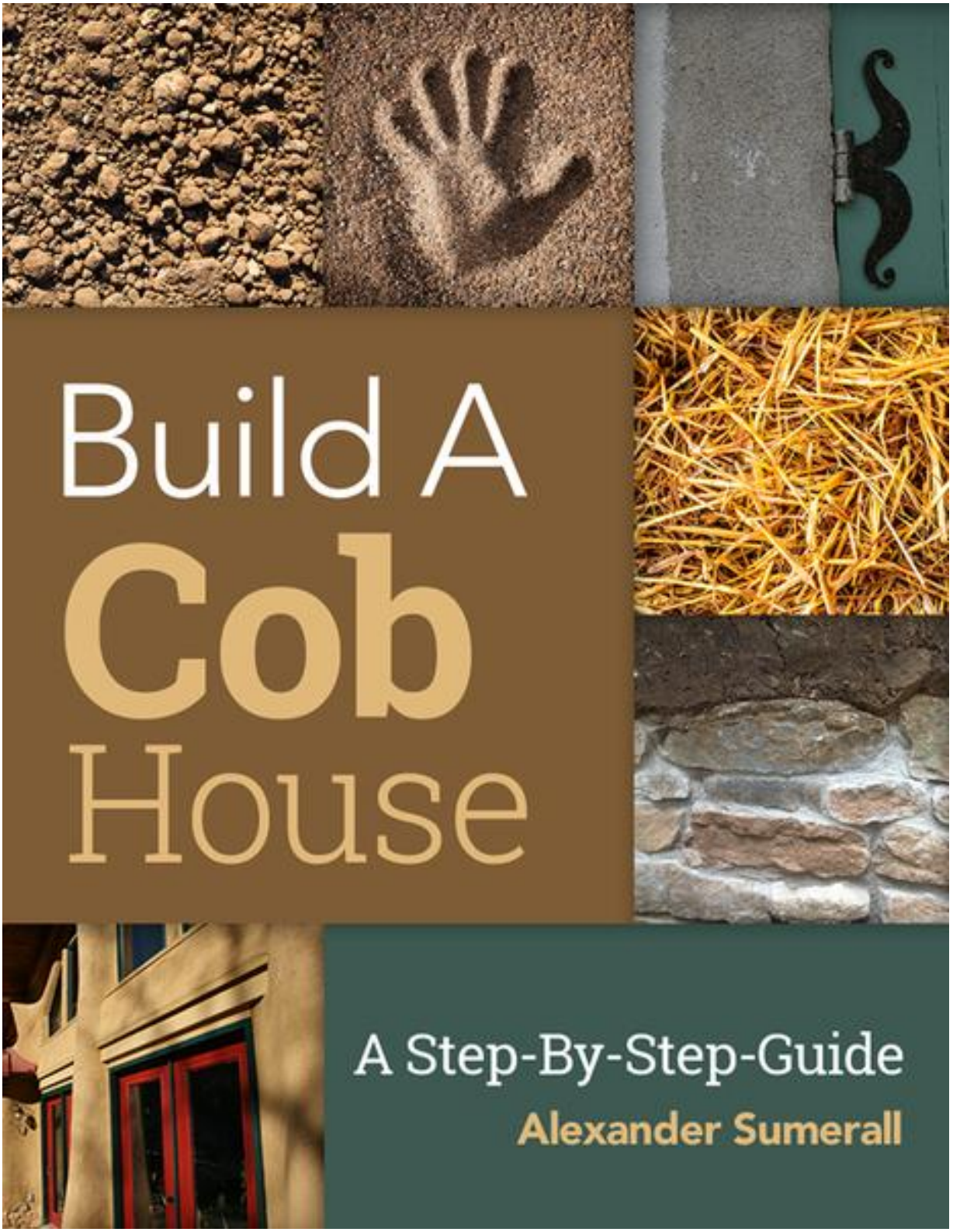

Build A
Cob
House
A Step-By-Step-Guide
Alexander Sumerall

Introduction to Cob and Earthen Building

What is Cob?

