and arranging the way you want your home laid out. Here are some examples.

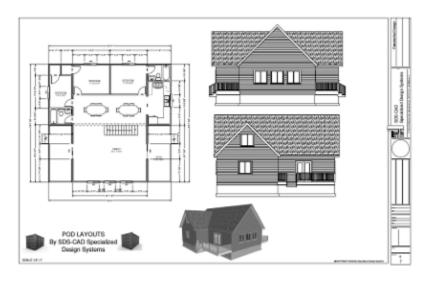


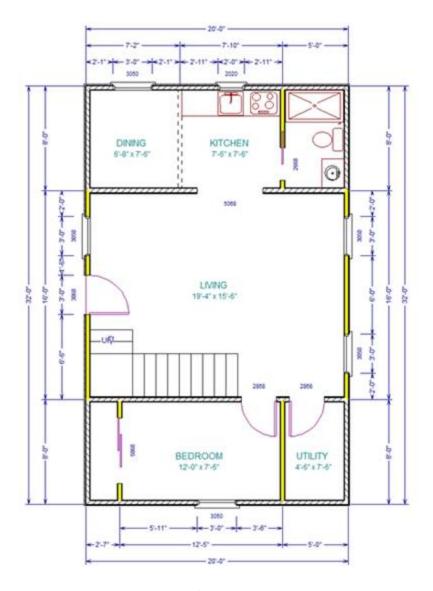




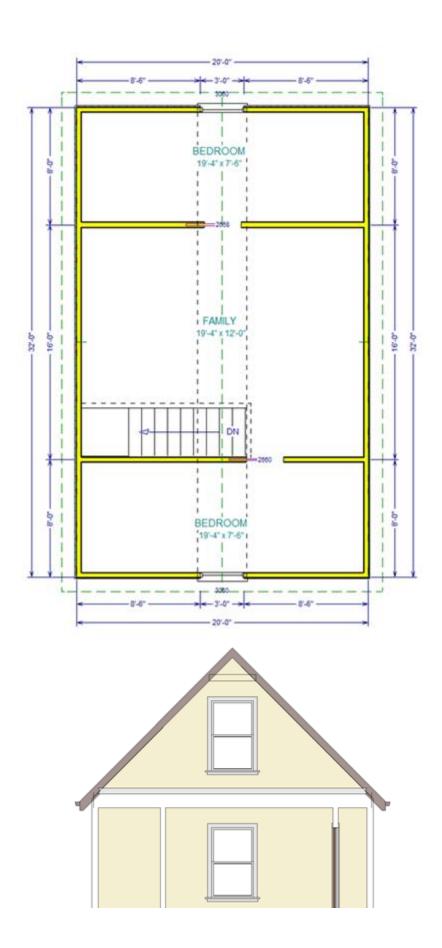






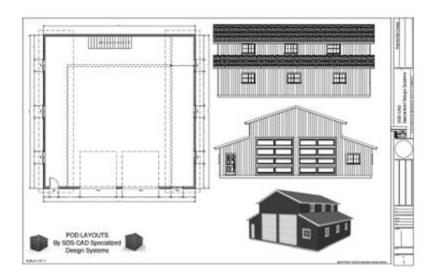


Here is a design using two 20 foot containers and then building walls between them to add the living space and then putting attic trusses on top to create a second story living area.





Next is a barn layout using two or three forty foot containers.





Excavation and Footings:

Once the soil conditions, water table level, and climate are determined, the structural engineer will decide on the depth of excavation needed for the foundation. The following are the steps involved in excavation:

- a. The top soil is removed and cleared out of the way
- b. The corners of the foundation are marked using 2ft long wooden stakes
- c. The corners are measured from side to side and corner to corner
- d. The boundary is marked using lime lines
- e. Decide on a place to dump the excavated earth
- f. It is common to dig 2-3ft bigger than the actual size of the home, as this allows you to have space to move around the foundation after it is poured
- g. The exposed earth (after excavation) is compacted; sometimes it is necessary to use landfill

After the excavation, the footings are erected by pouring concrete. Footings form the perimeter of the home and are wider than the container walls.

