Build a Cob House

A Step-By-Step Guide

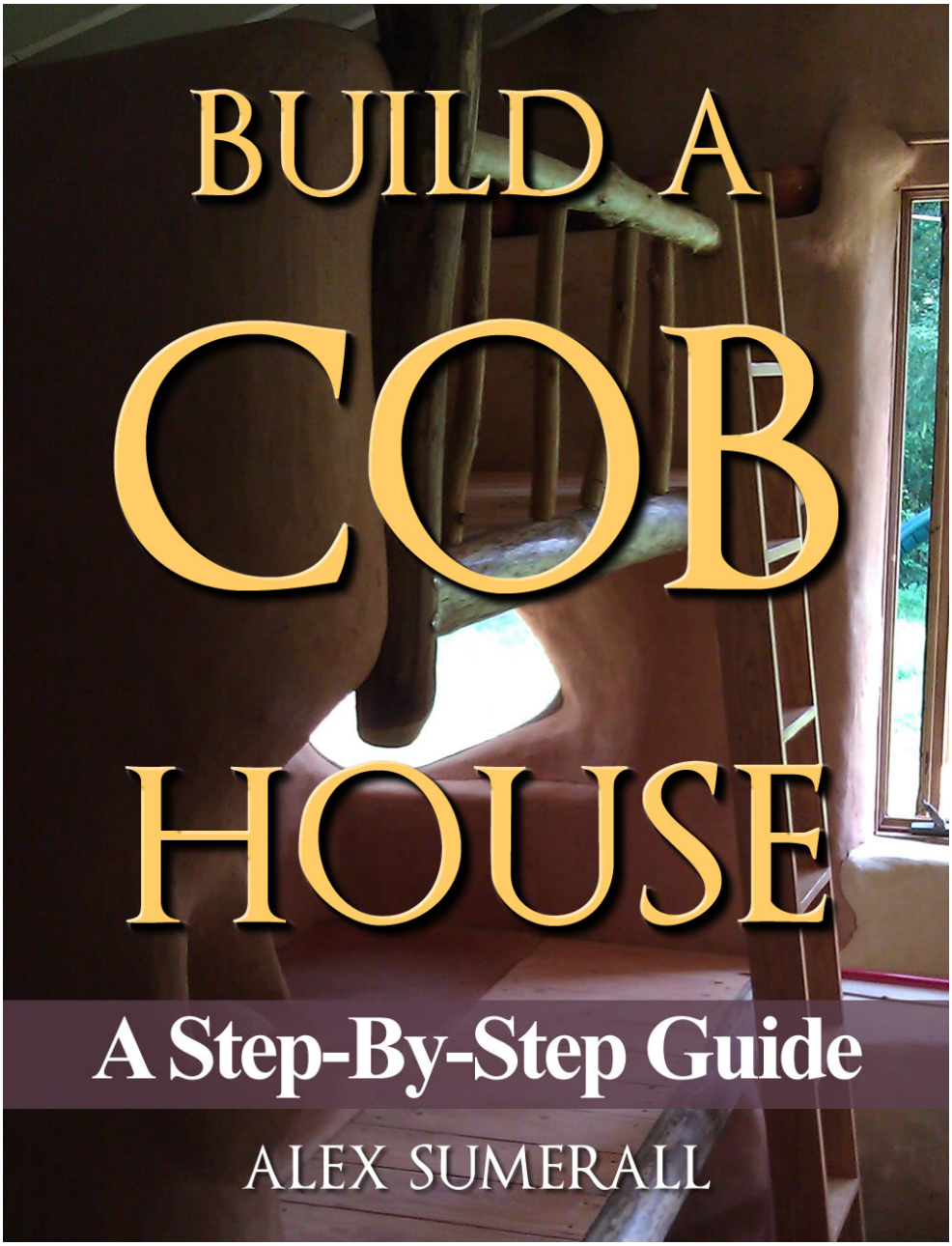


Table of Contents

Introduction

Cob is a building material made out of earth, clay, sand, straw, and water that is pliable and can be hand-sculpted into buildings. Many people are familiar with adobe, which has similarities, but cob does not use bricks or forms. Cob has been used and tested for thousands of years all over the world and has proven to be a very viable building material.

About thirty percent of the world's population live in homes built out of earth, and about fifty percent of the population of developing countries live in earth buildings. Earth is the most common and accessible building material on the planet.

There are many misconceptions today about earthen homes. They are not all mud huts in Africa with poor living conditions. Earthen homes can be very lavish, beautiful, and clean.

Cob has until very recently been virtually unknown. About twenty years ago, there were no cob builders in North America. However, since the 1980's, there has been a revival in cob building. People all over the world are now learning and reviving this ancient building technique.

This revival is coming at a very opportune time as well. As materials and resources become scarcer, prices are rising and construction is becoming more expensive, cob and other natural building methods are offering wonderful alternatives. They are far less expensive and the materials are much more available.

Cob offers answers and solutions to many of the problems that ail our buildings today, and people are very excited and enthusiastic about building homes out of cob. It's looking like cob is here to stay. Building with cob is not about returning to the past. It's about moving forward.

Building with cob is very intuitive once you learn the steps. If you can build a sand castle then I think you can build a cob house. I hope that this book encourages you to go out and build something unique and beautiful out of cob for your enjoyment and pleasure.

How, and By Whom, Should My Cob Building Be Built?

In today's society, people normally hire a professional builder to construct their home. In the past, homes were almost always built by the family (or community) who was going to live in them. This is something to consider today since there are more choices as to how a building can be constructed.

Although materials to make cob are very cheap and sometimes free, building with cob is very labor intensive, which makes outside labor costs relatively expensive. Compared to building a conventional building out of concrete cinder blocks, hiring a professional cob builder can also be an expensive option to pursue. Cob building, like most other

traditional crafts, is an art form as much as it is a construction method. If you want to build something out of cob, here are three options for building:

1. Have a professional cob builder construct your building for you. This can be expensive, due to labor costs, but is a guaranteed way to get a house or building that is functional, well built, beautiful, and unique. These days, there are quite a few professional cob builders in North America and scattered throughout the world. Apart from searching the web, one of the best places to find a professional cob builder is to ask the Cob Cottage Company. They have a large roster of builders and many of them have past through their apprentice program.

2. Build it yourself. Cob is the perfect material for do-it-yourself builders. It's easy to learn how to build a house with cob and it does not require expensive or sophisticated tools. Just simple tools will get the job done. Building with cob is totally safe and can be done by anyone. Building on your own is also a great way to get your community involved. Although it will take a lot of time to build your cob home, it will be a very cost effective process and you will feel a great sense of ownership and empowerment for building your own home. Take a course on cob building, read this book and maybe a few others, and you should have what it takes to build your own cob house.

3. Consult an expert cob builder. This is like a hybrid between options one and two above. By consulting a professional, you can get your project started off right, and you can still use your own labor to keep building cost effective. Having a consultant builder is also good if you need assistance at certain parts of the building process. You can think about having a professional cob builder design your building and consult for you throughout the construction.

Characteristics of Cob Homes

A cob home will have a very distinct and unique quality to it that you will not find among conventional homes. Living in a cob house is more than just abiding in a shelter. It includes a unique experience that is both uplifting and healthy.

Here are some concepts and advantages of cob homes to consider:

Cob Home Concepts

Small

Cob homes are known to be small and size efficient. There are many reasons that they are built to "tiny home" standards. Most builders and residents of cob homes understand and appreciate keeping things simple and down to earth. You won't find cob homes built to mimic the McMansions of conventional, mainstream planning.

Cob homes are also labor intensive to construct and they are often times built by the owners. It is usually more intelligent and efficient to only build to the size of your everyday needs.

Local

Building with cob falls under the umbrella of "Natural Building." Hence the need for natural resources, which can typically be found in your local area. A cob house can be built from the earth right beneath the building site, and whatever natural resources (sand, gravel, stones, timber, etc) not available on site can usually be sourced locally.

Artistic

People are drawn to cob homes in large part due to their beauty and creative designs. Builders are not limited to ninety degree angles and they can sculpt and mold cob to whatever shape they desire. There is so much room for creativity and flexibility of design when it comes to building with cob. You can freely use your imagination. A cob home could be considered a place of shelter but could also be considered artwork.

Natural

The main ingredients for making cob are: clay, sand, and straw. All "natural" resources. A cob house is not mainly composed of synthetic materials, but is instead built out of natural materials found in nature.

Social

Building a cob home can encourage your community and friends to come together in the construction. You do not have to be an expert to help in the building process either. Even

children can help build in many instances. Building with cob can be a good social activity and is good for strengthening a community.

High Standards

A house made out of cob is actually a high standard home. Many uninformed people would label a house made out of materials such as mud as a poor living environment like something that would be found in a third-world country. However, this is just not the case. On the contrary, a standard, conventionally built home could easily be considered low standard if you think about all of their negative health effects they can have upon their inhabitants.

Cob Home Advantages

Energy Efficient

With a cob house, you will not have to heat your home with nuclear electricity, Persian Gulf oil, or strip mining in Wyoming!

Cob is a “thermal mass” that absorbs sunlight and warms the building over the course of the day. This is called passive solar heating, and it will keep the inside of the building warm in the winter and cool in the summer.

Inexpensive (Mortgage & Debt Free)

The primary materials for cob are: clay, sand, and straw. These are very easily accessible and cheap resources to acquire. Other parts like windows and doors can also be salvaged or purchased as used from restoration depots or dumps.

People have built high quality cob homes for as little as a few thousand dollars. It all really depends on what you want your home to be like. You should never have to take out a loan or go into any kind of debt to construct a nice cob house. If you want to live mortgage and debt free then a cob home is a very good option to consider.

Owner Built

Cob houses can usually be built by the owner. You don’t need a degree in architecture or to be a structural engineer to build a cob home. Many people build their own homes after taking a one week long cob building workshop.

It is very rewarding to be able to build your home with your own two hands.

Healthy

Unlike conventional homes which are constructed with synthetic, industrial-formed materials, cob homes are built almost entirely out of natural, clean materials.

Industrial homes are full of indoor air pollutants and off-gassing of chemicals contained in the building materials. Cob homes do not have this problem. In fact, cob actually "breathes" through its tiny pores and keeps air fresh and clear. If you suffer from indoor allergies then living in a cob house could significantly improve your quality of life by eliminating the toxins that may cause them.

Strong

The straw, which is part of the cob mix, acts like a natural re-bar to hold the whole structure together as one monolithic piece. This makes cob homes extremely solid and resistant to earthquakes. Many cob homes have lasted for hundreds of years with minimal upkeep, whereas wooden structures generally survive only a few generations.

Build a cob home for your family and it will last for many generations to come.

Acoustic Privacy

Earthen walls have very good sound-absorbing properties that keep it quiet inside, both from exterior noises and noise generated in the same building.

Termite Proof

Since cob is a mixture of soil, aggregate sand, and straw it is not attractive to termites. To add to that, cob homes have not been known to become burrowing grounds for insects or animals either.

Fire Proof

Cob does not catch fire. However, still be aware of your ceiling or roof as it might not be flame resistant like the body of the cob home.

Common Questions About Cob

How durable is cob? How does it do in rainy climates?

Compared to the standard stud frame homes of today which are designed to last for only 50 years, cob homes and other earthen buildings have lasted from hundreds to even thousands of years. There are tens of thousands of cob homes in England that have been standing strong for centuries.

A cob structure needs to have a good roof and a good foundation to protect the building from water damage. A long overhanging roof can help to better protect the cob walls

from rainfall, and an adequately high foundation protects them from water runoff. Cob homes are also protected by a lime or earthen plaster which covers the outside walls.

Are cob homes cold and damp?

It is quite the contrary on this issue. Cob homes are warm and dry. Cob walls usually range from 1 to 2 feet thick which provides great thermal mass and adequate insulation. The thermal mass of the walls are perfect for passive solar heating, and little extra heating is required even during most winter months. The thermal mass of cob homes does not backfire during the summer time either. Cob homes are cool and comfortable in the summer days.

What about humidity and mold?

Cob developed in the British Isles (where it is known for its wet weather) and has proven in many places to hold up very well to humidity. Even in humid climates cob will not rot or grow mold on it.

How will a cob house hold up in an earthquake?

Cob homes located in seismic zones have a good record of survival. Many people have the misconception that cob homes will collapse in earthquakes like adobe buildings do. Adobe is mostly held together by gravity, whereas cob buildings are interlocked by thousands of interwoven pieces of straw. The straw in cob acts as a natural rebar that holds the building together in one solid monolithic piece.

How big can you make a cob house?

You can make a cob house as large as you want it to be. It depends on what you want and whether you want to sacrifice quality for square footage. Cob homes are usually small, providing an efficient and practical living space. You are really only limited vertically. Cob homes are normally just one story or two stories. It is usually not recommended to build higher than this.

How much does a cob house cost to build?

The total cost will depend on your building site, design, resourcefulness, creativity, and organization. Whether you want to involve yourself in the building process will also factor into the cost. Cob is one of the least expensive building materials there is. Doors, windows, floors, and other components can sometimes be the most expensive pieces in a cob house project. Many cob cottages have been build ranging anywhere from $500 to $50,000. It simply depends on what you want in a home.

How long does it take to build a cob house?

This will depend on how large your house is designed to be, how many people that you have assisting in the building, and your level of organization and management. If you're determined, you could build a cob house and be moved in within a year's time.

How do you deal with building codes and permits?

There is no building code in place for cob. That does not mean it is illegal to build with it though. Building codes protect corporate manufacturers of building components. There is no benefit to these mega corporations if people start to use alternative building materials like cob. Many people have built cob homes without involving building inspectors, and they usually have little problem doing things under the radar. Some legally permitted cob structures are starting to pop up in North America too, but considerable expenses and paperwork are required if you want to go this route. Learn more about building codes relating to cob homes in the *Building Codes* section of the book.

Site Selection

The first step to intelligently build a healthy, efficient, ecological, and beautiful place to live is by selecting a site. Site selection does not have to be a daunting task as many people seem to believe at first. Here are some important aspects to pay attention to when selecting a site for your cob home:

Good Drainage
The most important thing is to never build in a flood plane or marshy area. Ask the neighbors and locals in the area about past floods in the area, or check the local records of floods as far back as possible through your local building department or the Army Corps of Engineers. Floods may only happen every century, but that's still a risk that you don't want to take. Periods of wet weather can be drastically different from when you visit your prospective site so take this into account.

Sub-Surface Geology
The ground beneath your site should be a solid, homogeneous geology. If you are building on land where the ground is very clay rich then you need to make sure that your drainage system is effective at moving water quickly away from your building. Clay is very slow draining and could cause water to get backed up next to your building.

If your subsoil is very clayey it may be unstable, in which case you may need to dig below the clay layer to build your foundation on solid bedrock. When clay comes into contact with moisture it contracts and expands. Movement in your building, cracking, and instability can occur if there are different substrates underneath.

Dig test pits in all different locations around your site to see what's beneath the surface. It could be clay, bedrock, toxic waste, or silty soil that would be perfect for a garden.

Take the extra time to examine your site's sub soil and build a solid, strong foundation. Build on the most solid subsoil you can find.

Location
Don't build on an exposed hill or in a valley floor. Exposed hillsides can get extreme gusting winds, and valley floors get little sun and become pockets for cold air.

Access
Make sure that your site has road access. This will make it much easier to transport materials and items to your building. Think about what it would be like to live at your site if you do not have easy road access or you always have to travel up a hill at night with your grocery bags.

Aspect
Only build where there is good sunlight. North-facing slopes are not good to build on due to their limited sun exposure. You want to make sure that your cob home is receiving significant sunlight to get passive solar heating benefits.

Also make sure that the surrounding trees at your site are not blocking the sunlight exposure. If they are, determine whether you can cut them down to use in building your house or to use as firewood. If you're visiting your site in the winter time realize that sunlight will be different in the warm months when the leaves are on the trees.

Legal restrictions
Make sure that there are no legal restrictions on the land you wish to build on. It's best to find unrestricted land where you can build exactly what you want. Research the building codes for your location.

Orienting towards the sun
In order to take advantage of passive solar design you want to orient your cob home so that it faces south and south-west as much as possible. This way, between 11am and 3 pm you will get unobstructed access to the day's sunlight to heat the inside of your house.

Using natural resources at the site
Before you start building, determine what natural resources can be acquired from the land you are building on. Also determine how you will get them. If they are uphill from your site location it is much easier to transport them downhill compared to moving them uphill from a valley.

Testing your site
Imagine living at your site and having your home there. Go back there repeatedly and make sure that it's right. It's better to take this extra time beforehand rather than after you've built your home there and you find that it's less than perfect. If you have the time, get to know your land and how it acts throughout the year. Camp out on location and get a feel for what it's like. Hang out there and see where you naturally gravitate to.