Cob is a building material made out of clay-rich soil, aggregate, fiber, and water that is pliable and can be constructed into walls for buildings. Many people are familiar with a similar building material called *adobe*, which has many similarities, but cob does not use bricks or blocks as the adobe method does. Cob is more of a free-form material, and building with cob has more of a sculpting aspect to it. Cob has been used and tested in various forms, and under different cultural names, for thousands of years all over the world, and it has proven to be a very practical and durable building material.

Until recently, cob has been virtually unknown to people in most modernized places. About forty years ago, there were no cob builders in North America. But since the 1970s there has been a revival in cob building as the interest has risen in sustainability and the use of local resources. People all over the world are now learning the cob building technique and reviving this ancient building material.

This revival in cob construction is coming at a very interesting time as well; as building materials and resources become more scarce, prices rise, and construction becomes more expensive. Cob and other earthen building materials are offering great alternatives to many industrially produced building materials. The raw materials for earth walls are far less expensive and readily available throughout most of the world.

The simple material of cob offers solutions to many of the problems that ail our modern buildings of today, and people are very excited and enthusiastic about building homes out of earth. Cob is making a new comeback, and it's even gaining popularity in regions where it has never had a past history of use before. Building with cob is not about returning to the past. It’s about moving forward to a more sustainable, healthier, and wiser future for building.

What is Earthen Building?

Earthen building, also known as *earth wall building*, is the umbrella name for all methods of constructing buildings using soil-based materials. The term *earth wall building* further makes the distinction that, generally speaking, only the walls are constructed out of earth. The many other components of the building are not.

An earthen building is any building in which the load bearing walls of the structure are built with earth-based materials. We will further explore the various methods of earthen building in this book.

Note: Earthen building can also apply to the tradecraft of creating and applying earth-based plasters and finishes to a structure.

The very earth that we walk upon every day is the same thing that people have been using to construct magnificent buildings with for thousands of years. Some estimated two thirds of all people on the planet today still live in earthen dwellings. There is absolutely nothing new about earthen building, but to the modernized world we have lost so much sight on how the world functions outside of our domains that we see earthen building as strange and primitive.