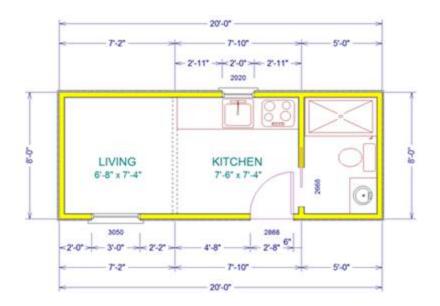
Types of Materials used for Foundation Construction:

It is important to use durable materials for building foundations. Foundations are subject to moisture, rodents, and termites. Thus, it is important to use materials that are resistant to the various weathering effects. Following are some of the materials that can be used:

- 1. Poured Concrete: Concrete is one of the best materials that you can use for the foundation. It can be easily molded into desired shapes and is resistant to moisture. The downside of concrete is its high cost.
- 2. Bricks: These are good choice in dry climates and they need protection from moisture.
- 3. Stones: They make an excellent choice as a foundation material if they are found nearby to the construction site. The drawback to this foundation is that it is difficult to stop termites because of the gaps between the stones.



Simple 20' container design



Chapter Three Placing the Containers

The dealer from whom you order the container will deliver it to your location for a fee or for free. The easiest way to place a container on your foundation is through a crane or a backhoe. Before ordering the container find out if your dealer has the necessary equipment to place it on the foundation; alternatively you can hire a small crane from the local builders to install the container.

If it is hard to find a crane, try hiring a forklift – a forklift has varying capacities and specialized forklift for shipping container is also available. Before ordering the container, it is a good idea to conduct research about the various available options for placing the container on your foundation.

Joining the Containers:

There are various ways to connect the containers; you can connect them using clamps, bolts, or through welding. While clamps are very expensive, bolts are not the most secure. The bolts come with punched metal plates that have to be fit inside the corner fittings. The advantage of using bolts is that it allows for easy dismantling of the unit in the future.

If you have decided not to dismantle the unit in the future, welding is the best option to join containers together. It is better to equip yourself with the basic knowledge of welding if you are planning on DIY welding.

Welding Basics:

Welding is the process of joining two metals through heating; the heat melts the metal, at the ends to be joined. Sometimes a filler material is also used to produce molten metal; the filler metal must be of the same composition of the metals being welded. In case of shipping containers, the material used is Corten Steel. Welding process can be either fusion welding or pressure welding. In fusion welding, heat is applied to produce molten metal whereas in pressure welding, no heat is used.

The common type of welding used for shipping containers is *Arc Welding* (Arc welding was previously called Metal Inert Gas welding). In this type of welding, a power supply is used to create and maintain an electric arc between an electrode and the base material; the electric arc melts the metals at the welding point.

Advantages:

- 1. This type of welding can be used to join metals of any kind and thickness
- 2. It is easy to learn
- 3. One can weld from all positions
- 4. It produces a good weld bead with little splatter

Disadvantages:

- 1. This type of welding is less portable
- 2. The weld is less controlled than Tungsten Inert Gas Welding

Parts of the Welder Kit:

You can buy a welder kit in your local hardware stores or off the internet. A MIG welder will have the following parts:

- a. The Welder this feeds the wire through the welding gun; if there is a wire jam, you must check this part
- b. The Gas Tank it consists either of 100% Argon or mixture of Argon and Carbon-di-oxide. The gas shields the weld as it forms; without the gas, the weld will splatter and look highly uneven
- c. The Welding Gun you will find a trigger on the gun that controls the wire feed and electricity flow; the outside tip of the gun is covered by a ceramic or metal cup it protects the electrode and also guides the gas to flow outside the tip of the gun.
- d. The Ground Clamp this completes the circuit between the welder, welding gun, and the material being welded.