Site problems to avoid

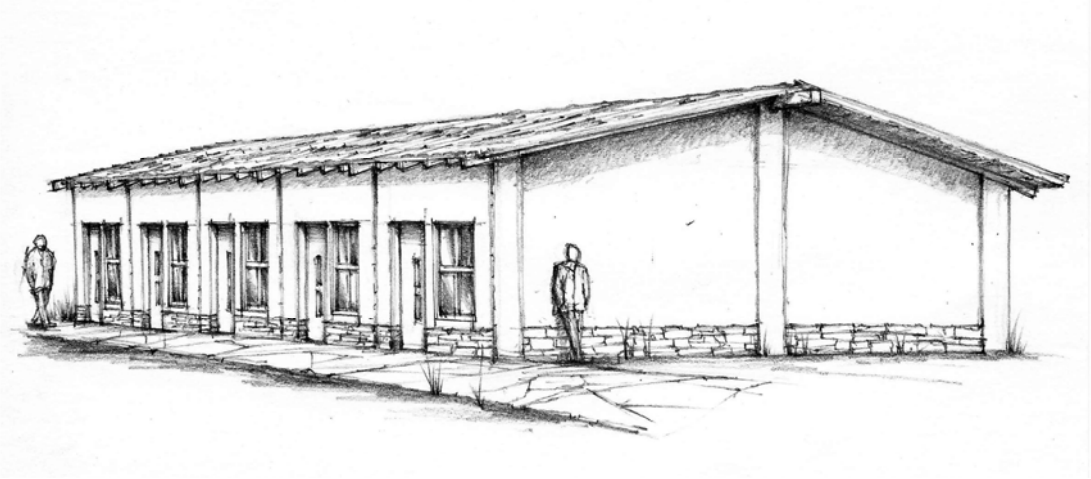
There are some problems with selecting a site for your cob home that are necessary to avoid. The following problems need to be avoided:

- A steep north slope
- No access to sunlight
- Flood plain
- Incompatible neighbors

It's difficult to find a building site that's perfect. There are many problems that can be worked around though. Just don't dig yourself into a hole by ignoring the facts.

Use all of these points when selecting a site, but don't over analyze things. Choose a site that works for you and that you will enjoy. You are probably going to have your home there for a very long time so make sure you like the spot.

Design



After you've selected the site for your cob home, the fun part of actually designing it can begin. With cob you are liberated from ninety degree angles, boxes, and rectangles which are the norm in most architecture.

You do not need to be an architect or builder to design and construct a cob house. You just need to have common sense and a determination to get things done.

Conventional materials like brick and wood don't allow you to create the shapes and forms that cob can. Cob is malleable and sculpting which allows you to create a living space unique and personal to you.

3 Important Design Considerations

- Appearances and how the building looks from the outside and blends into the surrounding environment
- Function and design of the inside and how it relates to your living activities and desires
- Passive solar design to maximize sunlight for heating the inside of the home

Building Appearances

The appearance and aesthetics of your cob home will be based on your personal preferences and possibly the surrounding environment.

The resources and materials located and retrieved from your site can also influence the style and appearance of your building. Natural buildings usually aim to blend in with the local environment and rely heavily on locally sourced materials.

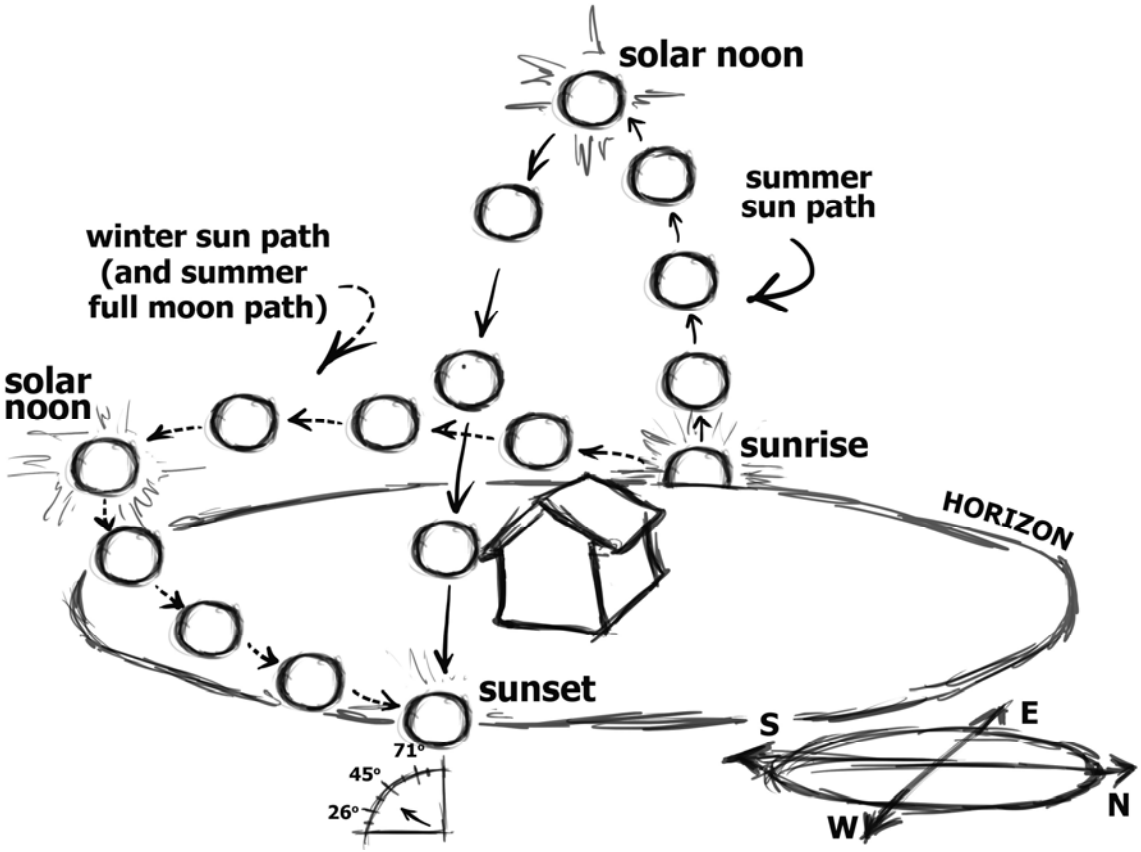
Cob has characteristics that allow it to be built into many different forms. Its plasticity lets the builder mold and shape their building without limitations like ninety degree angles and boxes. It is unlike any other construction material or method of building. With cob, circular and curvilinear buildings can be made.

Cob lends itself to certain geometry and properties: thick walls, solid, monolithic structure, tapers, rounded corners, vaults, arches, and curves.

Passive Solar Design

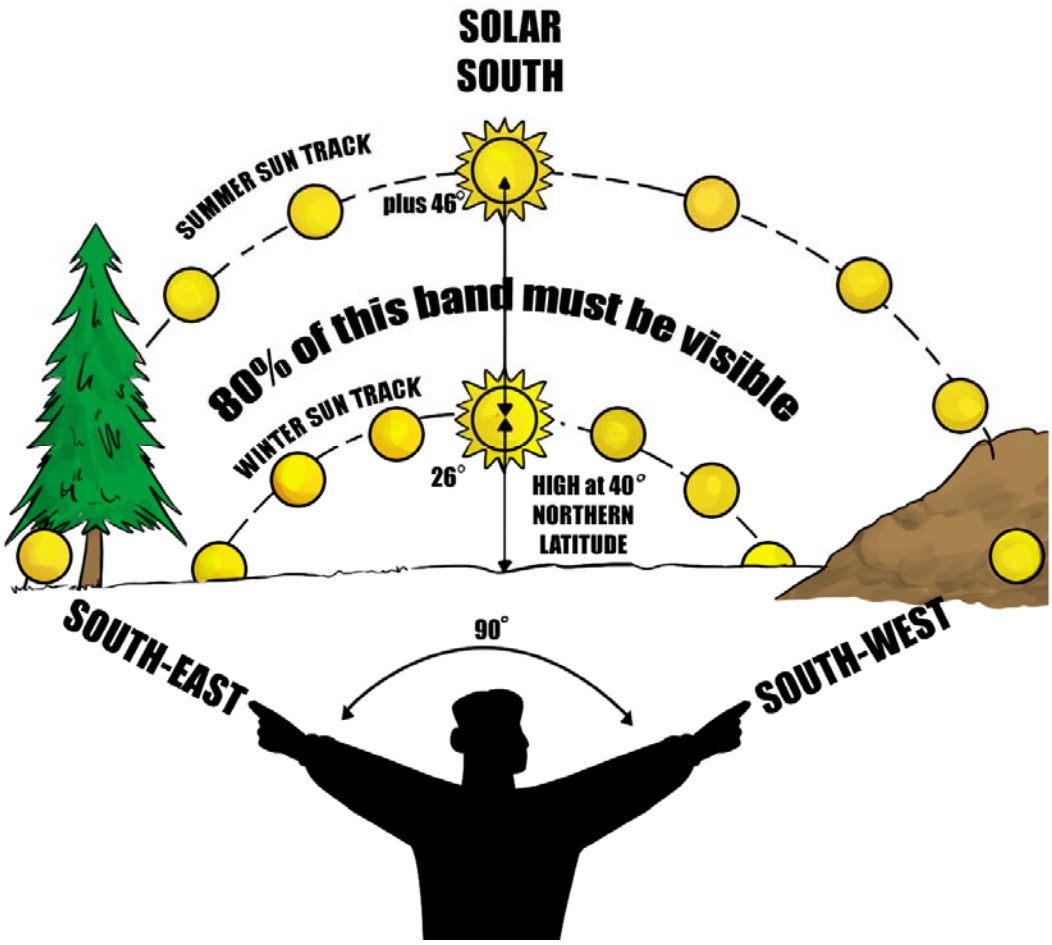
This concept is fundamental to building a cob home. Passive solar design has been used for thousands of years in various forms. It is about designing a building so that it can effectively use the sun's energy to create warmth and light inside a structure. The walls absorb the sun's radiant heat throughout the day and transmit it back out into the building space. As the temperatures drop low at night time, the temperature inside the building will self regulate by the heat storage being released from the thermal mass of the cob to the inside the building.

A lot of people get intimidated at the thought of learning how to apply passive solar design and completely overcomplicate it in their minds. In reality, you can probably learn all that you need to know about passive solar in about ten minutes.



Choose a south-facing site for your building. No north-facing slopes, northwest, northeast, or west facing slopes either. It also helps to find a spot that's sloping downward to the south, southeast, east, or southwest.

Go to your site and make sure that you have an unobstructed sky view. Face solar south, where the sun reaches its highest point in the day. This direction should be where the south wall of your building is placed. Extend your arms straight out, at right angles to each other. Your hands will point southeast and southwest. Within your arms, you need 80 percent of the sky to be visible and unobstructed above the arc of the winter sun's path and below the line of the summer sun's path, which is about 45 degrees above the winter arc.



The orientation of the building and the placement of windows are important design elements that must be taken into consideration when using passive solar. The intelligent placement of windows is important so that you can get enough sunlight to penetrate inside the building. The sunlight that you want to capture will mainly come from the south, southeast, and sometimes from the east.

With passive solar design you want to situate your main living spaces of the building between solar south and south-west, with larger and predominate windows placed between the south-east and south-west walls. Just don't place your windows too high in your walls. When the sun is high in the sky during the summer months you can get overheating if windows are placed too high.

Here are a few points for placing windows:

- Don't place your windows too high. This avoids overheating in summer and ensures that low winter sunlight enters building.
- Don't place windows in the north wall as this will just provide a point for heat to escape from inside your building.

- Some windows can be placed in the east wall to allow morning sunlight in.
- Only add small windows in the west wall. Don't add too many. Big windows in the west facing walls can create overheating in the summer time when the sun goes down.

For your windows, it is important to use double glazed or even triple glazed windows so that heat does not quickly escape back out through them. Window frames can also be poor insulation points. The best material for window frames is wood for its insulation value. To further prevent heat loss through your windows you may want to consider putting up thermal curtains, blinds, or shuttering. For the summer, you also may want to use blinds to prevent overheating. Be stingy with glass and windows unless your climate is mild. Any glass that's not adding to solar heating is constantly letting heat escape when you want to keep warm. Glass is also constantly adding heat to your building when it's too hot outside.

Orient the long side of your house toward the south to get as much sunlight exposure as possible.

It makes sense to design the inside of your house according to the sun's orientation throughout the day. You can place your bedroom or breakfast area on the east side to capture the morning sunlight. You can place your office or living space to the south to capture as much daylight sun exposure as you can. Then, for example, you can put a small nook on the west side to relax in during the evenings.

Given the outlook of our future situation on the planet, using passive solar design is a huge piece to consider when designing your home. You will save heavily on heating costs and won't have to rely on fossil fuels to heat your home. The long term benefits of using passive solar design are so huge that you would be robbing and shortchanging yourself doing otherwise. A cob home can freely collect heat during the day and warm you at night without costing you a dime.

Thermal Mass

Cob has a high 'thermal mass' which allows it to absorb heat from the sun's rays and then re-release it back into the living space of the building. Cob provides thermal mass for the heat of sunlight to be stored until temperatures drop at night. The heat inside cob thermal mass can be stored for hours or days.

To effectively warm your cob home with passive solar heating, it is essential to make sure that the walls and floors have good thermal mass properties. Cob has great thermal mass and can absorb heat from the sun's rays as well as indirectly from the warm air. This heat is stored in the thermal mass and then released into the living space as temperatures drop. Thermal mass can also help prevent overheating in the hotter months since some of the hot air inside the home will stay absorbed inside the thermal mass.

Insulation
It's important to insulate a natural passive solar building well. Cob has a very low R-value for insulation and is not good at preventing loss of heat. On the other hand, cob has a very low U-value which makes up for this. U-value (units of thermal radiation) measures a material's ability to store and transfer heat, rather than resist its loss.

Building code inspectors will not be favorable to cob's low R-value, but explaining to them the low U-value of cob along with passive solar design can help you if you decide to go through the building department when constructing your cob home.

It's a good idea to make up for the low insulative value of cob by over-insulating the roof, floors, stem walls, and making sure that windows and doors are tightly sealed.

If winter temperatures stay below freezing during the daytimes, then you will want to insulate with strawbales on the north and west walls. If winter nights drop to about 10 degrees Fahrenheit then you will want to put strawbale insulation all around.

Designing your "Home"
Brainstorm a lot. Brainstorm with your family and those who are going to live in the house. Also brainstorm with friends. More questions get asked this way and you'll cover more aspects of your building.

Try to keep your house small! Think quality over quantity. If you keep the building small you will save a lot of money to buy nicer materials and get finer craftsmanship. Many first time cob builders have made disastrous ruins by building too big. Only build as big as you can be guaranteed to finish in one building season.

Ceiling height
One thing that's not thought of a lot of times when designing a house is the ceiling heights. Think about how your ceiling heights should be in relation to each room or alcove. It can change the feel of a room.

Limit the number of doors
Keep one door per room, unless you are trying to make a corridor. It will ruin your experience if you have people constantly going in and out through various doorways in your rooms.

Alcoves
One of the most fun things about cob homes are the little nooks and alcoves that you can construct into them. They give cob homes so much character and feeling. Alcoves are small spaces that are separated from the main body of a space. They work best if their floor is higher or lower than the main room they come off of. You can make a sleeping alcove, an alcove for cooking, a cozy reading alcove, a coffee table alcove, or a window seat alcove. Get creative and think of your own alcove ideas.

Level changes

Another way to add interest to a home and define changes of mood is to use level changes. A step down or a step up can make people slow down and think about the new area they are entering. You can make your kitchen area higher than the adjacent living area, or a step down to get to your cozy reading space.

Roundness
Cob presents the opportunity to create rounded spaces and sculptures. You can round off your walls to give more comfort to your spaces. Ceilings can also be designed to be lower on one end of the house and higher on the other. Sculpt your spaces to accommodate the life lived there.

Make a Model
Before you start construction on your cob house it's a good idea to make a 3D model. This will give you an idea of how your spaces will appear and it will give you a better perspective to determine whether your house plan will function right.

First, you will need a solid base to build your model on. Depending on the size of your house you model might weigh quite a bit by the time you're done with it. So make sure you create a solid base for it to sit on in case in you need to carry or transport it. Get a 1'x1' or 2'x2' piece of plywood, and nail a support frame underneath it. Attach small pieces of wood along the edged of the plywood board to create a basic frame. This will keep your model foundation firm and it will make carrying the board much easier.

To create your house model you will need modeling clay. Sculpey is a good brand of clay that works well for modeling. It can be purchased at most art and craft stores. You can also use sticks and twigs for rafters, support beams, and other roof pieces. Pieces of cardboard can be used for doors. For windows, you can use small pieces of glass or you can take a clear juice bottle and cut out pieces shapes as windows.

The first things you will want to create are model figures to represent people. For your model you will probably want to use a scale of 1 inch = 1 foot or 1 inch = 2 feet.
So let's say I am using a 1:1 scale and I'm about 5'9" tall. My model will be about 5½" tall then. Make three human models and make one standing, one sitting, and one in a sleeping position. Use these models as you build your model and construct your spaces around them. It will give you a much better idea of how your rooms will really work with people in them. You will get a better perspective and be able to tell if a room is too small or maybe too large.

Build your model walls as you would build your house walls, bit by bit. Build them up in layers the same way you would build your cob house. Make your roof to scale and fairly realistic, but make it removable.

Draw an Outline Plan
Once your model is finished, draw a two-dimensional scale plan onto graph paper. Use the same scale you used for your model such as 2 inches = 1 foot or 1 inch = 1 foot.

Carefully transfer the dimensions of your model onto the paper using pencil. You can pen it in later when you're sure that it's right.

The paper version of your model will be much easier to transport and make copies of. Give a copy to everyone working on your building team and keep copies at the building site.

Materials and Tools

This chapter will describe the qualities that you're looking for in your basic materials: earth, sand, and straw. It will tell you where to get these materials cheaply or for free.

Selecting and Testing Soils

One of the most awesome things about cob is that it's made out of the soil that's right beneath our feet. We don't use the topsoil though because it's full of organic matter. We use the subsoil layer beneath it which is a composition of gravel, sand, silt, and most importantly clay. To make a good mix of cob for a strong, stable building your mixture should ideally consist of a ratio of roughly 15-25% clay and 75-85% sand. Depending on your soil, you will either have to add more sand or clay to reach these proportions.