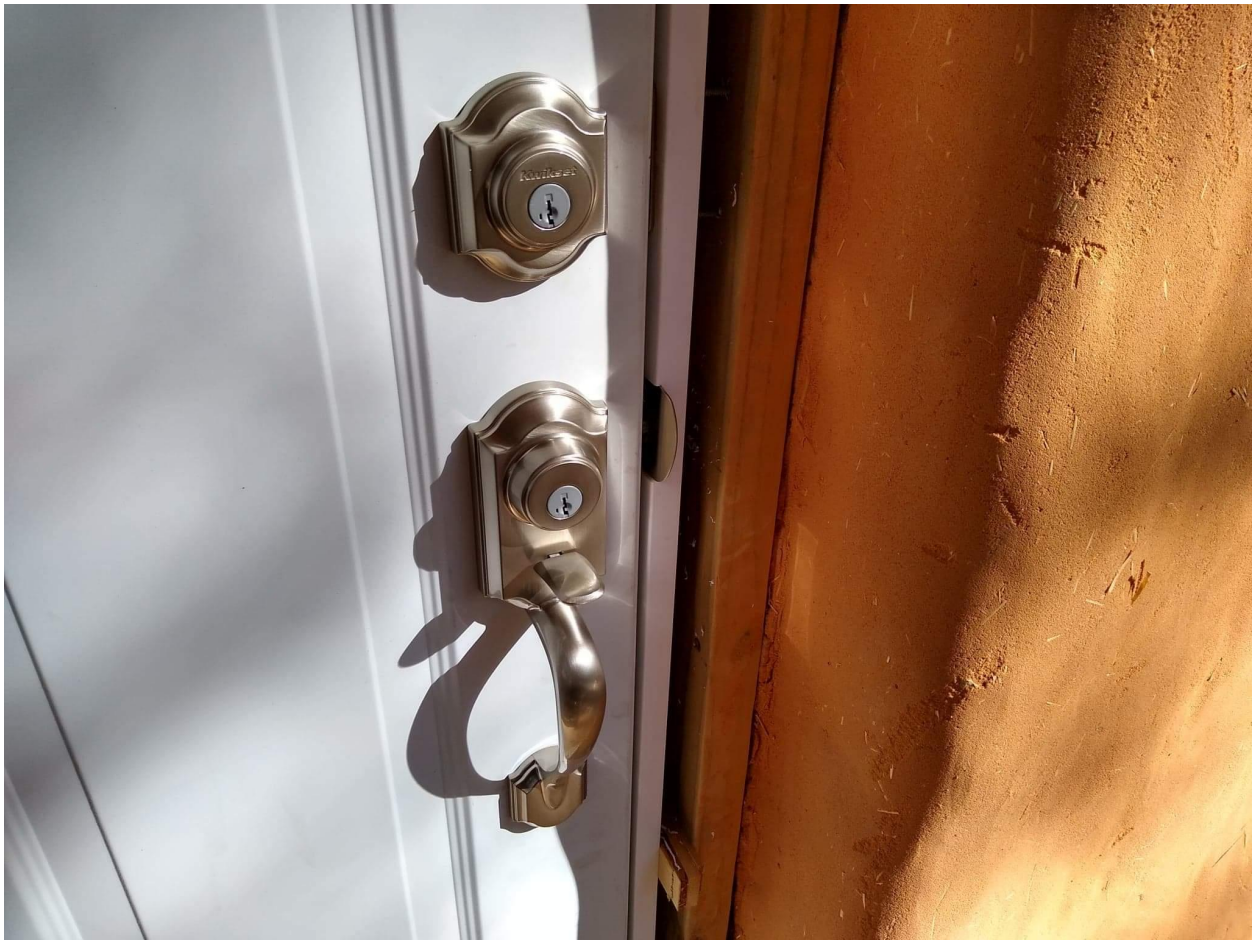
Most people in modern society have such misunderstandings and misconceptions about earthen building that they shun it and view it as dirty and faulty. They wonder why anyone would want to live in a mud hut. If only they knew the strength and beauty that this abundant material could be used to produce!

What is an Earth Mason?

An earth mason is a specialized type of mason who is involved in the tradecraft of building structural walls using earthen building materials and methods.

An earth mason is knowledgeable about one or more earthen buildings materials and methods, and can deal in the design and construction of buildings that have earth walls.

Some earth masons specialize in one type of earthen building method, such as cob, but most professional level earth masons are knowledgeable about several. A good earth mason should also have a solid grounding in the fundamentals of design, engineering, and other building skill sets. Earth masonry, or earthen building, is not a stand-alone skill. The expert earth mason knows how every component of a building works together holistically. This is especially important when dealing with earth wall buildings, which we will delve into more throughout this book.



Earthen Building Compared to Conventional Building

Now that we have defined what earthen building is, let's compare it to what conventional building is and see what the main differences are.

Although earthen buildings have many great benefits, there is actually very little difference in methodology when compared to conventional building. Proper planning, design, engineering, and execution of construction are carried out in much the same ways.

Differences are usually more nuanced. For example, earthen buildings are generally designed in a more holistic manner than conventional modern constructions. Successful earth wall buildings require a deeper understanding of how all the building components come together as one to create a sort of ecosystem within itself. I will explain more later how earth materials react and interact with other kinds of materials and environments. Knowing this can be very important for a successful, long lasting earth building.

Differences between earthen building and conventional building are not inherent and usually come down to the architect or engineer who is designing the building. Utilizing things such as

orientation, climate, and site conditions when considering design are some things that can be found more often with earthen buildings though.

Conventional buildings very rarely take these factors into consideration. You can find almost identical homes in the deserts of Arizona and the frigid tundra of Alaska, and they're both at a comfortable room temperature on the inside. Conventional homes like these are basically hooked up to life support systems to make them livable. On the other hand, earthen buildings tend to put more emphasis on using natural energy sources and designing according to climate and site in order to create comfortable living spaces.