Welding Safety Gear:

The light emitted during welding is very bright and will harm your eyes and skin. Therefore, it is necessary to wear a welding helmet or a mask; you can buy an auto darkening welding mask. The other safety gears to be worn during welding are:

- a. Safety glasses
- b. Gloves
- c. Welding jacket
- d. Leather apron
- e. Leather shoes

Prepping & Grinding the Weld:

Before you start welding, it is important to clean the surface of the metals that are to be joined. An unclean metal surface will result in a poor and weak weld. It is advisable to grind the surface of the metals that are to be welded together. If it is your first time welding, practice the formation of weld beads on a different piece of metal.

After welding the metals, you might see a lump of filler material – you can either leave it as it is or grind the excess lump to form a smooth surface.

Common Welding Problems:

Following are some of the common welding problems you might encounter:

- o You are unable to maintain a constant weld this happens when the gun is far away from the metal to be welded; the tip of the gun must be $\frac{1}{4}$ " $\frac{1}{2}$ " from the material
- o The weld splatters metal the shielding gas is not enough; increase the pressure of the gas. A low gas pressure might also cause a brown or green colored weld
- o The weld burns a hole through the material the power is too high; lower the power

o There is too much metal in the weld pool – adjust the wire speed, as too much wire is coming out of the gun

Container Reinforcement:

The structural stability of the shipping container will be compromised when you cut open the sides of the container or the interior container walls. Most people who build houses using these containers do not cut through them. However, sometimes it becomes necessary to open the sides of the container to attach more containers or to add aesthetic value to your home. In such instances, you must consult a structural engineer – they will work on the structural design to provide a stable and secure living environment. Usually, beams will be installed to provide structural stability and compensate for the loss of the internal walls.

Chapter Four Roofs

It is a common notion that a shipping container house doesn't need a separate roof, as it already has a top enclosure. However, this is far from true – the roof of the container can be used as it is only for shipping cargo and not for container homes. This is especially true for homes that use multiple containers – stacked vertically or horizontally. The top of a shipping container is designed with corrugation and an upward incline to displace accumulated water. When two containers are joined together, it closes the gap formed by the corner offset, thereby forming a pool of stagnated water.

Types of Roofs:

The different types of roofs that can be built for a shipping container home are:

1. Shed:

A shed is a sloping roof that is easy and cheap to construct. The advantage of a shed type is that you can fit solar panels on the rooftop to meet your electricity needs. You must know basic welding techniques for a DIY roof welding.

- a. Two steel plates at right angle (90^0) to each other are welded across the length of the container on both sides.
- b. Two wooden beams are fixed into the steel plates; the truss will be fixed into the beams
- c. Once the beams are fixed, screw the roof truss into place
- d. Place beams across the roof to complete the entire roofing structure

Note: It is important that your roof has sufficient ventilation – provide a roof overhang over the container for ventilation. There must also be an inch

gap in the soffit board and be covered with a mesh to allow air circulation into the roof.

2. Gable Roof:

A Gable roof is similar to a shed roof but with an incline on both sides. Following are the steps to follow to install a gable roof:

- a. Calculate the rafter length using Pythagoras theorem or Chalk Line Duplication method; you can also buy reference guides that calculate the rafter lengths for a given pitch
- b. Two steel plates at right angle (90^0) to each other are welded across the length of the container on both sides.
- c. Install ceiling joists on the steel plates you can use 2x4 lumber
- d. Use 2x6 lumber to cut a ridge board this goes on the roof peak
- e. For safety purposes, lay planks on the ceiling joists you can stand on them and remove the planks after framing the roof completely
- f. Cut the rafters (based on your calculations) and place them at 16" or 24" intervals
- g. Attach collar ties at peak of the roof to strengthen the rafters
- h. Assemble the gable roof and fix the planks to rafters the planks must be parallel to the ridge board
- i. Cover the end of the gable roof with mitered planks

Irrespective of the type of roof you install, it is advisable to consult a structural engineer to design the beams and rafters. A structural engineer will also be able to advise you on the ventilation options for various roofing systems. If you decide not to replace the container roof, apply a layer of tarpaulin sheet and cover it with asphalt – this will act as a barrier between your roof and condensation issues.