The topsoil, which is a dark color, is full of organic matter, roots, and dead organic material called humus. Topsoil is not appropriate for making cob. We want to use the subsoil beneath the topsoil layer. Your subsoil will consist of these basic particles:

Stones and Gravel: Any rock pieces that are bigger than a pea will be considered stones or gravel. They have high compressive strength so make a nice addition to any cob mix, but they aren't fun to tread on when making your cob mix. It's okay to remove or filter out larger stones, but it's not necessary to get rid of them all. They won't compromise the strength or integrity of your finished cob walls.

Sand: Sand, or aggregate, is any particle of rock ¼ inches or smaller as long as you can see the individual grains. The best cob mixes will contain a coarse, sharp sand of $1/8 - ¼$ inches. Unlike clay, sand is very stable and does not absorb water or shrink when it dries.

Silt: Agricultural soils are silty and make terrible cob. Make sure your soil doesn't contain more than a little bit of silt or it will be too much. Silt is made of tiny sand particles that are too small to distinguish with the blind eye. Silt will dilute the clay's thickness and is not strong in compression like rough sand.

Clay: Clay is made up of tiny microscopic plates of hydrous aluminum silicates held together by bonded water molecules. Clay's propensity to bond with water makes it sticky and causes it to shrink as it dries. Clays will shrink if they're not mixed with enough sand aggregate. As clay dries in the spaces between rough, sharp sand grains, the clay shrinks down tight and locks the sand grains together.

Soil Testing for Suitability

There are a few ways that soil can be analyzed. It can be analyzes just by observing it with the eye, doing field tests, or taking it to a lab. For making cob you really don't need to over complicate soil testing though. A simple shake test in a jar is all you need to do.

To get an accurate soil sample follow these simple guidelines:

1. Never use topsoil. Only use subsoil for your tests.
2. Always test several different samples from the same building site since soils can vary greatly even over small distances. Get to know the subsoil compositions beneath your construction site.
3. Remove any large stones or gravel from your soil sample.
4. Break up any lumps in your soil sample before performing your shake test.

The shake test will give you a good idea of the composition of your soil. It will not only tell you if you have enough clay in your soil, but it will also show you how much silt and sand there is too. The test will help you analyze how close your soil is to the 15-25% clay and 75-85% sand ratio. Once you know the amount of clay in your composition you can determine what amount of aggregate needs to be added or not.

How to do the Shake Test:

1. Select at least three spots around your site for soil sampling. Dig holes where you think you might extract building material. Dig down through the topsoil until you reach a clear subsoil layer. You will know when you've dug through the dark colored topsoil layer and reached the subsoil. The subsoil layer will have a range

of distinct colors such as: oranges, pinks, grays, and browns. Subsoil is also harder to dig through than the soft topsoil.
2. Label jars (one per sample), and fill with soil samples making sure not to include any topsoil. Organic matter from topsoil will distort your results. Also remove any stones from your sample.
3. Fill your jars one-third to one half full with subsoil samples, and add a teaspoon of salt into each jar to help the clay settle out faster. Once your jars are full, break up any clumps with a stick or tool.
4. Add clear water into jars. Fill to just below the top of the jar.
5. Tighten the lid of the jars and shake vigorously for thirty seconds to a minute making sure all clumps are broken up.
6. Set your jars on a level surface and let the sedimentation take place. Don't move the jars for at least 48 hours. Complete settlement can take days or even weeks depending on the type of clay.
7. Once your sedimentation has occurred and everything has settled out the water should become clear and you should be able to see the strata clearly in each jar. Take a marker and mark out each individual layer on your samples without disturbing the soil inside.

If the water at the top of the jar is clear within half an hour of setting the jar down then there is no clay in your soil. If the water stays brown and cloudy for a while that is a sign that there is clay present in your soil.

If your soil sample shows high levels of clay then you will know to add more sand to your cob mixes.

If your soil shows a high amount of sand then you will need to add more clay to your cob mixes.

The shake test should give you a clear picture of your soil compositions so you can make good cob. If your soil lacks clay and coarse sand then find a better source for materials and make use of whatever you do have locally abundant.

Sand

The best quality sands for use in cob are, in order: finely crushed rocks, glacial sand, river sand. Sand that is produced by wind like in deserts or on dunes, or produced by waves on beaches is too round. Preferably, you want to use sand that is coarse, hard, and sharp.

Where to Get Sand
You can buy sand rather inexpensively in large quantities such as by the truck load. Order a truck load of "fill sand," "rough sand," or "concrete sand." Before you order, know about how much sand your project will take. You might spend a few hundred dollars for

a truck load of sand plus the cost to drive it to your site. Considering that sand is one of the main ingredients for constructing your home, the cost is still comparatively very low.

Digging for your own sand is another story but can save you those extra bucks. Try looking in river or stream banks. Also ask around your local area to see if anyone knows of any old sand quarries or sand that's been revealed from construction projects.

If you find sand that's finer than coarse sugar then you will want to put that aside. It will not make good cob. Instead, you can use finer sands for plasters and detail work.

Clay

Clay is the most critical component of cob and can be the most difficult to recognize. As a cob builder, it is important to learn to differentiate clay from silt, peat, and slimy organic matter that all share slippery characteristics. Here are some ways to help you identify clay:

Stickiness: Do a clay content test by making a paste with your clay by adding water. Put a chunk between your thumb and index finger and squeeze. It will have clay in it if your fingers try to stick at all when you try to open your hands. Next, make a really wet ball the size of a golf ball and flatten it against your palm. Turn your pal over and open and close your hand. If you have a high clay content then it should stick to your hand. Repeat this four or five timse and see if the pancake stays stuck to your hand.

Plasticity
Roll another wet ball in your hand and then shape it into the form of a long pencil. Wrap it around your finger. The more it bends around your finger, the more clay that it contains.

Shininess
Take a very wet little ball of material in your hand and flatten it repeatedly with the palm of your other hand. The surface of the patty should shine.

Crush test
Take a piece of the soil in your hands and if it crumbles easily in your hand when dry it probably doesn't contain much clay. Instead, dry clay should be hard to crush in your hand.

Where to Get Clay

If you can't find clay deposits in close range of your building site then you will need to look farther out. There are lots of places that you can find clay. Most importantly, just keep your eye out for clay deposits. Sometimes exposed clay will be very dry and look like pieces of gravel. If you suspect that its clay, take a handful and pour some water on it. Mix it in your hand and see if it becomes sticky or not. If it's sticky and clay-like then it will probably be good for a cob mix.

You can find clay in road cut outs, ditches, old quarries, and many other places. Another good place to get clay is from excavation and building sites. Contractors are usually happy to get rid of the clay that they've dug up. Ask them if you can buy it off of them. They may even be willing to give it to you for free or just charge you for transportation costs.

Keep a few buckets and a shovel in your vehicle if you can. You may run across clay deposits when you aren't even thinking about it. Clays come in a wide variety of colors and can be used to make colored plasters.

Straw

The last component in cob is a biological one. Straw gives your cob walls tensile and shear strength and acts like a natural rebar. The straw is woven throughout your cob building giving it strength as a monolithic structure.

Use straw that is fresh and has been kept dry. Your straw should be in long pieces.

You can test the quality of your straw by taking a strand in your hands and bending and pulling it to test for strength and brittleness. You can also take a couple more strands, put them together, and try to tug the pieces of straw apart. They are much stronger when put together. They should be very hard or impossible to break with your own strength.

Many people worry that the straw will rot inside of their cob walls. However, using straw in cob has withstood the test of time. Straw has been found in cob buildings over 100 years old and the straw is still yellow and strong. Straw won't rot over time as people think. There is very little oxygen and moisture available inside of cob walls for microorganism to cause rotting. This way, the straw is preserved inside the walls.

Do not use hay in your cob. Hay is grass, alfalfa, clover, or another variety of food that livestock eat. Straw is the stem left over after oats, wheat, barley, etc are harvested.

Wheat stems are hollow and have great tensile strength. On the other hand, hay has lower tensile strength and will decompose. Hay has seeds in it and is still living whereas straw is just the left over chaff and has no food value to it. Hay is prone to sprouting and could make your cob walls look like a giant chia pet! It is also prone to rotting. As they say, hay is for horses. Don't use it for cob!

Where to Get Straw

You can find straw at farm feed stores, farmers, or sometimes at local home improvement stores such as Lowes or Home Depot. It's also a good idea to search online for people selling straw bales. Craigslist is a good site to find these deals.

Make sure that you get straw that has not been rained on and is not rotten. Between midsummer and early fall is the best time to purchase straw. This isn't the only time that you can find it, but you will get the best quality and the best prices around this time of the year after harvest. If you buy it in the spring or early summer you may have to pay more for it.

Always try to store straw indoors if possible. It's risky to store it outdoors for any length of time. If you do keep it outdoors, store it up off the ground and keep it well ventilated. Covering it with tarps is good, but they usually leak and build up condensation. Store it underneath some leak-proof roofing material. If you have sheets of plywood or steel roofing you can lay that on top to cover your straw. Think about it this way; using dry hay is better than using wet straw. So make sure you keep that straw dry.

What kind of straw is good? Straw grown during the winter months is the strongest and better than spring time growths. Oat, rye, and winter wheat straw make for the best and strongest cob mixes.

Other Building Materials

It is best to start gathering materials early. Keep your eyes out and start accumulating the ingredients you will need for your cob home. Make a list of all the materials and things you will need to build your house; all the way from the foundation stones to the cabinet hinges. Check off your materials list as you go. This will save you a lot of time when you start building, and you won't be rushing around trying to gather things. Keep all of your materials close to your building site. It's also a good idea to construct a basic shed or covered area to store your materials and tools.

Some places to look for used materials:

- demolition sites
- remodeling sites
- yard sales
- junkyards
- dumpsters

- reused materials stores (ex.: Habitat For Humanity)

Tools

You don't need heavy machinery or power tools to build a cob home. Simple, handheld tools will get the job done just fine. You will at least need a few basic tools to get you started:

- shovel
- machete
- mixing tarps
- 5 gallon buckets
- a level
- cobber's thumb (a stick to poke holes in the cob)
- wheelbarrow
- mattock
- barrels for water storage
- basic carpenter's tools
- basic mason's tools

You can purchase a lot of these tools used. Look on eBay, Craigslist, and yard sales.

All the tools in this second group are nearly indispensible. You should make sure that you have them before you start building.

- Excavation tools (mattock, pilaski, grubhoe) to loosen soil and dig foundation trenches.
- Shovels
- Tarps - They should be between 6 and 8 square feet or even a bit larger)
- 5 Gallon Buckets - Get as many as you can. 20 is a good number of them.
- Carpenters Level – You should have one at least 4 feet long and a smaller one.
- Machete (Make sure its stiff. Cold Steel makes good ones for low prices.)
- Wooden Cobber's Thumbs (for sewing and perforating fresh cob)
- Pocket Knife
- Wheelbarrow – The heavy contractor's models are the best
- 55 Gallon Drums (with removable tops) – Used for storing water, soaking clay and lime, and cleaning tools.
- Squirt Bottles – For wetting down cob and plaster. Liquid detergent bottles work well.
- Hammer
- Nails
- Saw
- Measuring Tape
- Screens – For sifting soil and sand used in plasters and floors: ½ inch, ¼ inch, and 1/8th inch mesh on rigid wooden frames, about 2x3 feet.

- Hoe – A flat, swan-necked one for mixing plasters and floor mixes.
- Jars – For soil testing.
- Garden Hose
- Scaffolding or Step Ladders
- Plasterer's Trowels
- Mixing Boat – For plasters and floor mixes.
- Axe or Chain Saw
- Safety Glasses and Dust Mask
- Stakes – To mark areas on the ground.
- Cordless Screwdriver/Drill

Preparing Your Site for Building

Before you can start building you will need to prepare your site. There are a few important things that you will need to do.

Test Your Soil

As discussed in the last chapter, dig test holes all around your site. Fill your jars and test the soil composition. Afterwards, fill in the holes you dug so nobody falls in them later.

Transfer Your House Design onto the Ground

Take the designs and floor plans that you've created and transfer them onto the ground at your building site where you want your house to be. Use stakes as markers on the ground since you will need to make adjustments and they are easy to move around. Outlining your plans can be tedious depending on the shape of your house that you've designed, but just take your time and think it through. If your building site is not level you will have problems. Make sure that your site is leveled off before transferring your design to the ground.

Drive Stakes into the Ground

Once you've transferred your plans onto the ground, drive the stakes deep so that they won't come out easily. Put enough stakes to clearly mark the inside and outside lines of the foundation. You foundation should be at least as thick as your cob walls will be. (More on this in the next chapter)

Insert Datum Stakes

Datum stakes are used to mark the floor levels. Put one datum stake in each room. They will be in place throughout the construction process so make sure that they are secure, out of the way, and visible to workers.

Use a water level, which is just a clear plastic hose filled with water, for marking the floor level on each datum stake. Make a marking on each stake and call it height “0” for reference. Base all of your floor heights and ceiling heights by measuring off of the zero point on your datum stakes.

Clear the Site

Remove vegetation and organic matter from the footprint of your building site, and clear the building’s footprint down to solid subsoil. You will want to separate the topsoil into a pile nearby for later use. Create a level platform for your house to be built on. Organize your building site and keep excavated material in strategic locations for use during building.

Foundations

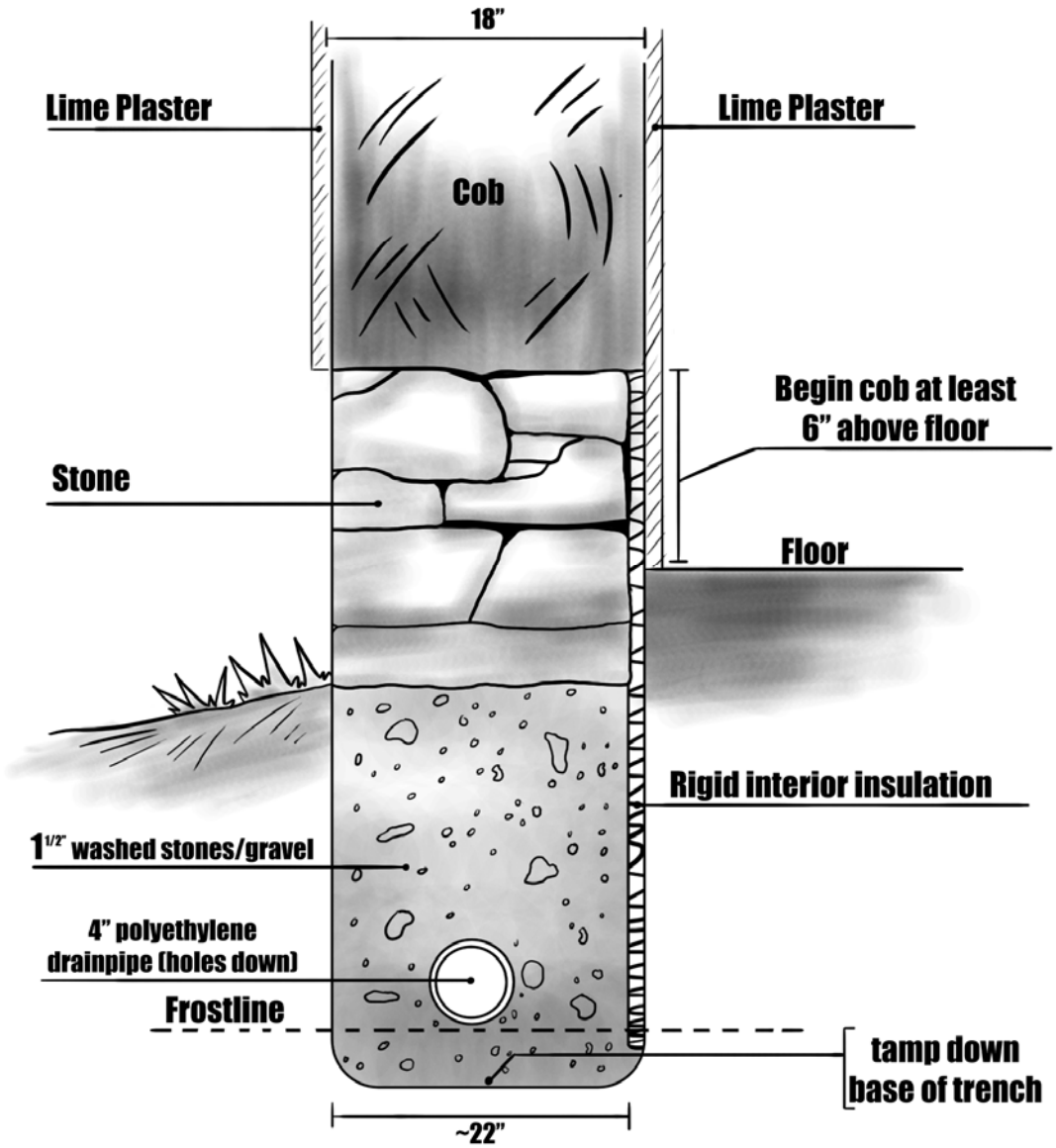
The first part of building your cob home will be the foundation. The foundation holds the weight of your walls, roof, and upper floors. Your foundation will distribute the weight of the house over a large area and prevents it from sinking into the ground, which can be catastrophic to a building’s structure.

Foundations for cob buildings include the rubble trench below ground and the above-ground stem wall that holds the cob walls. The rubble trench below ground level works with the stem wall to further distribute the weight of the building evenly. The stem wall, which sits above ground on top of the rubble trench, extends up at least 1 ½ feet. The stem wall acts as a protection to the walls and floors from water. Water runoff along the ground is not able to touch the cob portion of the walls, and water splash back from

rainfall can not reach that high. Its important for your foundation to protect your walls well from water since your cob walls will deteriorate if they are soaked by it.