Earthen Building Materials

All earthen building materials usually consist of a few simple ingredients. It's not the materials that change so much as the methods in which they are used to build with.

The main ingredients you will find used for earthen building materials are:

- Clay-rich subsoil
- Aggregate (either sand or gravel)
- Fiber (usually natural fibers with high tensile strength)
- Lime or cement (sometimes used as stabilizers to strengthen the material)
- Water

Earthen Building Methods

In this section, I will explain the main methods used for constructing walls with earthen materials.

These methods are:

- Cob
- Rammed Earth
- Adobe
- Wattle & Daub

- Superadobe (Earthbag)

Cob (Layered Mud)

The word cob is derived from Southwest England, and is known by other names around the world. In the Middle East, South and Central Asia it is referred to as layered mud. This term describes the material and building process quite well. Cob is basically globs of doughy, mud material that is stacked and compressed on top of itself in layers to create structures.

Cob is a combination of clay-rich soil, aggregate (sand), straw (fiber), and water. The ingredients are mixed together into a stiff, dough-like consistency that can then be easily stacked and molded.

Cob buildings are known for their thick walls and rounded sides and corners. The material gives the builder a lot of flexibility in design. It's a lot like sculpting and shaping a building out of clay as a sculptor would form a model.

Another architectural feature of cob walls is the gradual thinning as the walls rise from bottom to top. This reduces the weight at the top and reduces the risk of leaning or collapse from being too top-heavy. (Note: This typically applies to cob buildings of two or more stories high.)

History

Cob, or whichever name it goes by in a specific region of the world, is as ancient as building itself. The material has been used across most of the globe since the materials are readily and locally available in most places.

Cob, or layered mud, has been used throughout history to construct all types of structures: homes, shops, fortresses, government buildings, temples, walls and fortifications.

Cob buildings have been known to last for hundreds of years, though not for as long as their related mud brick and rammed earth structures. The greater compression of mud brick and rammed earth gives them better resistance to erosion than cob. However, the proper construction and maintenance of a cob building can make up for this disadvantage between these other methods.

Cob Building Technique

Cob buildings are constructed in layers. Each layer is built, set to dry, and then the next layer is built on top of that. There are typically no forms used to build walls with this method either. The cob is simply laid, compacted with hands or feet, and trimmed to the desired shape. (I will discuss *Slipform Cob*, also known as *Shuttered Cob*, later in this book. This method of casting cob walls inside of forms holds many significant advantages.)

Old and Recent Examples

There are still thousands of cob homes and farm buildings in Devon, United Kingdom that date back from the 14th century to the 19th century. Cob buildings can easily last for several hundreds of years if maintained. Maintenance requires keeping the roof, foundations, and plaster finishes in good condition to protect the cob structure from moisture.

There have been many new cob buildings constructed in the recent past with the resurgence of interest in earthen building. For one example, Kevin McCabe, a UK cob enthusiast, has been building several large cob homes in England. He’s even constructed a 10,000 square foot cob “citadel”!

Advantages and Disadvantages of Cob

Advantages:

- Low cost for materials
- Simple, easy to learn, requires little or no experience
- Produces beautiful buildings

- Strong and sturdy
- Long lasting
- High thermal mass

Disadvantages:

- Labor intensive
- Slow building process
- More subject to cracking than other earth building techniques
- Lacks the convenience of modular bricks or forms
- Poor insulation value

Rammed Earth

Rammed earth or “beaten earth” is a fairly simplistic building technique but it can produce some of the grandest earthen buildings. It has been used on five continents and continues to be used in Australia, China, France, Germany, Morocco, South America, and it is having a small revival in the United States.

Rammed earth is very easy to spot when you see it. The distinct layers in these types of walls are usually left with no plaster finish covering them because the layers are very aesthetically appealing. You will also find that rammed earth has very straight plumbed walls, ninety degree corners, or clean chamfered corners. Rammed earth also tends to be found in very modern, upscale buildings in its contemporary use.