How to cut Shipping Containers

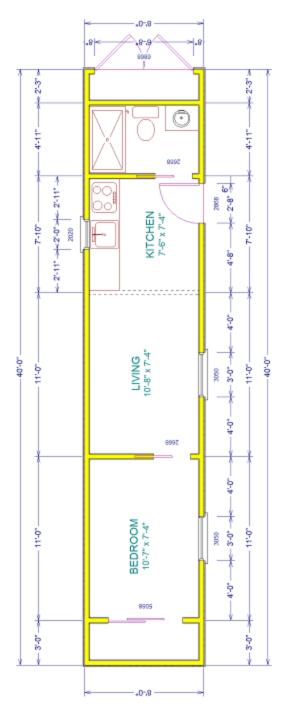
If you are attaching multiple containers, or want to add windows, doors and/or aesthetic value to your container home, it will be necessary to cut

open one or more container walls. You can use a plasma cutter, grinder, cutting torch, or even a jigsaw to cut the container; using a plasma cutter gives you smooth edges with a much cleaner cut than the other options. It is advisable to get professional help, as it reduces the risks and dangers involved in cutting structural steel. Following are some precautions to be taken before you proceed with cutting the container:

- 1. Wear heavy duty leather gloves and eye protection
- 2. Cutting steel will produce high decibel noise protect your ears with ear plugs
- 3. The metal shavings from the cutting will be extremely hot wear heavy duty full sleeved shirt and long pants to protect yourself
- 4. Before you start cutting, make arrangements to secure the pieces that will be dislodged during the cutting process
- 5. The cut panels will be heavy for a single person to move (if you are cutting out an entire wall)

Cutting open the sidewalls will leave large gaps in your container. You can fill these gaps using caulk, spray foam, or coarse steel wool.

40' Container design



Chapter Five Advanced Framing

Advanced Framing or Optimum Value Engineering (OVE) uses a number of techniques to reduce the consumption of lumber and waste produced in building construction. Some of the techniques used in Advanced Framing include:

- 1. Spacing of wall studs (2x6) at 24" on center instead of the traditional 16" on center spacing
- 2. Spacing of floor joists and roof rafters at 24" on center
- 3. Not using headers in non-load bearing walls
- 4. Use single lumber headers and top plates at appropriate places
- 5. Eliminating cripples and double studs around windows and doors

When you frame the walls, make allowances of few inches for adding insulation and sheathing between the closed door and the framings. You will require bolts and a drill bit to drill the bolts through the container and the frames. Galvanized bolts and washer must be used at places that are exposed to external surroundings; you can use regular bolts for internal purposes. If you are building a container home with multiple rooms, you must frame the internal walls before proceeding to the sheathing and insulation.

Once the framing is in place, the next step is to sheath your container. You can use regular OSB boards for sheathing purposes. Following are the sheathing wraps to consider for your container home:

a. Asphalt felt or tar paper – are excellent water resistant materials and has high permeability when wet; the disadvantage is that it will tear easily and deteriorate under UV exposure. This can be used both as a sheathing wrap and as a roofing underlayment

- b. Grade-D building paper this is usually used under stucco and deteriorates if saturated with water
- c. Synthetic house wrap this is used as a sheathing wrap under siding and has good permeability. Perforated variety of this house wrap has low resistance to water and is generally used in dry areas; the non-perforated variety has high resistance to water and can be used as air-infiltration barrier (if taped) at all the edges and seams
- d. Draining house wrap this too is used as a sheathing wrap under siding and acts as a moderate rain screen

The main purpose of using a sheathing wrap is to protect the house against water leakage. Therefore, it is important to cover the roof, gable ends, and walls with a sheathing wrap. It is also advisable to flash the window and door with a sheathing wrap; using a caulking material or a sealant will not protect your container house from weathering effects in the long run. Investing in a sheathing wrap is one aspect where you must not cut corners. This will not only act as a protective barrier but will also increase the longevity of your house. According to the building code, if you are using a plastic house wrap, you must wrap the corners at least 6" each way.