Rubble Trench Foundations

In this book you will learn how to construct a rubble trench foundation with a stem wall. There are other methods to build foundations for cob homes, but this one is easy, reliable, and suitable for many climates.



How to Build a Rubble Trench Foundation

1. Once you've removed all the topsoil and organic matter and marked out the perimeter of your building (Discussed in the last chapter), you need to dig your trench. Dig your trench slightly wider than the width of your stem wall, and dig it down to the frost line. The frost line measures the lowest point at which the ground freezes. The frost line is going to depend on your region and climate, but if your cob building is in an area with mild winters where the ground doesn't freeze, a depth of 12 to 18 inches is usually deep enough. For an 18" thick cob wall, make a 24" wide rubble trench. For a 2' thick cob wall, make a 2'6" wide rubble trench. So, add an extra 3" onto both the interior and exterior of the trench. Make sure that the bottom of your trench is sloping downward toward one exit point extended away from the building. You can test your drainage slope by dumping a few buckets of water into the trench and seeing if the water runs directly down to the exit point. Lastly, make sure that the walls of your trench are vertical and that the floor is compacted down.

2. At this point you can lay your utility ducts in the bottom of your rubble trench before you fill it in. These ducts can be used for electrical cables, water pipes, and phone lines later on. Utility ducts are curved, flexible pieces of pipe. Just make sure that your utility pipes don't raise up your perforated drainage pipes trapping water. Once installed, plug up each end of the utility pipe so no debris gets inside while building.

3. Next, fill your trench with about 6" of drainage gravel (1" - 4" in diameter) and compact it down thoroughly.

4. On top of your compacted drainage gravel, lay a 4" diameter perforated drainage pipe circling the whole perimeter of your building. Make sure it extends at least 11 feet past the exit point and away from your building. This will direct the water that comes down around your building to a different area.

5. Fill in the rest of your trench in 6" increments tamping in between each layer until you reach about 6" from the top. At this point, it's a good idea to place a layer of open-weave fabric on top of the drainage gravel. This will prevent any silt or soil from clogging up your gravel drainage trench.

6. Start laying your foundation stones on top of your tamped gravel trench. Try to use your largest and most flat stones available. This will give your building more stability and create a better base for your foundation. These first stones should span across the whole extended width of your trench. Make sure they are set thoroughly into the gravel and they don't wiggle. If you step on them they should be totally stable. Have these stones come up to ground level.

7. From this point, build up the stem wall to your desired height. The next layer of stones should narrow to the actual width of your cob walls. Any layers from this point should be set together using a lime and sand mortar.

You can make a lime/sand mortar mix with:

- 1 part lime putty OR hydraulic lime (use NHL 5)
- 4 parts coarse sand
- ¼ part pozzolanic additive (can be purchased from lime suppliers)

If you can't get a hold of any lime/sand mortar mix then you still have some options, though less ideal. You can use no bonding mortar at all. Some people do this for smaller homes which works fine. Just dry stack your stones this way. Or you can just use a cement or mortar from your local hardware store.

Basic Stone Laying

1. Sort out the stones you have and look for ones that have at least one good flat side and a ninety degree angle. They don't have to have these characteristics, but it requires less fiddling around with your stones.

2. Put your stones laid out on the ground next to the wall you are building and familiarize yourself with the stones and their various shapes and forms. This will help you pick out the right stones as you go.

3. You want to create a solid base for your stem wall so lay the largest stones first. This will create a larger surface area for your house to rest on. As you build up, use smaller and smaller stones.

4. You want to rest the stones together using lime mortar. It cushions the stones together and fills in the gaps so they don't move. Make sure that your lime mortar is wet enough so there is good suction between your stones, but not so wet that it gets sloppy and won't support them together.

5. Carefully fit your stones together so that even if you didn't use any lime mortar your stem wall would still be solid and stable. Many people don't even mortar their stem walls together. It's not the mortar that makes your wall solid. Just keep this in mind when building.

6. Lay your stones so that every two neighboring stones are bridged above by a stone between them. Always stagger your stone joints and never stack them vertically right on top of one another without a proper joint.

7. This step is optional, but its recommended for insulating a cob house and increasing the thermal efficiency of the cob walls. This step is easier to do if you are building a thicker cob wall around 2' in width. You will create two separate stone walls for your stem wall and leave a cavity in between them. Use large stones at intervals to connect the two walls together. Then you will fill the open cavity with insulative material such as: sawdust/clay mix, perlite, or vermiculite. A sawdust/clay mix can be made by mixing sawdust and mud slip together until it can compact into a ball in your hand.

8. All of your stones should lay stable on the mortar without any wobbling around. If they continue to wobble, chip off any bumps that may be causing them to not lay right. You can also use small stones to wedge underneath to help stabilize them.

9. As you build up your stem wall you want to make sure that the outside and inside faces are plumb and vertical. Use a level to make sure you are doing so.

10. Your final layer of stones needs to be level across the width of you wall. It's not important to have it level going all around your wall horizontally. Some undulations will actually help your cob wall to key into the stem wall foundation. You just don't want your stones sloping inwards or outwards because your cob walls could potentially slip off.

11. Clean off any lime residue off the stones right away with water and a stiff brush. If it's already dried on the stones a wire brush will get it off.

12. Before you can start building the cob walls you need to wait for the mortar to set properly. Wait one or two weeks before building.

Lime Mortar Benefits

Lime mortar has many advantages over cement for joining stones and bricks together. Unlike cement, lime mortars accommodate for any small movements of a building and won't crack. Also staying true to natural building, lime mortars "breathe" the same way that cob and lime plasters do. Stone needs to breathe in order to stay healthy, just like cob, but to a lesser degree. This "breathability" allows moisture and dampness to be able to escape out through your stones or masonry. This way you will never need to use a waterproof permeable layer of plastic to guard from moisture. These non-breathable membranes are the opposite of what natural, breathable earth walls are about. Never put them up against your cob. They will collect moisture behind them and deteriorate the walls.

Alternative Stem Wall Materials

Stone perfectly complements cob and looks beautiful, but it can be expensive. Using stone to build a stem wall is also very labor intensive. It can also be expensive to hire a stonemason to do the job.

Locally sourced stones or recycled stones are cheaper, but if you still can't afford the stones that you want there are still many alternative materials. Here are your material options for stem walls:

Stone

You can use any type of stone that you like. Stones give the house a natural and homey charm to a cob house. However, the stem wall may be one of the most expensive parts of building a cob home due to the cost of stones.

Urbanite

If you want to save money constructing your stem wall then you may want to consider using urbanite instead of stone. Urbanite is recycled concrete that comes from old sidewalks, buildings, etc. It is very versatile, free, and lasts practically forever.

Fired Bricks

Another option is to use fired bricks. They can be any type. The price can vary, but you may be able to find old ones to save on money.

Concrete Blocks

You can use solid concrete blocks or cinder blocks. Cinder blocks work, but they are not recommend due to their fragility.

Poured Concrete

You can also create forms and pour concrete for your stem wall. You won't get the same natural appearance as stones, but this method will perform fine. You can plaster over the concrete if you want to later.

How to Make Cob

Making the cob is the most time consuming and labor intensive part of the building process, but it can be a joyful experience. There are many ways to make a cob mix (mixture of clay, sand, straw, and water).

Tarp Method

The most basic and one of the most practical ways of making cob is using the tarp method, which was developed in 1994 by a cobber in North America named Becky Bee.

This can be done by yourself or with one other person. You will need a large tarp and 4 or 5 five gallon buckets. This process can be done solo, but is best done with two people.

1. Get all of your materials close to your building site. Sand, clay subsoil, straw, water, tarp, and buckets.
2. Lay out your tarp on a flat space. This is where you'll be mixing.
3. Put your dry ingredients (clay subsoil and sand) in the middle of your tarp in a pile. Your ratio will always differ depending on where your materials come from. You will probably need to experiment with the first few batches to determine how much clay and sand are needed for a good mix. Here are some common ratios:

Sand	**Clay**
2	1
2	2
3	1

4. Now you want to mix the dry materials together on the tarp. Have each person grab two corners of the tarp and both people walk forward to the center of the mix, folding the tarp in half. The dry material should be together in the center of the tarp. Put the tarp back in its starting position and lay it out flat on the ground again. Go to the other end of the tarp and repeat the process of turning the dry materials over. Do this 3-4 times or until the dry materials are mixed thoroughly. Put the dry ingredients back to the center and lay the tarp flat again.

5. Pile up your dry ingredients in the middle of your tarp and dig out a small crater. It will look like a tiny volcano. Add a little bit of water into the volcano crater. Its always best to add too little water than too much! It is a whole lot easier to add more water than to try and fix adding too much. You will have to first experiment to determine how much water you will need in your mix. Sometimes a standard ratio of five parts dry ingredients to one part water will be good. But you can't always stick to this standard. You very well might need more or less. You'll figure out how much water to put through experience. Remember not to add too much water though. It might be easier to mix, but it will not hold up as well when you start building and will slump sometimes. A wet mix of cob can also crack more as it dries. However, if you do add too much water you can either leave the batch to dry out in the sun, add more straw to soak up some excess water, or add more dry ingredients.
6. Use your feet to push the outsides of the dry material into the center of the crater filled with water. Once you cover the water, start stomping on the pile. You can do it by yourself or with others depending on how much room there is on the tarp. Twist your heels into the mixture for the best mixing. You can also jog or dance on top of it as a mixing technique! The goal is to make sure that all the dry materials are mixed together well and that all the clay and sand are smeared together thoroughly.
7. Next, you will pull the corners of your tarp to fold the mix on top of itself again. Stomp the mix some more, and repeat this a few times until the mix flattens out like a pancake on the tarp. You can add some water to your mix if its hard to get mixed thoroughly together. Just add little bits at a time though. Eventually your whole mix should be forming into what some people call a "burrito" shape when you roll the tarp back and forth. Once it takes this shape you have a good indicator that your cob mix is almost done. At this point you are ready to add straw into the mixture.

8. Stomp on top of the burrito of cob mixture until its flattened again. Take some handfuls of straw and sprinkle it over the flattened mix. Again start to stomp the cob mixture until all of the straw has been covered and smeared with cob. Use the tarp to gather the mix up and turn it over again. Stomp some more until flat. Add more straw and repeat the process. There is no exact amount of straw to use, but one good ratio that people tend to use is one part compressed straw to five parts of dry ingredients. Keep repeating the process until all of the straw is thoroughly distributed and mixed into the cob. You've just made cob!

Making Test Bricks

It's a good idea to make a few sets of test bricks from your cob mixes. When the bricks fully dried you can test their strength by examining cracking, crumbling, and breakage.

Make a few batches of cob without adding any straw. For each batch, use a slightly different ratio of clay to sand, and keep track of the proportions for each one.

Make a test block from each mix (about 4 x 8 x 2 inches) and number them to keep track of the ratio used.

Add straw thoroughly into the rest of each mix, and form more test bricks.

Let all of your bricks dry in the sun until they are dried all the way through. This can sometimes take a few days. If you made enough bricks, you can break one apart to see if it has dried all the way through.

If there is surface cracking on your bricks that signifies that there is too much clay in the mix.

Test the hardness of your bricks by scratching the surface. Scratching it should not cut deeply or cause it to easily crumble.

Now take your bricks that contain straw and attempt to break them by twisting them in your hands. It should be almost impossible to break them with your hands if your mix is good and they are dried all the way through.

Alternative Mixing Methods

In the past, animals were often used to trample over the mix. Today, we have found some inventive new ways to create the cob mix.

Today, the most commonly used technique is to use a tarp. This is a great way to make cob, but it sometimes has its limits. If you have a group of people mixing on tarps, you can make a lot of cob at a pretty quick pace doing this. However, sometimes you don't have a large crew or the time to mix individual batches on tarps.

Here are three more ways to mix cob that may improve your rate of mixing:

Using a Bobcat – This has got to be one of the best methods for making large batches of cob in an efficient amount of time. Get a hold of a Bobcat machine, scoop your materials into a big pile, add water, and run the bobcat back and forth over it to make cob! It would take a lot of foot power to do this with the tarp method.

Watch this video of the Cobcat Bobcat! See for yourself.

Using a Mortar Mixer – Another piece of heavy machinery you could use to speed up your cob mixing is a mortar mixer. Take note that there is a difference between a mortar mixer and a cement mixer. Cement mixers will not mix cob to the right consistency, but a mortar mixer will because of the separate mixing forks inside. Unlike cement mixers, mortar mixers have independently rotating paddles and smears that move in a figure-8 pattern. They chop and mix it much better than any cement mixer will.

Make sure that you get a powerful mortar mixer with a motor of at least 8 to 10 horsepower.

With one of these, a crew of just two people could put up a small cob house in a few weeks. One person could make the cob in the mortar mixer while the other applies it to the walls.

Mixing cob in a mortar mixer might look something like this.

Using a Backhoe – If you want to get really heavy duty then you can use a backhoe to do some massive cob mixes. Have someone operating the backhoe and one person to throw straw on the mix. It's basically the same technique as with a bobcat, but you can do larger loads with a backhoe.

After making your large batches of cob, unload them onto large tarps where you'll be working and apply it to your construction. You don't want to wait too long to get it on your building or it will possibly dry out too much.

Note on Using Machinery
If you decide to use machinery to make your cob understand that it will probably not be as superior quality as cob mixed by foot. You may want to make your walls thicker if you use machine mixed cob. For any areas where high quality cob is needed, make small batches by foot or remix parts of your machine mixed batches by foot.

Cob Mixing – Problem and Solution

- If your cob mix sticks to your feet or to the tarp add more sand.
- If your mix continues to crumble and won't hold together then add more clay and/or water. You might also have too much straw in your mix.
- If you wet cob rolls/burritos pull apart easily then add more straw. Keep the straw long.
- If your test bricks crack when drying then add more sand to your mix.
- If your dry test bricks are soft or crumbly then add more clay to your mix.
- If your dry test bricks easily break in half then add more straw, or longer straw.

How to Build Cob Walls

Once you've laid your foundation you're ready to start building your cob walls on top of it. The process of building cob walls in not very complicated and can be learned quickly.

In this chapter you will learn:

- How to make cob loaves and transport them to the wall
- How to connect cob wall layers
- How to keep your walls vertical
- Ways to trim the walls

Cob Loaves

Probably the most popular method used around the world for building cob walls is to use cob loaves. There is no hard set rule or technique that must be used to build your cob walls, and many people develop their own modifications and methods.

Some people call them "cob loaves", "cob balls", or just "cobs" for short. In this book, they will be referred to as "cob loaves" to distinguish them from other cobbing methods out there.

Cob loaves are basically just a big handful or two of cob mix rolled into a compacted ball or clump. Using cob loaves gives you the ability to accurately and firmly attach cob into place.

Cob loaves are also easy to transport since they can be easily tossed. You can toss them across a building site or up to a builder on the top of a wall.

Making cob loaves is not complicated. It involves some physical labor, as does all cob building, but is not very stressful on the body.

Once you have mixed up all your materials on your tarp and you have a finished cob mix, gather all of the cob mix to one side of the tarp.

You can kneel down or sit on your knees next to your pile of cob. You will be on the ground for a while making cob loaves so get comfortable. Some people prefer to sit on something. If this is the case for you, go find a 5 gallon bucket, turn it upside down, and sit on it.

Reach to your cob mix and grab a double handful. Tear a sizeable chunk off the pile and compress it in your hands as you roll it towards yourself.

Use your body weight and roll it into a loaf. It doesn't have to be pretty or have any kind of uniform shape to it. Just get your handfuls of cob compacted together. Cob loaves are mostly made so that they can be transported to the walls easily for building. This should only take about 10 seconds to form each one.

Cob Toss

One of the most efficient ways to move cob loaves around is to do a "cob toss." Take your building team, line them up at intervals, and toss the cobs down the line to their destination.

This method is quick and efficient in most cases for moving cob loaves around. Toss them to the area of your wall that you are working on and stack them on the side. Don't stack them on top of the wall because they can fall and hurt somebody below.

Monolithic Building

A cob building is supposed to be a monolithic structure. Each layer of cob that you add on needs to be attached to the layer above and beneath it. Good bonding between layers is important for giving your walls strength and you won't just be relying on gravity to hold them together.

You want to sew each piece of cob together with its surrounding pieces, and you want a three-dimensional textile of interwoven straw between your cob. You can sew the cob together either using your fingers or a cobber's thumb. A cobber's thumb is just a stick or other item used to poke holes in the cob. Poking holes into the cob will sew straw between layers. Each layer that you build should be well perforated with holes. These

small holes help the wall to dry more quickly and evenly. They also help the next layer to bond and key into the current layer.

Using your hands, smear and pinch all of your individual cob loaves together as you apply them to your walls. Smear and fill in any cracks or gaps between cob loaves so they don't pull apart when dry.

Once you've applied your cob loaves, pinched them together, and perforated the layer with holes its time to make what's called "spine and ribs" to complete the layer. Doing this helps to "key in" the next successive layer of cob to the current layer.

When you're done with a layer of cob or if you're finishing up building for the day, make a spine and ribs. Make a ridge of cob loaves down the center of your wall, attached well together and attached well to the bottom. On both sides of the ridge attach cob to it at right angles going from the ridge to the edge of the wall on the inside and outside. Between each rib, just leave about the space of one cob loaf. These gaps will be filled in first when you start the next layer.

Applying Cob

Apply cob to your walls one piece at a time. Always try to work below your waist when building your walls too. You need the help of your upper body weight to push and prod your cob together.

Don't overwork the cob on your wall. It doesn't need to look smooth or flat. Basically just slap it on your wall, form it to the rough shape you want, and sew it together with the surrounding pieces.

When building walls you can use one hand to push down on the cob while the other hand can be used as a temporary form to hold the edge of the wall vertical where you are applying.

Connecting New Cob Walls

If you plan to attach a new cob wall to your existing wall in the future there are a few things that you can do.

You can install wooden “dead men” stakes or rebar to act as a pinning attachment between the old and new wall. Insert them half way into your current wall, and the other half will be reserved for the new wall being built.

Instead of using pins, you can create a vertical keyway into your existing wall. The new wall will be built into this keyway locking the two walls together.

How Thick Do You Build Your Walls?

For starters, build the base of your cob walls just a bit thicker than they will be at the top for stabilization. Keep them slightly tapered like a tree trunk would grow.

- Curved walls have extra strength and don’t need to be tapered.
- Unsupported ends of walls need wide buttresses or flares at the end to give them extra strength.

One important thing to take into account when deciding on how thick your cob walls need to be is how much heat storage you need in particular parts of your building. For example, walls that get a lot of sun exposure or a wall next to your fireplace or stove can be made thicker to absorb extra heat.

Knowing how thick to make your walls will come with experience, but there are a few basic guidelines that you can follow.

- Load bearing walls should be between 18 and 24 inches thick at the base.
- Interior walls can be thinner. Straight interior walls should be between 12 and 18 inches thick, and curved interior walls can be as thin as 6 inches.

Making Your Walls Straight or Tapered

For structural reasons your walls should be close to vertical, or you can use a predetermined taper as you build up. Its good to be consistent in checking your walls as you build up. Don’t wait until the end to trim your walls.

Use a level to check whether your walls are staying vertical. If its not vertical, use a machete or other trimming tool to trim off the excess. If you need to add more on to the

wall to make it vertical add on more straw-rich cob and sew it on with your cobber's thumb. Keep using your level to gauge for plumbness.

If you want to taper your walls you should make a special leveling tool. You will make the tool according to the tapering degree you want. Many cob builders use a 5 degree taper. Duct tape a 4 foot level to a 4 foot piece of 2 x 4. The piece of 2 x 4 needs to be cut vertically according to your angle. For a 5 degree angle, make it 3½ inches at the top and 1 inch at the bottom.

Tapering walls can significantly reduce the amount of cob you have to mix and gives the top of your walls much less weight to bear compared to the bottom. Tapering walls is often done on the exterior but not on the interior since it makes it awkward for placing furniture.

Trimming Excess Cob

No matter how careful you attempt to build your walls flat and vertical you are going to have to trim them. As you trim lumps and bulges off of your wall, collect them and reuse the material. The trimmings can be easily remixed and applied again later. Trim your cob layers a day or two after you have laid them since its hard to trim wet cob or cob that's too dry.

The most important and practical tool you will need for trimming your walls is a machete. Keep the tip and the blade sharp. This tool will allow you to slice and hack off bulges or bumps from your walls. You can also use a handsaw to trim your walls. Sometimes using a handsaw works better on wet cob because it doesn't have as much impact as the machete. A handsaw can sometimes also get into tight corners and spaces that machetes cannot.

A hatchet can be good for cutting out small niches into walls or getting into tight corners as well. A spud is also a great trimming tool. A spud is basically a flat bladed sharp shovel. This tool is good for reaching high places on your walls for trimming.

Working Up High

When working with cob, always remember to stay working just below waist level. If you do otherwise you will put unnecessary strain on your lower back or other parts of your body.

As you work higher on your walls you will come to a point where you will need some form of scaffolding. Get creative with this. There are many things around your work site that you can use to get you started.

For example, you can either use bales of straw or empty barrels with a board laid across them as low level scaffolding. (3 to 5 feet high)

Anything higher than this you will need to use ladders or lean-to trestles.

How High Can You Build?

It's very rare to see a cob house go up more than two stories tall. However, there is no particular limit if done right. In the country of Yemen there are cob structures that reach up to seven floors. The bases of the walls are built very thick and narrow as they go up.

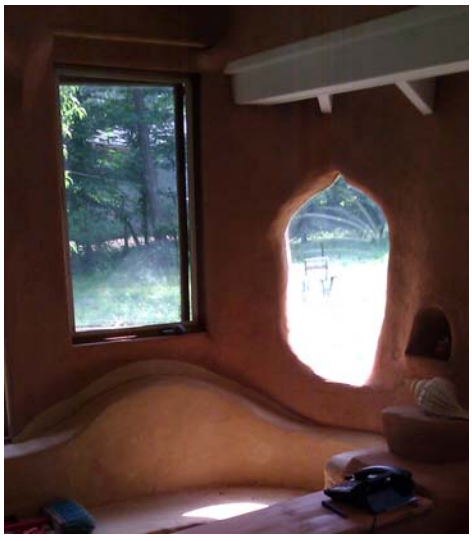
Another thing to consider if you want to build up high is that building slows down once you get on scaffolding. You are more limited in movement and material has to be delivered up from the ground. Some good ways to move cob up to scaffolds is to toss, hoist in buckets, or use a long-handled fork.

How Fast Can You Build a Cob Home?

The answer to this question depends on a variety of factors and there is no definite answer. Many people have built cob homes in a month, a few months, or a season. Sometimes it can take a year or much longer. It will just depend. Here are some factors to consider:

- How large is your building?
- How many workers do you have helping?
- How thick are your walls?
- How will you be mixing your cob?

Windows and Doors



Windows open up your home to the world outside. They are like the eyes through which you see the world. Windows provide many different functions: they light our homes, show outside views, ventilate our homes, and let in heat from the sun.

Cob allows you to be creative with your doors and windows because of the wall thickness and malleability of the material. You can create and install whatever type of door or window that inspires you. Instead of just buying a standard size door or window you can make your own to fit a specific style or function in your home.

Arches and Lintels

For windows and doors you will need to make sure that the wall is still supporting the weight above those openings. Lintels and arches are the way to support the weight.

Arches are a great way to hold the weight of your cob walls above either windows or doors. Arches are good for rounded windows that are fixed and don't open and openings without doorways or passageways between rooms.

To make arches with cob you can use what's called "corbel cobs." These are similar to regular cob loaves but they are longer and have more straw running lengthwise. Some people call them cob "burritos" because of the way they look with the cob sandwiching the straw in the middle of the wrap.

To make corbel cobs you need a wetter cob mix and long pieces of straw. Make your cob mix without putting in the straw. Then take a handful of it and wrap it over a small handful of straw lengthwise to create your corbel "burrito" shape. Knead the cob with the straw so that its all held together well.

To build an arch, make both sides of the opening flat where you want the arch to begin. Start building with your corbel cobs on each side at the same equal rate. With corbelling arches you do not want to build too fast. Let each layer dry for at least a day before adding the next one.

You will build a sort of "web" with your corbels that will gradually arch across your opening. Take some corbels and lay them horizontal from your leveled starting point. From there you will lay some corbels on top of those in a perpendicular direction. Then put the next layer of corbels laying flat on top of those as you did with the first layer. As this starts to gain height, add corbels running vertical on the outside. This will create a criss-cross pattern of corbels. Continue to build your corbels in this fashion extending out more and more with each layer to form your arch shape. You can build up regular cob on the sides of your arch as you go.

Arches can be easier to build if you use a rigid form as you go. You can make one out of thin, flexible plywood. It can be faster to build around a form like this but not as strong.

Another alternative to a rigid form is to use a cardboard template that you can put up to guide your arch construction. Or you can put a stick across the bottom of your arch and attach a piece of string measuring the radius of your arch to the center of the stick. You can use the end of the string as your guide.

The other option for headers is to use lintels. These are appropriate for windows and doors that create rectangular openings. Lintels can be made of any strong, stiff material such as: wood, stone, urbanite, and steel. Wood works well with cob and is the most common material to use for lintels, but its up to you to what you use.

Look for wood or other materials that will look nice exposed above your opening and give character to your building. The top of the lintel will be covered with cob but the sides will be visible still. You can leave the top side that doesn't look pretty on the top side and finish the other sides nicely for everyone to see.

When you place lintels above your openings, make sure to insert temporary supports below them and keep them there until the cob above is completely dried through and solid.

Another standard rule to follow with lintels is to have the lintel extend 4" into the cob on both sides and add 1" per foot of the windows length.

When you set a lintel onto fresh cob it can settle and sink down which could potentially crack your window or damage your door. First, let your cob dry as much as possible before you put on your lintel. You also want to add ¼" of cob per foot of the window's height. This will allow room for settlement without putting pressure on your window or door.

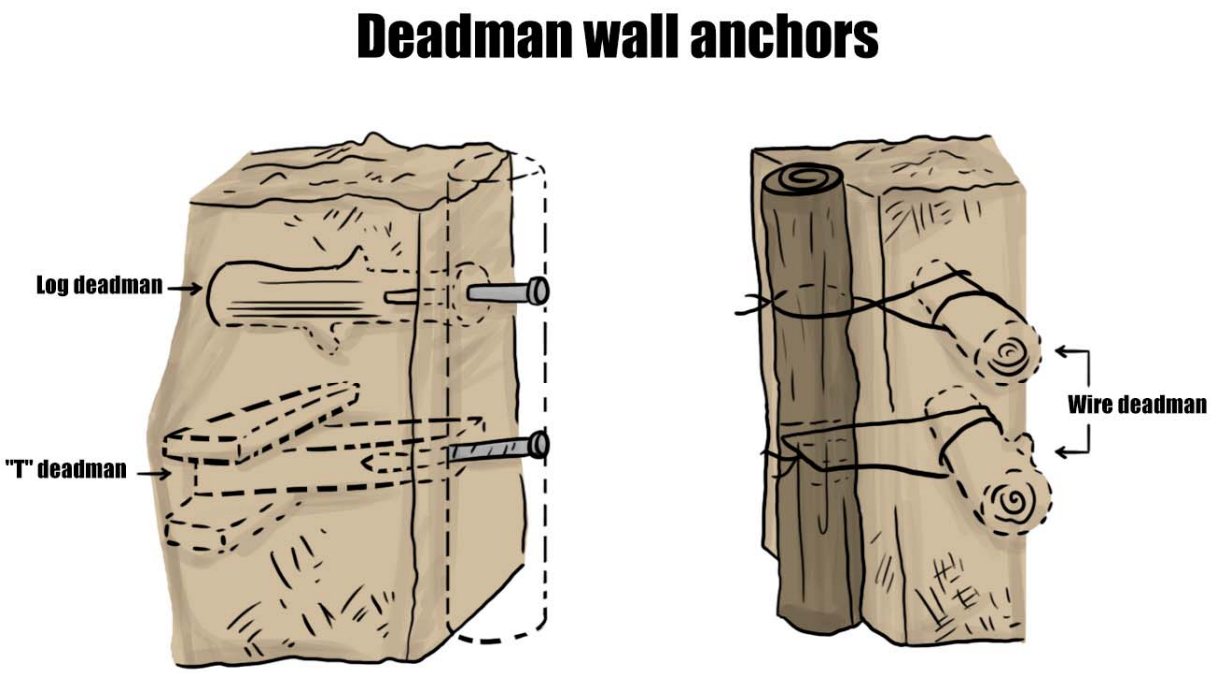
Wall Anchors

Most of the time, windows and doors are connected to wooden frames to hold them securely in place. With cob building you need to know how to connect the frames to the cob wall.

When installing your frames temporarily cross brace them beforehand since wet cob can put pressure on them and possibly bend them out of place. You will also want to brace doors and tall windows to the ground or something else that's solid.

To actually connect the frame to the cob you will have a few options. You can put nails into the outside of the frames with the heads exposed an inch or two (the nails can be bent too). The nails provide a grip for the cob to hold onto.

For big windows and doors its a good idea to use a stiff piece of wood which is buried in the cob called a "deadman." These can be old pieces of 2 x 4 or thick branches. Deadmen are built into the cob walls and have one face left exposed. Make sure that the exposed face sits flush to the wall. Window frames, door frames, shelves, cupboards, and cabinets can all be attached to the exposed faces. Install these fixing points wherever you think you will need to fasten something to the wall in the future.



The best way to install doors is to set the door frame in place before you build the cob walls. Connect the bottom of the door frame to the foundation, cross brace and anchor it, then build the cob walls up around the frame burying your anchors as you go.

For doors, attach an anchor near the top and bottom of both sides. This should be enough attachment for lightweight interior doors, but you will want more anchors for any heavy, wide, exterior doors. For these, put an extra anchor near the top hinge and an extra anchor about waist height next to the door handle.

After installing your frames there may be a little bit of shrinkage away from them as the cob dries. These cracks can later be filled in with cob or lime plaster when the cob has completely dried.

Non-Opening Fixed Windows

Its much easier to install a non-opening window into a cob wall. These types of windows are fixed in place and are built right into the wall without a frame. Use the thickest glass that you can find for these types of windows though. Thin glass tends to crack without a window frame.

Fixed windows can be fun because they allow builders a lot of creativity and artistic freedom. You can make rectangular, circular, oval, or whatever other shape you want. The piece of glass that you use does not have to be the shape of the window that you want. You can just build the cob around the piece of glass to form the shape you want. You can even use broken pieces of glass. Just be sure to duct tape the edges so you protect the glass from chipping on the edges and so nobody cuts themselves on it. Its best to not build your glass too far into the cob because the glass will take on a lot of undue pressure and can crack with cob settlement. A quarter of an inch is usually deep enough for your glass to go into the wall.

To install a fixed window, start by building a level site where your window sill will be. Leave room for padding beneath your piece of glass. You can use a piece of foam or other compressible material.

Set your window sill first before you put in your glass. Your glass and padding can sit on top of the sill. Make your window sill on the outside slope downward away from your window. Your sills can be made of various

materials: wood, stone, tiles, or bricks. Have your window sills overhang off of your walls a few inches so water doesn't drip onto your walls.

Build the cob wall at least one third of the way up the sides of the window opening to hold the glass in place. Continue to build up around the glass as you build your walls.

Roofs

For many people, roofs can be one of the most intimidating parts of building a cob home. Since its such a critical part of the building and requires careful consideration and planning. This is all true, but building a roof is still not rocket science. There are many great books that teach how to construct roofs. This chapter will cover the basic concepts of roof building and how they can be attached to cob. If you don't feel confident in constructing a roof by yourself there is no shame in getting help from an experienced builder or engineer.

In this chapter you will learn how to put a roof on your cob building and feel confident with the choices you make. There are a lot of different roofing types and styles to choose from. This chapter will also help you decide which is best for your building. You will want to consider things like: climate, size of your building, abilities, and cost.

Here are some good roofing options for cob homes to consider:

- Slate, ceramic, clay, or concrete tiles
- Wooden shakes and shingles
- Thatch
- Metal roofing (Steel or Aluminum)

- Living roof

Your roof should have a few basic functions and provisions:

- Keep rain and snow out of your home and away from your walls. This is especially important for cob homes because cob walls are vulnerable to water damage.
- Keep heat inside during cold weather and keep unwanted heat out during hot weather.
- Protect the inhabitants of the building from the outside elements.
- Direct rainwater and snow away from the walls.
- Be able to carry an extra load from things like: snow, ice, workers on the roof, and fallen branches.
- Hold solar panels for energy production.
- Be able to collect rainwater for use around the home and garden.
- Add aesthetic value to the building.

You should think about what kind of roof you want and how to build it before you start construction on your building. During the planning phase, design your roof and how it will be held up. There are a lot of factors to consider when designing your roof:

- How much area will the roof cover?
- How much money are you willing to spend?
- How much will the roof weigh?
- Will the roof have good fire resistance?
- What will the angle of the roof be?
- Do you want to collect rainwater from your roof?

Roofs consist of two basic components:

- The timber frame structure which gives the roof its strength and shape.
- The outer covering or skin which is attached to the framed structure to protect from water and the elements.

Gable Roofs

In this book we will discuss building a gable roof. For many reasons this is a good style of roof for cob homes and its pretty easy to build. Some advantages to gable roofs are:

- Simple design structure.
- It is good for rainy climates because it can provide plenty of protection to the walls from rainfall.
- It does not require a lot of wood.
- Load bearing cob walls distribute the weight of a gable roof evenly.
- Creates more space inside the building with higher ceilings.

A basic gable roof consists of a ridge beam spanning the length of the buildings with paired rafters connected on each side of it. The rafters extend from the ridge beam down

to the walls where they rest on collar beams. Without collar beams at the bottom the rafters could push the walls apart.

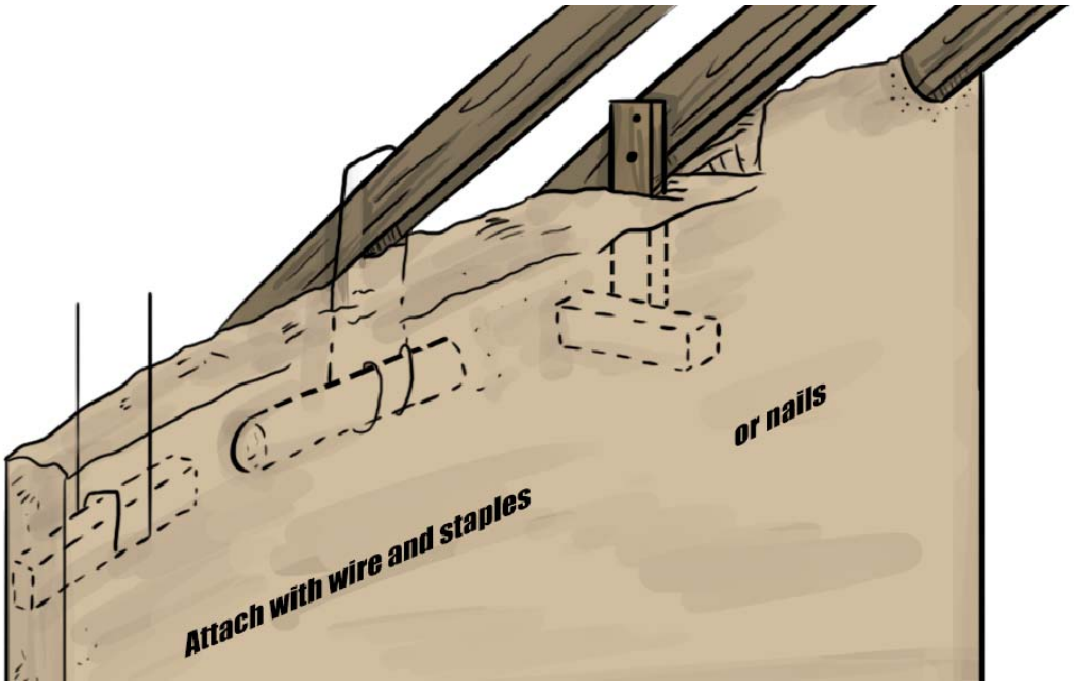
The ridge beam will extend across the length of the roof and the ends will sit supported on the walls. This leaves space in the roof open for a “cathedral ceiling” and gives you the ability to add in lofts and storage spaces. If your building is too long for a ridge beam to extend all the way across you can use trusses instead. Building a gable roof with a ridge beam is easier to construct than trusses.