The next step after sheathing is to install your windows and doors. It is advisable to pre-order your doors and windows before beginning your framing work. You can opt for traditional style doors and windows or French doors; if you live in a warmer climate; consider using sliding doors, as they allow more sunlight inside the house.

Rough Electrical & Plumbing Work:

Once the internal and external framing is completed, you must proceed with the rough electrical and plumbing work. If you are converting a single 20' container into a home, the electrical and plumbing work must be easy. Before you start placing the switches and outlet points, walk through the container a few times and decide on the installation points. It is very important that you sketch the electrical and plumbing layout and can use a spray paint to mark those points. It is not advisable to provide an electrical outlet outside of the container for safety reasons.

You cannot use the regular switch boxes but need thin electrical boxes that do not conduct electricity through the container's steel walls. Apart from this, you will also need electrical wires, and switches. If you have no prior experience with wiring, it is advisable to hire a professional to complete the electrical and plumbing work. Alternatively, there are companies that sell electrical systems that can be placed in your container.

Solar Panels:

If you are planning to install solar panels, build a roof with a 45° or 60° pitches, as these two angels provide the optimum usage for the panels. You can opt for multiple locations to install the panels. For example: consider having one of the panels installed on the roof and another at ground level, which can be easily mounted and dismounted based on your needs. When you are mounting the panel on the roof use mounting brackets specifically designed for corrugated roofs (your local hardware store will have them); you will also need weather resistant bolts, nuts, and washers.

Plumbing:

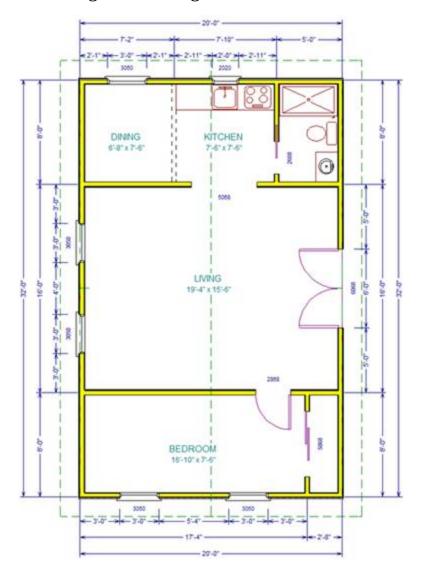
Plumbing for your container home is no different from plumbing for regular houses. If you are building your container home in a remote location with access to the main water supply line, follow these steps to connect to the supply line:

- 1. Locate the underground water line and pipes sensitive instruments are used for this purpose; unless you are experienced in locating water lines, hire professionals who can do it easily
- 2. Decide where you want to install the plumbing line of your house; drill a hole directly from that point till you locate the pipe; care must be taken while cleaning the surrounding debris as to not to damage the water pipe
- 3. Request the water company to turn off the water pipe; cut into the pipe to make a connection to your plumbing line. Again extreme care and precaution must be taken not to damage the main water pipeline
- 4. All the pipes from the sink, shower and toilets must drain into the main central plumbing pipe beneath the house

5. Fill up the sinks, and shower and flush the toilet a few times to test the plumbing for leaks

If you live in a wet climate, consider installing rainwater-harvesting system to meet your water supply demands. Alternatively, you can also buy/construct a water storage tank connected to a nearby water source.

Two 20' container design with living area built between.



Chapter Six Container Home Insulation

A container home offers many advantages but lacks on the insulation front, as it has very poor insulation properties. The main point of insulation is to control the heat entering and leaving the container. You might consider buying a pre-insulated container that already has foam insulation — while you can save on the insulation materials, you must remember that such a container is structurally different, as it is made of aluminum rather than corten steel. Following are some of the material options to consider for insulating your container home:

- 1. Batt insulation made of fiberglass or wool it is easy to install
- 2. Foam insulation made of polystyrene or foam core
- 3. Loose fill insulation cellulose fibre, fiberglass fibre; professional help is required for this installation
- 4. Eco friendly insulation such as sheep wool, hemp, recycled paper products
- 5. Spray on insulation this will not tolerate moisture

Thermal Bridging:

Any break in the insulation material at joints or openings creates a path for heat loss and this is called Thermal Bridging — a factor that must be considered during the design stages. Lumber and steel that are used as framing materials also reduce insulation efficiency and the loss is called framing factor. Thermal bridging and framing factor is more pronounced in container homes because of the inherent poor insulation qualities of the container. Placing insulation materials in series (perpendicular to heat flow) rather than in parallel (parallel to heat flow) can reduce framing factor.