Roof Pitch

An important thing to consider for your roof is the pitch or angle that it will be built at. This will also affect the way your roof looks. Probably the most important influencer of how your roof will be pitched is what type of roofing material and style you will use. Any kind of roof that uses overlapping pieces like tiles, thatch, shakes, or shingles will need a steep roof of about 35 degrees. If you’re building a living roof then you will need to have a pitch less than 25 degrees. If you pitch is too high on a living roof then your roofing matter will fall off the sides. Thatch roofs should have a minimum pitch of 45 degrees and ideally have a pitch of 50 degrees.

Tying Your Roof Down

Its important to secure your roof to the walls of your building. To prevent your roof from ever coming off in a storm or hurricane you will want to securely connect the roof to the cob walls. You can tie your roof down to the cob walls using deadmen and wire.



Bury a deadman about two feet below the end of each rafter and ridge beam. Use a thick piece of wood about 18” long such as a thick branch or piece of wood. Use a strong galvanized wire, wrap it around the deadman twice, and staple it on securely. Electric fencing wire or any other heavy fencing wire is a good option.

Next, you want to place your deadmen beneath each rafter or beam and cover them with cob keeping the wires sticking straight out the top of the wall. Once your rafters are laid in place, wrap each wire around twice. Don’t tighten the wires down until the cob has settled though. Once it has settled and won’t shrink down anymore you can staple the wires to the rafters with fencing staples.

Ceilings

Your indoor ceiling acts as a support for your roofing insulation and provides an attractive surface. There are a lot of ways to do a ceiling. You can put the ceiling in strips between rafters, beneath rafters, on top of rafters (so the rafters still show), between trusses, or suspended down from rafters for more insulation.

Ceilings can be made of:

- Boards
- Plywood
- Drywall
- Bamboo
- Woven bamboo mats
- Fabric or sheets

Sheathing Your Roof

Roof sheathing is what covers the top of your rafters. Some types of roofs don't use sheathing and just have horizontal purlins or battens to support the roof covering. You can use boards, plywood, OSB. It depends on what you want and how natural and toxin-free you want to keep your building.

If you want to stay on the natural side, avoid the OSB and plywood. You can look for recycled wood as an alternative. Slab wood is also a good material. This is the part cut off of a tree before milling it into flat boards. One side of a slab is flat and the other is rounded with the outside of the tree. You can place the rounded sides up for living roofs and you can place them flat side up for other types of roofs.

Thatch Roofs

Thatching is the craft of building a roof with dry vegetation such as straw, water reed, sedge, or any other vegetable material, and layering the vegetation so as to shed water away from the inner roof. Thatching is one of the oldest and most widely used roofing techniques in the world. It is a one hundred percent natural, extremely energy efficient roofing system that has several benefits:

Natural Insulation
Thatch has great natural insulating properties and can stand alone without adding any extra roofing insulation. Because of cob's thermal mass and high U-value (U-value is a measure of heat loss in a building element. Lower is better.) It is necessary to add an extra layer of insulation for cob buildings to improve their thermal efficiency. Like straw bale walls, the hollow straw stems in thatch trap air well and keep heat from escaping. Thatch also regulates temperatures well like cob does and keeps indoor temperatures warm in winter and cool in the summer.

Renewable and Sustainable
The material used for thatch can be grown each year and is completely renewable. It can often times be locally sourced in your area. Wheat straw is a byproduct of the grain threshing process.

A thatch roof also requires very little wood.

Biodegradable
Thatch is a biodegradable material that can be taken off of a roof and used again as garden compost. Thatch roofs can last a long time, but if and when you do decided to replace the roof you do not have to deal with replacing and disposing of asbestos and other toxic materials.

Pleasing to the Eye
Thatch complements the curvilinear lines of cob buildings almost perfectly and is very aesthetically pleasing. It will blend very well into a natural environment and it will give your cob home or building a very charming appearance.

There are also some disadvantages of thatch roofs that should be taken into consideration:

High Skill and High Cost
The biggest disadvantage to building a thatch roof is that it is a highly skilled craft not suitable for the owner-builder to take on who doesn't have thatching experience. It also takes an extreme amount of labor adding to the cost. These days, there are only a few professional thatchers in North America.

Risk of Fire
Thatch poses a fire risk. Be smart about how you build your chimney and how you place your wiring. Put the least amount of wiring in the ceiling as possible. Refer to your local building codes for stipulations regarding fireproofing thatch roofs.

A thin layer of cob beneath a thatch roof will dramatically decrease the chances of a house fire spreading up to the roof.

Scarce Materials
Good thatching material is scarce in North America and much of the UK these days. Hybrid farming methods yield grains with short stalks making them unsuitable for thatch roofs. Modern harvesting machines also do not cut and pack whole straws with their butt-ends aligned.

Strong Thatch and Maintenance

Thatch roofs are recommended to be about 16" thick. It is best to get wheat straw that has been grown organically and harvested in a traditional manner. This produces the strongest material and won't be weakened from modern harvesting methods.

A thatch roof can have a long life, usually between 40 and 60 years, if it is well maintained. Remove any plant growth from your roof and immediately fix any holes that you discover. Plants and holes will disrupt the ability of your thatch roof to shed water and can lead to damage.

Living Roofs

Natural builders are always interested in how to construct living roofs. They complement cob and natural building very well and are very economical. A living roof is basically a roof that has a layer of soil and vegetation growing in it. Sometimes they are called sod roofs. This kind of roof is becoming more and more popular these days and can even be found in cities on top of large buildings.

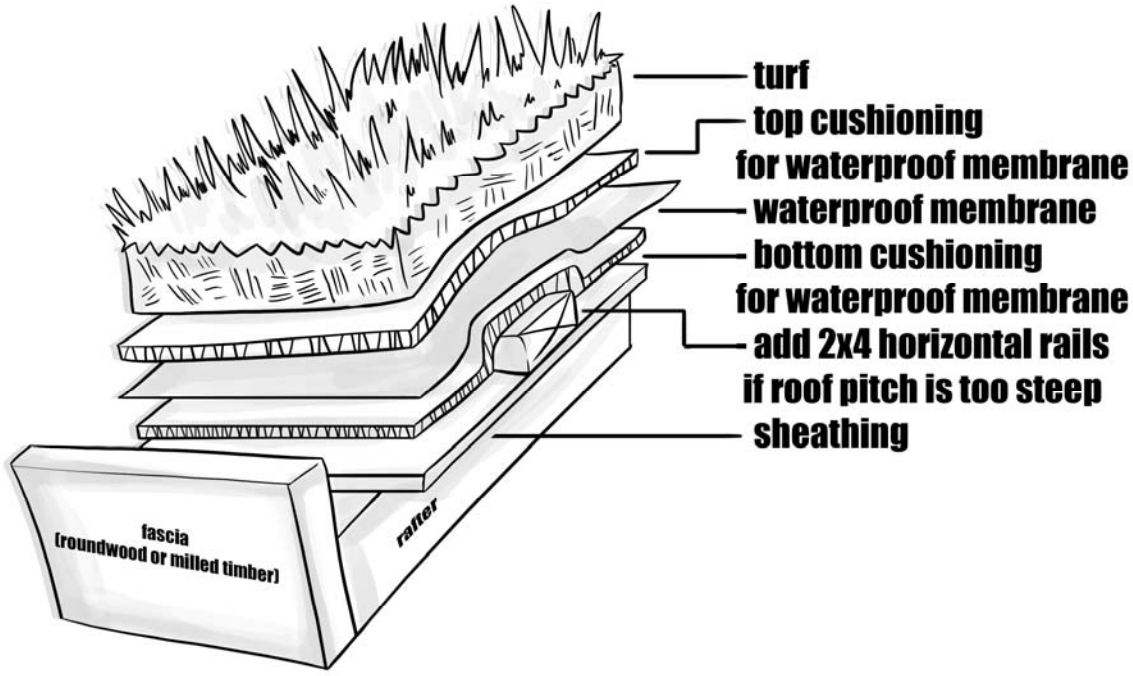
Some advantages of living roofs:

- Lowers indoor temperatures in the summer
- Reduces water runoff from rainfall
- Provides sound insulation from the outside
- Attractive and natural appearance
- Easy and inexpensive to construct
- Can last for decades if well maintained

How to Construct a Living Roof

Your roof needs to be built at a low angle to accommodate a living roof. Don't build your roof too steep or the soil that you place on top will just slide off of the edges. The maximum pitch that your roof should be for a living roof is 5 x 12 inches. Meaning for every 12 inches your roof increases in height by 5 inches. In other terms, keep the angle of your roof below 25 degrees.

If your roof turns out to be too steep you can fasten horizontal wooden rails onto your sheathing to help keep the soil in place. Also attach a large fascia to the edge of your roof to keep the soil from falling off the sides.



On top of your roof sheathing you will lay your impermeable layer. This is the most important part of your living roof because it keeps water out of your building. There are many permeable membranes available, but one of the most reliable and highly recommended membranes to use is an EPDM. They are very durable and resistant to piercing. They will also last for at least 50 years underneath soil.

Make sure that there are no holes in the membrane when you lay it out on your roof. Pull the membrane up and over the top of the fascia and fold it over the outside edge. If you want to have some extra protection, place a cushioning layer beneath your permeable layer. Cardboard works well for this and you can find tons of it in dumpsters behind supermarkets and retail stores. Make sure there are no staples of pointed things sticking out of it though since it can tear your permeable layer.

Another layer of cushioning goes on top of the permeable layer to protect the top side. This one is not optional like the one underneath though. Use more cardboard or pieces of carpet.

Now you're ready to place your soil on the roof. Add a layer of soil over your roof surface 2 to 4 inches thick. Just be aware of how much weight you think your building can carry. If you want to have your soil layer thick then you need to make sure that your rafters and sheathing are strong enough.

Instead of just piling soil onto your roof you can use pieces of sod. Sod holds itself together quite well too so you may want to consider placing sod pieces on the edges and ridges of your roof.

From this point, your living roof is basically completed. You can seed your turf or you can just let nature work its course. Winds and birds will transport seeds to your roof soil too. Eventually your roof will sprout and bloom with a beautiful covering of plant life.

Over time the soil on your living roof may shift at the ridge. This exposes the permeable layer to ultraviolet light which is damaging to it. You can add more sod to the ridge to protect this area. If gaps or cracks appear in your soil, fill them in with more soil or sand. It's best to do this when you're having dry weather so your sod is not saturated with water and expanded.

Insulating Your Roof

It's important to insulate your roof in most climates. Since hot air rises it will escape out of your roof unless you have good insulation in your ceiling. Insulating your roof will keep your home warmer in the winter months and prevent your ceiling from overheating in the summer months.

Natural builders would advise against using any industrially made insulants as they are bad for the health of those who install them and live with them. This book will present some natural, non-toxic insulation materials that you can use instead.

Where to lay your insulation:

- Insulation can be laid flat on top of a horizontal ceiling if your roof uses trusses.
- Insulation can be placed between rafters if you have a cathedral ceiling.
- Insulation can be placed on top of a suspended ceiling beneath your rafters if you have a cathedral ceiling.

For most areas in North America you will want to have a foot of insulation. If you're in an extra cold climate you will want to have 16 to 18 inches of insulation though.

You will also need to have at least two inches of space above your insulation to act as a vent so air can flow and take away any condensation that builds between your insulation layer and the roof sheathing or cover. You don't want your insulation getting wet since it won't insulate well when wet and can rot and break down your roofing structure. Keep your roof well maintained and fix any leaks as soon as they happen.

Cob walls are not susceptible to rodents and insects but your organic insulation is. You will want to keep it protected with a double layer of wire screen over any openings or

inlets around your insulation. Use a fine layer of wire screening to keep out insects and a stronger one to keep out rodents.

Smart Insulation Options

Here are a few good insulation alternatives that you can use to replace the conventional and toxic glass or mineral fibers, polystyrene and polyurethane insulation materials.

Blown Cellulose

- Flame retardant
- Recycled material
- Easy to acquire and install

Recycled Newspaper

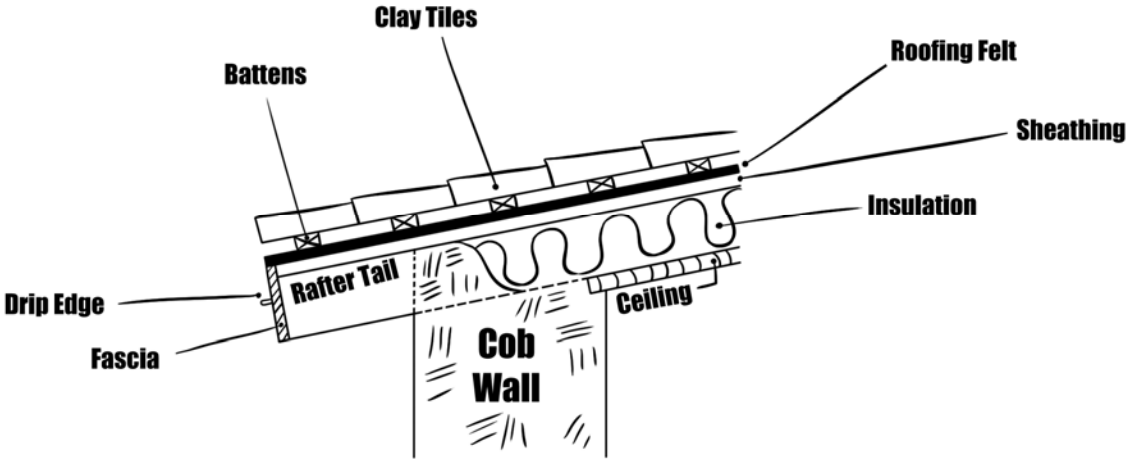
- 100% recycled material
- Non-toxic and is not hazardous to your health
- Fire resistant
- Protected against fungus and insects

Sheep's Wool

Sheep's wool performs just as well or even better than the equivalent conventional insulation products. It can be used loose or in quilt form which makes it very easy to install.

- One of the best natural insulators
- Breathable
- Insulates even when wet
- Has natural flame resistance
- Durable and long lasting
- Toxin-free and harmless to people

Sheep's wool is not widely available in the United States as of now. You may have the best luck acquiring it directly from a farmer. You don't need a massive amount of it though. One pound of wool can provide one to three cubic feet of insulation.



Roofing FAQ

Q: Is it necessary to put a synthetic waterproof membrane between the rafters and roof covering?
A: This is not always necessary with natural roofs. Most times it is best to not have this type of layer because it prevents your roof from breathing. The success and health of your roof sometimes can rely on its ability to breathe through with free flowing air.

Q: Can I build a traditional timber frame building to support my roof and still use cob?
A: Yes, absolutely! Timber frame accompanies cob perfectly. You can build your framed structure and then surround it with thick cob walls. There is a rich history of blending timber frame with cob in the United Kingdom.

Q: How do you attach metal roofing to your cob house?
A: Metal roofing is perhaps the easiest roofing system to install and can be done by even an unskilled person. The metal roofing is going to act as the covering for your roof structure. You will attach it in a similar manner to any other roofing cover. Across your rafters, you will attach horizontal wooden battens or purlins. On top of these battens you will lay your metal sheeting. Drill the metal sheeting to the horizontal battens. Avoid scraping the protective coating on the metal sheets since this can lead to rusting in those spots.

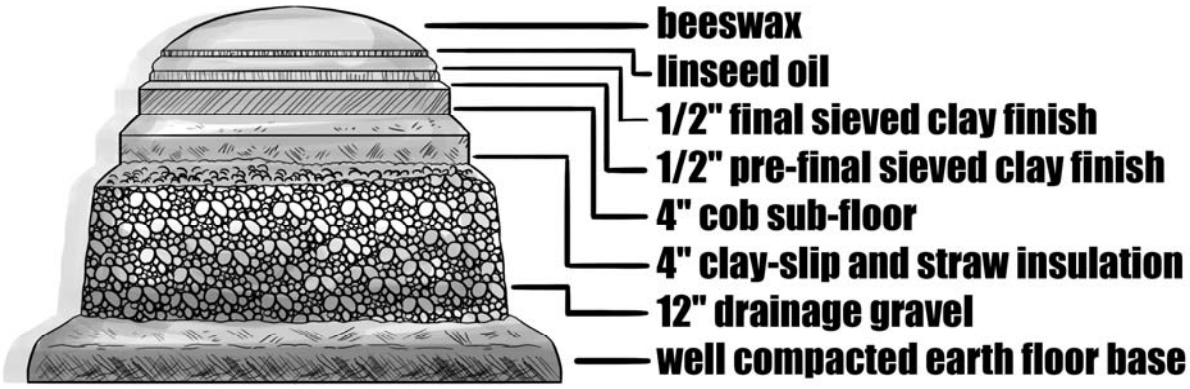
Earthen Floors

Earthen floors are both functional and beautiful. They are very durable, non-toxic, inexpensive, warm, waterproof, quiet, and comfortable to the bare feet. An earthen floor consists of layers of earth mix (similar to cob) laid on top of a gravel drainage layer, and finished with a layer of linseed oil and beeswax. Contrary to what people think, earthen

floors are easy to clean and maintain and are not dusty. They don't scratch or stain easily, and they are very low maintenance.

Earthen floors are a great alternative to wooden floors and are much healthier than those with fitted carpeting. Carpeted flooring is one of the worst causes of allergies. They off-gas toxic fumes and build up bacteria, mold, pollen, and dust. Earthen floors have none of these problems and are easy to wash.

An earthen floor plays into your passive solar design due to its high thermal mass. Your floor receives much more direct sunlight than your interior walls do. The absorption of sunlight into an earthen floor keeps your floor warm and toasty compared to a concrete floor which constantly draws the heat from your feet into the ground and makes it cold and uncomfortable to walk on without shoes.



The layers to an earthen floor (top to bottom):

- Beeswax
- 4 layers of boiled linseed oil
- 2 layers of sieved clay/fine sand/chopped straw mix
- Standard cob mix sub-floor
- Clay-slip and straw insulation
- Layer of gravel
- A well compacted sub-floor

You must have a well draining site in order to have an earthen floor, and the final layer of your earthen floor must be at least 6" above the ground level of the outside of your building. This is to prevent any moisture from getting into your floor and ruining it. The gravel will let water drain freely and prevent water from wicking up into the floor. Do not use any plastic impermeable layer beneath your earthen floor. Condensation can form on it and ruin your floor. Take this into account during your planning stages. A good earthen floor will be about 1'6" thick.

Bathrooms, where there is a lot of water splashing around, are better suited for tiled flooring.

Don't finish your earthen floors until all the rest of the work is done on the building. Roof your building and plaster it inside before attempting to finish your floor because you don't want it getting messy. You can build your earthen floor to the sub-floor level until everything else is finished though since this will give you a good surface to work on while building and it won't hurt it to get a bit dirty. Anything that falls on the sub-floor can be cleaned off. You can even do the drainage layer, insulation, and sub-floor layers before you build your walls. Only do this if you have a proper covering over your building though so it doesn't get wet.

Materials

The materials to construct an earthen floor are similar to the materials you would need to build a cob wall. You can find them easily and obtain them without spending a lot of money.

You will need:

- Drainage gravel for base layer
- Clay rich soil
- Straw
- Sand
- Linseed oil (boiled, NOT raw)
- Turpentine
- Beeswax

Tools

You can use many of the same tools that you already have in your cob buildings arsenal. The ones that you may not have are easy to get and are not expensive.

You will need:

- Shovel (digging, mixing)
- Tamper (can be home-made or purchased)
- Pitchfork
- Level
- Trowels
- Sponges
- Stove (to heat the beeswax)
- Paint brushes (to apply linseed oil)
- Cloth rags (lint-free to apply the beeswax)

How to Install an Earthen Floor

1. You will first need to prepare the ground for your earthen floor to sit on. Inside the interior of your building, create a solid platform for your earthen floor by digging down to solid ground and leveling it off. Get rid of any organic matter, roots, and topsoil. After your platform has been cleared, you will need to compact the ground thoroughly with a tamper. Tamp it down when the ground is dry because it won't compact if it's wet. If you want, you can slope the platform toward the outsides to help water run off into the rubble trench drains. Let the whole ground platform dry before starting to build your floor on top.

2. Add your base layer of gravel (3/4 to 1½ inches wide). It can be as little as 4" deep or in the range of about 12" - 14" deep after being thoroughly tamped down. More is better. This layer is important as it creates a barrier so that water doesn't rise into the sub-floor. Attach your level to a 2" X 4" piece of wood, level the surface, and scrape off any excess material. At this point in the process you can mark the stem wall with the height of each layer that you will be installing. This will help you to see exactly where you need to build each layer up to.

3. Next you will add a natural insulation layer to prevent heat from leaving the building through the floor. Use a 4"- 6" layer of clay slip mixed with straw. This is made by adding water and sieved clay to a barrel or container and letting it soak for a day or two. Once the clay slip is made you will mix in a lot of straw for insulation value. An alternative type of insulation would be to use vermiculite or perlite. Mix it with just enough clay so that it sticks together. Four inches should be enough if you decide to use one of these materials.

4. You can lay the sub-floor layer as soon as your insulation layer is thoroughly dry. Next, you will be creating the main mass of the floor which is made with a mix very similar to regular cob. However this mix will require more sand than regular cob and even a little bit of gravel to give it some extra mass. Make sure that your mix is able to be spread but don't let it be too wet either or it could crack. It should be about the consistency of a stiff cake batter. The sub-floor should be a bit rough when you're done with it to help key in the next layer that will go on top of it.

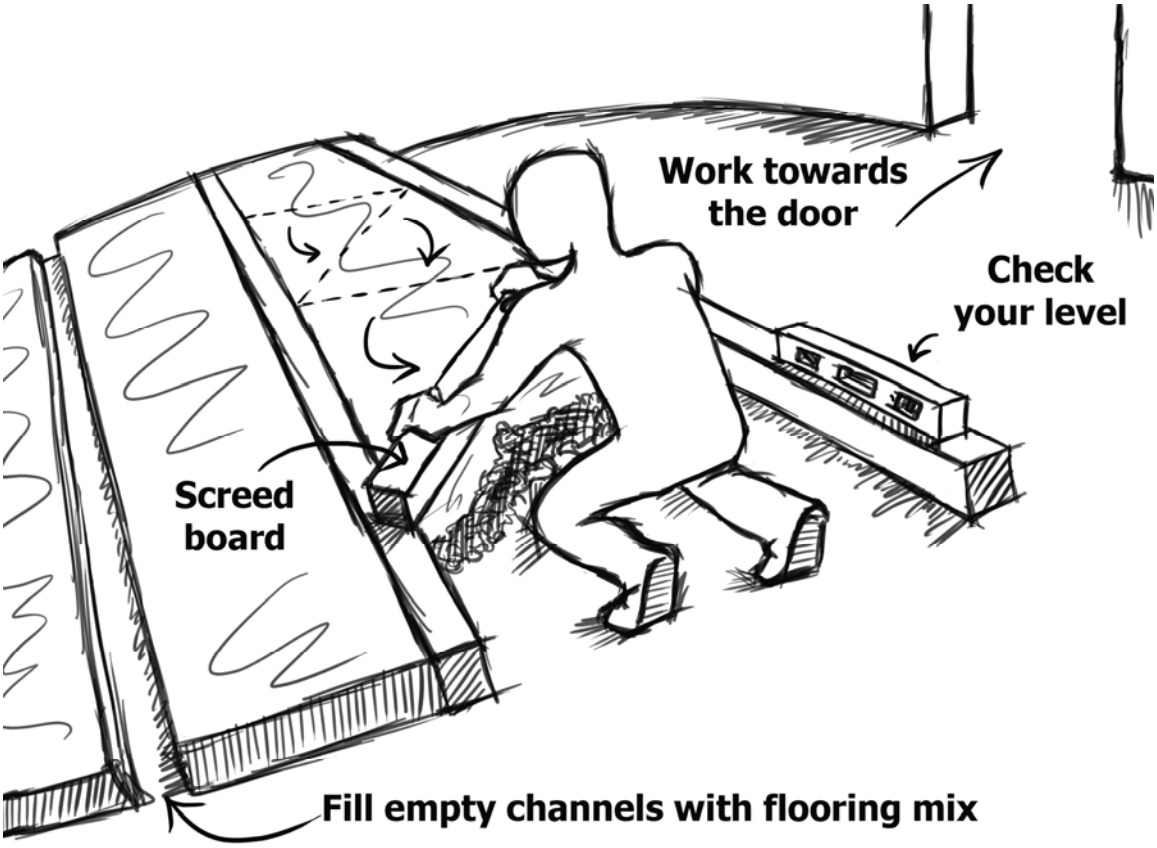
- You can help key the sub-floor to the insulation layer by lightly wetting the top of the insulation layer.

- Get two of the straightest 2"x4" lengths of wood that you can find that can span all the way across the floor of your room. Lay them on their edges on the floor from one end of the room to the other about three feet apart from each other. The two boards must be level with one another when set on their edges like this.

- Place your cob mix onto the floor in between your two boards.

- Fill in between the two boards to the top of each length. Spread out your cob evenly and compact it down well using a tamper, thwacker, or mallet.

- Use another long piece of 2”x4” board and lay it on top of the two guide boards you already set down. Use the perpendicular board on top to scrape off any excess cob.



- Remove the guide board furthest from you and immediately fill the empty channel with cob floor mix. Rough the edges so that there are no seams left that could crack.

- Set the removed guide board about three feet in front of the remaining guide board and repeat the same process until your whole floor is covered. Continue repeating the process towards the doorway.

Let the sub-floor layer dry thoroughly before walking on it and starting the next layer. As with any cob, good airflow will help to dry it faster.

5. Next, you will apply the finish layer. First, prepare your floor to be worked on. Sweep the sub-floor layer to remove any dirt, dust, and debris, and then dampen it to help bond it to the finish layer.

For this layer’s mix you will need:

- Screened clay rich soil (use a 1/8” screen)

- Sand (Use a finer sand if available)
- Chopped straw (chop by putting straw in a trash can and cut it up by using a weed whacker)

Its important to avoid cracking in this layer so you want to use more sand in this mix than usual.

Mix your ingredients on a tarp. Apply the mix on top of your sub-floor and keep it no thicker than 1 inch. Use a trowel to plaster it smoothly to the floor. Also be sure to keep your floor level. You can attach a level to a long board and slide it across the floor to discover any inconsistencies or bumps. You can scrape them off with the board. You want to keep this layer a little bit rough as well to act as a key for the next layer.

6. Once the finish layer has hardened some but is not completely dry, you can add the final layer. In the exact same way, add the final layer using the same mix. Keep this layer ½" thick. If you noticed cracking in the previous layer then you will know to add more sand to your mix this time through. Keep off of the finished floor until you have sealed it.

7. Apply four coats of linseed oil to the floor. This will make it waterproof, give your floor more durability, and give it a nice clean shine.

Before applying the linseed oil, check your final layer for cracks. If you discover any, dampen the floor and work some of the final layer mix into the cracks with a sponge.

You will need boiled linseed oil and turpentine. The turpentine acts as a solvent to help the linseed oil penetrate into the pores of the floor. Its important to use a solvent otherwise the linseed oil will just form a weak crust over the surface of the floor.

Combine the linseed oil and turpentine together in a 5-gallon bucket and apply it to the floor with a paint brush. Let each coat of oil dry before applying the next one. Keep good airflow going through the room to help the oil dry. Also, don't step on the floor until each coat has dried.

Coat #1: Add a pure layer of boiled linseed oil
Coat #2: ¾ boiled linseed oil / ¼ turpentine
Coat #3: ½ boiled linseed oil / ½ turpentine
Coat #4: ¼ boiled linseed oil / ¾ turpentine

The more coats of oil that you apply to the floor, the harder it will become. You can add more than four coats if you want to.

8. Lastly, you will need to apply a beeswax polish to make the floor shiny and more waterproof. On top of the linseed oil, the beeswax will make the floor more waterproof and water should bead up on the surface if poured onto it. Only apply this after the linseed oil layer has completely dried.

You are going to need hard granules of raw beeswax.

- Place the granules in a bowl
- Place the bowl inside a pan of boiling water
- Let the beeswax melt and become liquid
- While the beeswax is still warm, add two parts of boiled linseed oil (1 part beeswax / 2 parts boiled linseed oil)

This will turn the beeswax into a paste form so you can spread it onto the floor. Make sure that the floor is clean and then apply the paste to the surface of the floor with a lint-free piece of cloth. Work the wax thoroughly into the floor using circular motions. When complete, stay off of the floor until the wax polish has completely dried.

Earthen Floor Maintenance

The linseed oil and beeswax layers will make your earthen floor very durable. You will want to do an annual maintenance by applying a fresh coat of beeswax though. This is the part that gets the most wear and tear so you want to re-apply it to protect the floor and keep it shiny.

Natural Plasters and Finishes

Plastering your cob home is like putting the icing on the cake. Once you have built your walls, built your roof, installed windows and doors, and laid the base for your earthen floor then you can begin to plaster your building. The plaster will protect your walls from rain on the outside, and it will protect your cob walls from any crumbling off on the inside. Also by using natural plasters and paints, you avoid the added toxicity of cement stucco, drywall, chemical paints, and the destructive industry that produces them all. In this chapter, you will learn about natural lime and earthen plasters that you can use to protect and decorate your cob home with. This is an exciting area of natural building that is having a new resurgence and it leaves a lot of room for creativity and experimentation.

A good foundation and a good roof overhang (a good hat and boots, as they say) will protect your cob home from most weather and rain. Some people decide not to plaster the exterior walls of their cob homes and they are fine in many cases, but you will still get deterioration. It is recommended to plaster your walls to protect them from driving rain and frost.

You will also want to plaster the inside of your cob building. Plasters can brighten your home by reflecting natural light inside. Plaster with light and pale colors around windows and lights for better reflection. Use darker colors or colored pigments to set a certain mood. It's up to you how you color your home so get creative!

Never Use Cement Stucco with Cob

You need to let your cob walls "breathe" freely. Using cement stucco on cob blocks off its ability to breathe through the tiny pores of the cob structure. Do not use any impermeable moisture barriers, tar, oil-based paints, or latex-based paints on cob buildings or structures. Water vapor that's generated from inside of the building from your kitchen, bathroom, and even breathing needs to eventually make its way outside through the walls.

Moisture will condense behind cement stucco and soak your cob walls completely destroying the strength and integrity of your structure. This is why it is so important to never use these types of coverings over your cob walls. Always use natural plasters and paints. They are cheaper, more beautiful, and better for your health anyway!

Materials for Plastering

The materials you use for making natural plasters are very similar to those you use to make cob. Clay, sand, straw, and some additional materials are all that you will need to make earthen plasters. Lime is also an important ingredient which will be covered later in this chapter.

Earth/Clay – Earthen plasters require a main earth ingredient with enough clay content for the plaster to stick to the wall. For cob mixes you just use the earth as it comes from the ground. For plasters you will need to take the earth and sieve it through a screen. The

size of the holes in your screen will depend on what type of plaster coat you are planning to apply. You might use a ¼ inch sieve for a base coat layer, or a 1/8 inch or 1/16 inch screen for a finish coat. The smaller your screen holes are, the finer your earth will be. You don't want chunky bits in your finish plasters, but a little roughness in your base coat is good to help grip your finish coat on top of it. You can sieve your earth through a screen dry, or you can make a clay slip and pour it through the screen wet.

You can also look for different clays with various pigments to them. If you search around you can probably find a few different colored clays. You can use colored clays as a base for your plaster mixes to get certain colors.

Sand – With sand you will want to pay attention to how smooth it is. For base coats you can use the same coarse sand that you use for cob wall mixes, but for finish coats you will want to use smooth, fine sand. Beach or dune sand is great for this purpose.

Straw – Straw for plasters should be short. You can cut it up with a machete, a lawnmower, or scissors. One of the best ways to chop your straw is to put your long pieces into a plastic trash can. Take a weed whacker, turn it on, and stick it down into the trash can to cut your straw up into little bits. Keep the lid over the top as much as you can while doing this so straw doesn't fling out the top. For finish coats you can chop your straw and then rub it through a 1/8 inch screen. Straw will give your plaster tensile strength to cope with the tiny movements in a cob building. It also helps to prevent cracking.

Manure – Animal manure can also be used for natural plasters. It sounds kind of nasty at first, but it has short, natural fibers and digestive enzymes that help clay to plasticize. Cow and horse manure are the most widely used for this purpose worldwide and has very little odor at all when dry. Try to use fresh manure. Otherwise you can use dry manure but make sure that the fibers have not decomposed. Both horse and cow manure are safe to use since very few pathogens in their dung can transfer to humans.

Tools for Plastering

You will need a few basic tools to get you started with plastering. You can build your arsenal of plastering tools over time, but to get started you will just need a few essentials.

Trowel – You should have a rigid rectangular trowel and a flexible trowel with rounded corners.

Plasterer's Hawk – You can make your own plasterer's hawk with a square of sturdy plywood. Attach a vertical handle to the bottom and you're set. Otherwise you can purchase a good plasterer's hawk new for about $20 or less.

Screens – You will need to screen your materials through a wire mesh for plaster mixes. Make a framed screen in the sizes of: ¼ inch, 1/8 inch, and even a 1/16 inch. Attach a

large piece of screening to a wooden frame and attach legs to both sides so that it can stand up at a diagonal angle.

Wheelbarrow or large mixing boat – Either one of these is good for mixing plaster in.

Swan-necked Hoe – These are great for mixing your plaster together with. It's easy to get a back and forth mixing motion with this type of tool.

Spray Bottle – A plastic spray bottle is useful for wetting down a dry cob surface before you begin plastering.

Rubber Gloves – You'll want rubber gloves that cover your hands and wrists when handling lime. They are also good for applying and smoothing out plasters with your hands.

Brushes – Paint brushes are good for applying alis paints and lime washes. A stiff mason's brush is also useful for brushing off plaster that has fallen onto your foundation while plastering your walls.