Flooring:

The floor of any shipping container that you buy is treated with pesticides and chemicals; it might have also been exposed to dangerous chemicals. Thus, it is necessary to replace the existing container floor with a new floor. Following are the types of flooring that you can choose for your container home:

- 1. Vinyl flooring
- 2. Steel overlay
- 3. Floor coating
- 4. Ceramic tiles

The floors are usually treated with isopropyl alcohol before applying a layer of polyurethane or epoxy polymers. If you are using ceramic tiles, remember to buy a binding paste that sticks to both the wood flooring and the tiles. Sanding the container floor will release toxic substances, and one must be extremely careful while working on the container's floor. It is advisable to seek professional help or alternatively use mask and protection gear if you intend to lay the flooring.

You can also install a subflooring to protect your floor and to even out protrusions that arise from cutting open the container sidewalls. Before installing the subfloor add an insulation material of your choice. You can also install insect screen/barriers at the edges to keep away mice and other rodents. The thickness of insulation material and the subfloor depends on the climate and the irregularities in the container levels; when two or more containers are attached, you might have to add more inches of insulation/subfloor to get a level surface. A hardware cloth of ¼" is also a must if your place has mice and rodent problems. If you are living in a warmer climate, make use of a concrete floor, as it is durable and easy to install.

After installing the insulation, lay the flooring material (you can use ½" OSB) and secure it using coated deck screws. Painting the inside of your container with your favorite color is a cost effective way to transform your home and make it appear pleasing.

Safety Locks for your Container Home:

Safety of your house is a very important concern and must be addressed adequately. A shipping container usually comes with a low locking gear mechanism where the handles operate near the ground. However, containers that are used for a single trip or those that are built with end user in mind come with a high locking gear mechanism along with lock boxes.

A lock box provides good safety to your container home and comes in two varieties:

- 1. Weld on lock boxes these lock boxes will be a permanent fixture on your container home, as they must be welded on to your container; you can either weld it yourself or request the shipping container dealer/company to weld it for you. Most shipping container dealers sell lock boxes and it costs around \$100, depending on the quality.
- 2. Bolt on container lock boxes if you already have your container firmly fixed to the foundation and do not have welding gun to weld the lock box, buy a bolt on lock box. You will need a drill, screwdriver, and wrench to install this lock box and will cost around \$80.

Chapter Seven: Resource Directory

Popular Mechanics 45 Shipping Container Homes http://www.popularmechanics.com/home/how-to/g172/shipping-container-homes-460309/

Pinterest – Container House Ideas https://www.pinterest.com/cbitros/container-house-ideas/

ISBU Association http://www.isbu-association.org/

Container Dealers Association http://www.containerdealers-association.org/

Association of Portable Storage http://www.npsa-us.org/

Fabprefab - Prefab Dwellings http://www.fabprefab.com/fabfiles/containerbayhome.htm

Sustainable Homes http://www.jetsongreen.com/

Video Directory http://www.jetsongreen.com/

http://www.greencubenetwork.org/greencube-tv

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Chapter Eight: Plans

Here are the links to download the high resolution plans in PDF

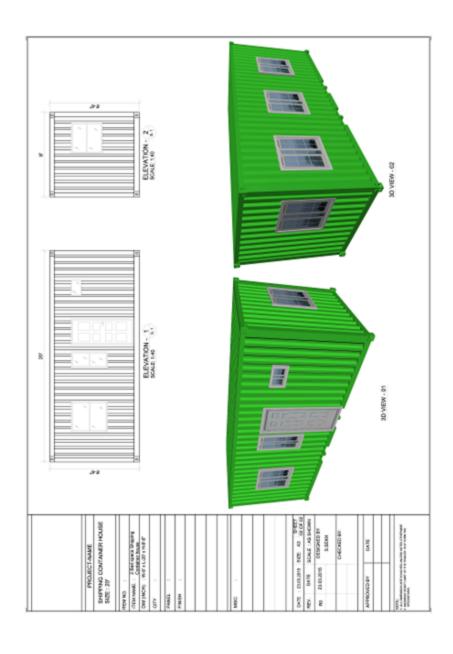
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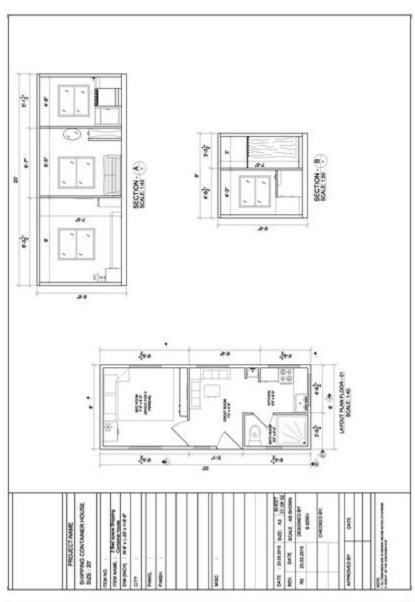
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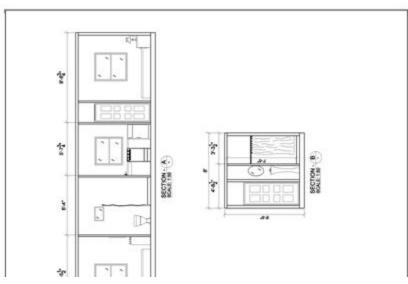
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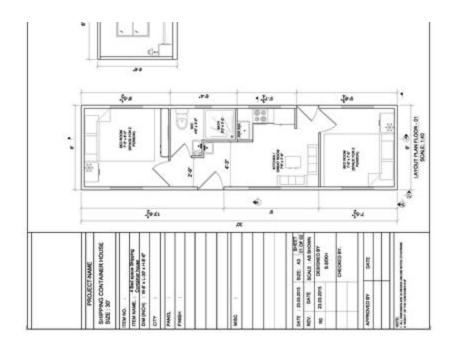
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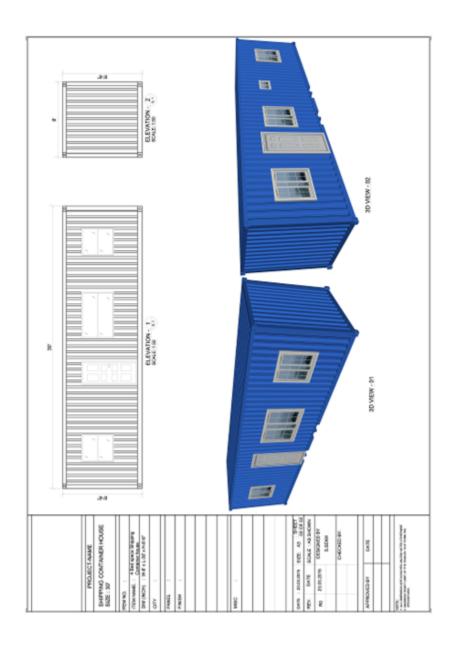
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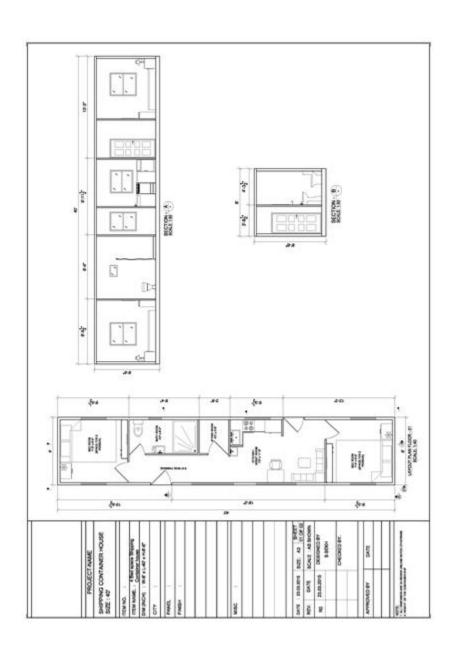