Earthen Plasters

Earthen plaster is created with a mixture of clay-rich soil, sand, straw, and water. Because the ingredients are screened and chopped finely, the mixture comes out as a much smoother and wetter mix than cob. There are three layers to plastering: the base coat (also called a "brown coat"), the "scratch coat," and the finish coat. Earthen plaster doesn't require all three layers though, and it does well with just one single coating most of the time.

How to Mix Earthen Plaster

- Use a ¼ inch wire mesh to screen your clay-rich soil through. This will be used for the base coat and the scratch coat.
- Screen your sand if it is very coarse or has small stones in it.
- Add the soil into your wheelbarrow or mixing boat and add water.
- Begin stirring and slowly adding in the sand.
- When it begins to look like a thick cake batter, then add in a substantial amount of chopped straw.
- Mix it all together well. It should stick to itself and it should stick to a cob wall if you throw it hard at one.
- Make sure that your walls are trimmed vertically before plastering them.
- Thoroughly wet the cob surface you are going to apply plaster to.
- Apply a coat of plaster by smearing it on the wall with your hands. Use rubber gloves and keep your hands wet to help smooth it on. You can also use a trowel if you prefer. Either method works well. Put a load of plaster on your hawk and set

it up against your wall. With your trowel, push some plaster off the hawk and onto the wall. Smear it up the wall in vertical motions with pressure on the trowel.

Each layer should be no more than ½ inch thick and finishing plasters should not be more than ¼ inch thick. Try your best to keep each layer even in thickness all across your surface to help prevent cracking. Always remember to dampen the surface that you're about to plaster. Just don't have it dripping wet. Do this for your first coating and between each layer you do.

Exterior earthen plasters should have less sand than interior ones. When sand comes off of the wall due to weathering, it runs down the wall and slowly grinds the clay off. Use a lot more straw in your exterior plasters as this will protect your walls more from the weather. Before you apply a plaster over a whole wall or surface, test your plaster mix in a small area to see if it works for your purposes.

Lime Plasters

Lime plasters have been used for thousands of years. It is a breathable material that works very well with cob. Using a lime plaster on cob will give it a skin of thin limestone, which will protect it well from the elements and beautify your home.

Lime can come in many different forms. Ready-made lime putty and quick lime are the best types of lime that you can acquire for plastering a building. However, they are still not readily available in the United States. They are widely used in the UK though. Bagged, hydrated lime and hydraulic lime powder are available in the United States and are still effective. Hydraulic lime comes in NHL 2, 3.5, and 5 denoting the amount of silica and alumina impurities contained in the mix. This determines the strength and permeability of the lime. NHL 5 is the strongest and gives the most protection from water. It's a great choice to use on things that get very wet. For example, an exposed cob oven with no roof over it is something you would want to use an NHL 5 on. NHL 2 is good for making a lime wash, and NHL 3.5 is suitable for either interior plastering or external plastering of cob walls.

When working with lime it's important to wear a mask to prevent breathing in any lime dust. Always wear gloves too so that it does not burn your skin! Please don't forget this, and stay safe.

Lime is a very caustic material. If it gets on your hands or skin wash it immediately with water. You can also rub your hands in vinegar to neutralize the alkalinity of the lime. If any lime gets in your eyes wash them out with water immediately.

If all you can acquire is hydrated lime powder then you can still make your own lime putty with it. Get a barrel and fill it up no more than two thirds full of water. Pour in your hydrated lime and stir it until it is thick and smooth like a milkshake. When it's all mixed up, pour a layer of water on top of it and tightly close the barrel with a lid. Let it sit for a few weeks to a few months. It is like a fine wine. The longer it sits, the better it will be as a building material. You can let it sit for as long as you want and it won't spoil. Just remember to keep the cover of water over it so that it doesn't dry out and start to set.

Lime plaster is a mixture of lime putty, sand, and water. You use more sand in the mix for scratch coats and less sand in the mix for finish coats.

Common Proportions:

- Scratch coat: 1 lime / 5 sand
- Medium roughness: 1 lime / 3 sand
- Finish coat: 1 lime / 1 sand

Use very fine sand (beach sand) for finish plasters to get a smoother coat.

Combine your sand and lime putty in a wheelbarrow or mechanical mixer.

How to Apply Lime Plaster

- Dampen your wall with a spray bottle or wet brush.
- Apply your first coat of lime plaster at about 3/8 of an inch thick.
- Using a trowel or your hands (wear rubber gloves), throw the lime plaster onto the wall from a few feet away.
- When this coat is firm to the touch but not completely dry ("green dry") you can add the second and final coat in the same thickness. Wet the base coat before applying the finish coat though.

You need to give lime plaster plenty of time to dry. Keep it covered from direct sunlight, rain, and strong winds, and don't apply lime plaster if there are freezing temperatures. These precautions will help the lime cure and prevent cracking.

Lime Wash

Using lime wash is one of the cheaper ways to cover and protect your walls. Lime wash is basically just lime putty watered down to the consistency of milky paint, and you can apply it to your walls with a paintbrush. It can also be made with Natural Hydraulic Lime. You will get the best results with NHL 2 powder.

For added protection to you walls, you may want to apply an earthen plaster first. You will probably need several coats of lime wash to get a white finish over a dark mud color. Remember to mist your wall with water before applying any lime wash. Always wait 24 hours before applying your next coat of lime wash.

Try not to apply lime wash in direct sunlight or in the rain. A cloudy day is the best day! Cover your lime wash with sheets for 24 hours to protect it from sunlight exposure.

Natural Plaster Suppliers

Lime Works - www.limeworks.us
This is a full-service supply company based in Pennsylvania that provides Natural Hydraulic Lime and natural lime paints.

American Clay – www.americanclay.com - www.americanclay.com/shop/
American Clay offers natural plasters that are environmentally friendly, non-toxic, and made in the United States of America.

Solamente Color – www.solamentecolor.com
This company offers a range of colors designed to be used with American Clay Earth Plasters.

Additional Information

Natural finishes and plastering is an art form and a science unto itself. There is a lot that you can learn about this topic and there are many great resources available. Two very good books with practical knowledge are:

Using Natural Finishes by Adam Weismann & Katy Bryce

All About Lime, Lime in Building by Jane Schofield

Electrical and Plumbing

Before you start construction of your cob building, you will need to carefully plan out where your electrical and plumbing will be placed. You will need to plan how you will place your wires and pipes as you build the structure. Decide where your electrical outlets and water outlets will be and then design their supply system.

Wiring can be installed as you go or installed once the walls are done and right before you plaster them. You can install your wires into the walls by carving out channels, and then cobbing or plastering over them. Switch boxes can simply be nailed in place.

It is very safe to put wiring directly into cob since it can not catch on fire, but it is recommended to still install your wire inside of conduit for maintenance purposes.

Plumbing can be installed through cob walls but it's a good idea to take some precautions so you don't get leaky pipes inside of them. Dripping pipes inside of cob walls can be devastating. Make sure that there are no pipe joints inside of the cob walls. You can also encase your pipes in plastic tubing as another precaution to catch water if one does manage to leak.

Keep your pipes toward the inside walls or insulate them if you live in a very cold climate. If you're in a very frosty, cold climate also keep any water pipes that run exterior to the building below the frost line.

If you don't have experience with electrical and plumbing it is best to consult an expert or someone who knows what they are doing.

You can also fashion a removable wooden board to the edge of your floor or inside of a wall so that you can easily get to water pipes and electrical conduit at a later time.

Pipes and wires can enter from the outside of your cob structure either through the base of your cob walls or underneath your stemwall foundation. You can use a piece of PVC pipe to feed your wires and pipes through to the inside. Remember to plan your system ahead of time since it will be much more difficult to implement this when your walls are done.

Building Codes and Permits

The way that the building codes stand now, they support the construction of toxic homes, made out of unnatural, industrial-created materials that are negative to our health. The only natural material that is used in conventional homes is milled wood.

The main problem with building cob homes is that there are no recognized building codes for cob which prevents people from building with it.

When people first learn about building homes and structures out of cob they get really excited and their imaginations go wild with creative ideas and all the possibilities that the material offers for creating things.

Then at some point in our excitement we get a rude awakening to the thought of how we might actually go about building a cob building in our bureaucratic society. We tend to worry about how we'll make it past all the laws, regulations, and building codes required to build according to our own imaginations. Not to mention the expensive inspections!

In the United States, we follow the International Building Code. This is supposed to be here to safeguard us from dangerous and risky construction methods. While it's not totally useless and offers some true benefits, it is narrow minded in its scope and hinders creative ideas and innovation. David Eisenberg further explains and expands on the narrow minded thought patterns of building officials and how following the IBC can actually backfire on our safety:

> "The fact is that our current scale system is flawed, behind the microscopic codes money has become the ultimate measure for everything. Innovation is constrained by currencies and not lives." – David Eisenberg

According to the International Code Council (ICC), the purpose of the International Building Code is to "safeguard public health, safety and general welfare… from hazards attributed to the built environment."

But take it for what you will. As Cob Builders and Natural Builders we have to take the Orwellian-like system into account at some point. It might seem daunting to face but there is actually hope!

Cob Building Codes and How to Get a Permit to Build

It is not specified in the building code whether or not building with cob is illegal or not. For many people, they have first been required to get a permit to build with cob. They have had to hire an engineer to help develop their building plans. Once cob designs are approved by a "licensed design professional", the building department will usually give you approval and permit you to build. Just be ready to fork over a lot of extra money in the process!

What Other Options Do I Have? Easier Ones Please…

I asked Mike McDonough, an experienced Cob Builder who apprenticed with the Cob Cottage Company, what his thoughts were on cob building codes and regulations. Here's what he said in a nutshell:

> "There are no codes for cob in the United States. There is a code for adobe in New Mexico, and strawbale in California, although these are clearly different systems. Most codes in the US follow the International Building Code (IBC). Each state has their slight variation of it, as do counties and major cities. However, just because there is no code for cob doesn't mean that it can't be built legally. It really comes down to the people in the local building department, how they interpret the code, and doing what it takes to satisfy their concerns with an unfamiliar material. This can mean having the building engineered or stamped by an architect, which removes the building department's liability in case of failure."

Here's the real kicker!

> "There are cases in which you don't need to get a permit for a building at all, and can just build what you want to. **This is common in rural counties,** and for buildings under a certain size footprint, usually 12×12 (if it has no utilities)."

So in some cases you do not even need a permit and are free to build as you please. There are permit exemptions if you build: under a certain size, for agriculture or storage use, or build in a rural area that does not require a permit.

Light at the End of the Tunnel

Don't let the thought of codes and regulations get you down. Keep pushing the boundaries by creating and innovating with cob and natural materials. Some people might look at Natural Builders as crazy for what we do, but we're on the cutting edge here. It's to be expected.

The future of building belongs to us. We need to keep networking and educating people on the advantages of natural building methods like cob. Sooner or later, more people will wake up to the reasons why we use the methods of building that we do.

As people realize the need, we could get building codes enacted for cob and not have to worry about this issue anymore.

I encourage you to get a copy of my eBook, *Cob to Code*, to get a much more detailed guide on how to build cob homes according to code specifications.

Our Uncertain Future: Cob Offers Sustainable Solutions

How would you cope in a country where gasoline and electricity become unavailable? What if clean water stops flowing out of your tap?

Whether people are ready for it or not (mentally, physically, and spiritually), life as we know it has the potential to dramatically change in the next few years and the next few decades. It is my shared belief that there will be many political disruptions and worldwide instability in our near future. It will be up to you to decide whether to take heed to early warning signs, but I am certain that life will be radically different from the way it has been during these years of prosperity. Basic services, goods, and electricity may be disrupted on a mass scale.

What you will do to prepare for the future is up to you. This chapter simply focuses on how cob and natural building will play a role in the future as resources become extremely expensive and scarce.

Cob will offer many solutions for building and housing in our near future. Global economic depression will leave people with little money or valuable assets, and conventional building materials will become too expensive to purchase for the average person. You won't be able to go to Home Depot or your other local hardware store to pick up the supplies that you need to build your home with. That option may cease to exist.

Even if we lose access to standard building materials like cinder blocks and 2x4 studs, we can simply use the natural resources around us to build with. People have been building with earth, stones, and natural timbers for as long as man has existed. We can go back to our roots and build with these natural materials once again.

Basically, a cob home requires: clay-rich soil, sand, straw, water, stones, and timbers. These can all be locally sourced or purchased cheaply. No matter what type of economic instability occurs, people will still be able to acquire these basic materials for building. You do not need to take out a loan or have a mortgage to build a cob house. Debt is a problem you want to heavily avoid. It will not be good for you now or in the future.

Modern building methods are no longer sustainable for our global population of 7 billion people. It is not only very damaging to the environment, but the materials and building techniques are going to become too expensive to produce with. Cob and other natural building methods offer unique solutions to this dilemma. We can replace polluting, expensive methods that we have now with sustainable, clean, energy efficient ones.

The future is going to force people back to their roots and to live in more harmony with the natural environment around them. People will find themselves living in a much more ecological, self-sustaining way. I believe we will see a huge increase of people building with cob. About thirty percent of the world's population live in homes built out of earth,

and it is the most common and accessible building material on the planet. Returning to this natural resource makes perfect sense.

This revolution in building will not take place until something dramatic takes place. Our current system protects the industries that manufacture and produce our standardized building materials. Current building codes prevent many people from building with cob or other natural building methods to protect these giant industries. In the end it's all about money and control. To the system, you are supposed to work up to your eyeballs to pay for your home. You are supposed to have a mortgage and loads of debt. This is slavery. The borrower is a servant to the lender. Contrarily, alternative building methods like cob offer people freedom.

The future may look very uncertain and grim, but there is some hope for great positive changes to occur in the realm of natural building. To reap the benefits of these positive changes you will be required to take initiative and act. Cob will probably never become a standard building method in the cities, and will remain outside those realms. My recommendation for living a happier, healthy, and more sustainable life in the future is to strategically relocate out of cities and populated areas. Start a homestead or sustainable community in the rural countryside and begin to stop relying on a system that is so fragile that it could shatter at any moment. You will always need shelter to live. Build yourself a cob home.

Beginner Cob Projects

Lots of people envision building their own cob house or cottage one day. Some people hire an experienced cob builder, but most of the time they build it themselves.

Building with cob is so much easier than modern conventional building. If you can build a sand castle then you can build a cob house! Well, okay… It's not that easy, but you get the point I think.

Anyway, we all need to start learning somewhere. Here are a few cob projects to get you started. This is what I tell people to do when they don't know where to begin.

Stop feeling intimidated about building something you've never done before. Just find your motivation and the will to put thought into action, and I guarantee that you will surprise yourself at what you can create and achieve.

There is no specific order to do these projects in, and you don't have to do them all. They all rely upon the same basic concepts and skills. Just choose the one that sounds best for you.

Cob Oven

Building a cob oven is a great idea for a first project using cob. There are some more technical details that have to be paid attention to compared to the other projects that are listed below, but there is less cob that has to be mixed overall.

Building a cob oven will let you get your hands dirty by learning how to make cob, a rubble trench foundation, and a stem wall. These are the same three components of any cob wall that would be used for a cob house.

With a cob oven you will also learn how to make insulation mixes, oven mud, and natural plaster (either lime plaster or earthen plaster).

Before I made my first cob oven, I didn't even know how to make cob at all. I had only read books about how it was done. When I decided I was going to build a cob oven, I got a copy of Kiko Denzer's book Build Your Own Earth Oven. I simply followed the instructions in the book and built my own cob oven. I really recommend that you get this book if you want to build a cob oven. It will lead you through every single step in the building process and you'll learn a lot!

Click here to watch a video of a cob oven being constructed.

Cob Bench

A cob bench is a great starter project for new cob builders. Imagine building a couch out of cob. You can build as big or as small as you want it though, and you can mold it however you want it to look like.

Building a cob bench will teach you the basics of cob building. You will learn how to make cob, how to make a rubble trench foundation, how to build a stem wall, and how to finish with plaster.

If you can build a cob bench then you can easily build a cob wall for a house. The same concepts apply.

Cob Garden Wall

A garden wall is a good project to begin cobbing with too. You will learn how to dig and construct a rubble trench foundation, set a stem wall foundation, mix and apply cob, and

plaster. You can also add roofing shingles on the top of the wall if you want. This will help protect your wall even more from weathering.

A cob garden wall can be as long and as high as you want it to be. There are all kinds of places that you could build one. Spruce up your garden or your yard with one. Learn how to build your own – Click here to get my construction plans for a cob garden wall!

Cob Dog House or Play House

Another good project you may want to start with is a cob dog house or cob playhouse for children. This project is more advanced than the other ones I listed, but it's definitely doable if you're motivated to take the extra steps.

The concepts from the other projects apply here once again.

You will learn:
- How to make and apply cob
- How to make a rubble trench
- How to make a stem wall foundation
- How to finish with plaster

If you decide to do this project you will also learn how to insert windows, possibly doors, and how to build a roof.

Bibliography

Ianto Evans, Michael G. Smith, Linda Smiley. The Hand-Sculpted House: A Practical and Philosophical Guide to Building a Cob Cottage. White River Junction, VT: Chelsea Green Publishing Company, 2002.

Adam Weismann, Katy Bryce. Building with Cob: A Step-by-Step Guide. Green Books Ltd, 2006.

Rob Roy. The Complete Book of Underground Houses: How to Build a Low-Cost Home. New York, N.Y.: Sterling Publishing Company Inc., 1994.

Kaki Hunter, Donald Kiffmeyer. Earthbag Building. Gabriola Island, BC: New Society Publishers, 2004.

Matthew Stein. When Technology Fails: A Manual for Self-Reliance, Sustainability, and Surviving the Long Emergency. White River Junction, VT: Chelsea Green Publishing Company, 2008.

Happy cobbing!