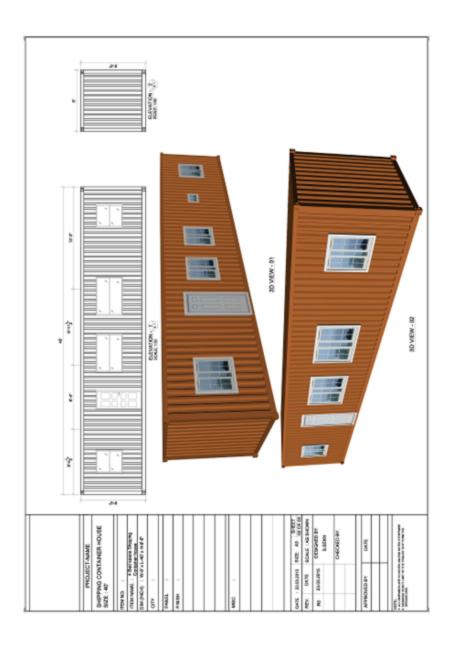












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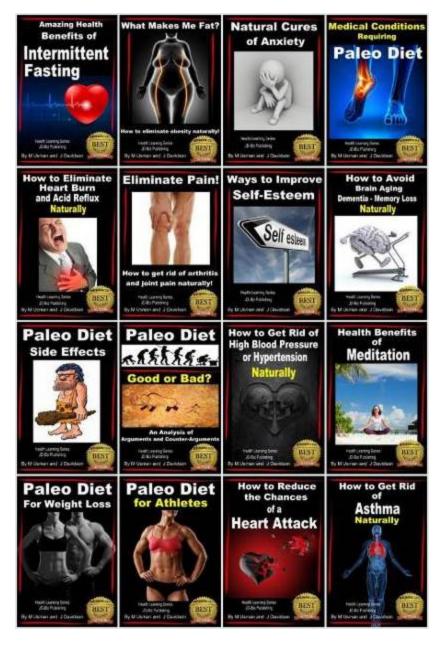


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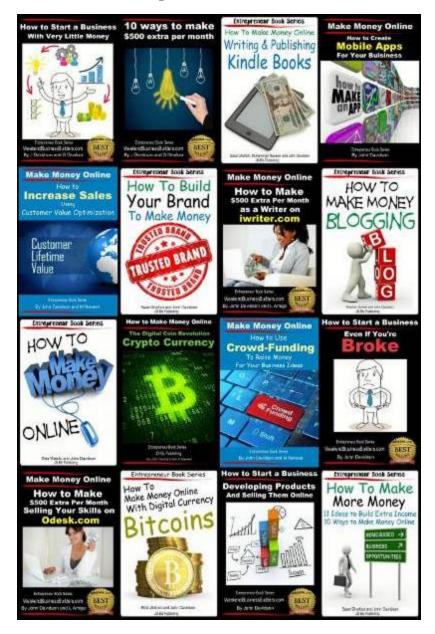
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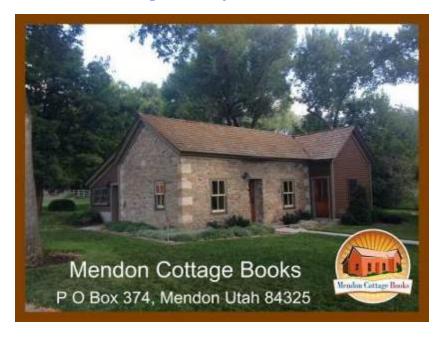
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