History

People have been building with packed dirt for nearly 10,000 years. Rammed earth has one of the longest and most successful histories as a building technique. It has even produced some of the largest and most elaborate earthen buildings.

Rammed earth dates back to the time of the pharaohs of Egypt and had its roots in North Africa and the Middle East. It also dates back about 5000 years in Asia with parts of the Great Wall of China. The Romans also used rammed earth throughout much of Europe.

Rammed earth construction is still practiced around the world to this day and is appropriate for a variety of climates.

Rammed Earth Building Technique

The first step to building rammed earth walls is to erect wooden or steel forms. These forms are very similar to what are used for building concrete foundations, walls, and other structural components. Once the forms are set, moistened dirt is then put inside. The dirt may have sand added to it. These days, cement is also sometimes added to give it extra durability and to meet certain code requirements.

Once the material is put into the form it is tamped down and compacted with any of a variety of hand tools or power tools. After this, the next layer of material is added and tamped. This process repeats until the form is filled. After this, the forms are removed and the rammed earth wall remains.

Old and Recent Examples

There are several examples of ancient and new rammed earth buildings around the world.

One of the most recognized rammed earth structures is the Great Wall of China. Certain portions of the Great Wall were built with rammed earth. The western stretches of the Great Wall

extended into the arid climate of the Gobi desert. This region's resource scarcity likely presented rammed earth as a primary building method.

Recent examples of rammed earth construction can be found on many continents. There are many rammed earth buildings in France and Germany that were built in the nineteenth century.

There is even a 100-room, four-story resort hotel constructed out of rammed earth in Queensland, Australia.

Advantages and Disadvantages of Rammed Earth

Advantages:

- Low cost for materials
- Requires minimal water
- Produces flat, vertical walls and clean corners
- Suitable for building load-bearing, free-standing columns
- Very strong and durable
- Long lasting
- High thermal mass

Disadvantages:

- Labor intensive
- Poor insulation value
- Requires expensive machinery if you want to build at a fast rate
- Requires more engineering and labor into building formwork

Adobe (Mud Brick)

Adobe blocks are probably the oldest manufactured building material. This method of building is ancient, like rammed earth, and has been used almost everywhere in the world throughout history.

Adobe, also known as mud brick, is a building block composed of mud that is dried by the heat of the sun inside of small block forms. The mud used comes from subsoil that contains clay and sand. The amounts will vary in every geographical location so its best to test your soil. You can add sand into the mixture if need be. Chopped straw is also included sometimes to help prevent cracking.

The word adobe actually refers to the bricks, the mortar, and the earthen plaster that covers it. This understanding is derived from the Spanish word *adobar*, and may not carry the same meaning in other parts of the world where adobe is called by other names.

History

Adobe structures in Egypt, the Mediterranean, and the Near East date back to about 5000 B.C. Much of the knowledge of this technique disseminated from these regions.

Mud brick has been used from ancient times right into the present for all types of buildings. However, modernization has continued to push this building technique away in many countries with replacements such as concrete and fired brick.

Adobe Building Technique

Adobe bricks are stacked with a running bond to create walls. The bricks are cemented together with a mud mortar. The size of an adobe brick varies from one region of the world to another.

Adobe buildings begin at the corners, and then the first layer of bricks is placed on top of the foundation. Mud mortar is placed on top of the first brick layer, and the next layer is set on top of this in a running bond formation. Having running vertical joints is significantly weaker and should be avoided.

Old and Recent Examples

Adobe is suitable for a wide variety of climates (It does not have to be an arid region), and it works for a variety of architectural styles too. From one room dwellings to multi-story palaces, and just about any other type of building you can imagine, adobe is suited.

There are a number of old and new examples of adobe buildings throughout the world.

Some of the most magnificent mud brick buildings are the tower homes of Shibam, Yemen. These buildings, made of mud bricks, rise 5 to 11 stories in height. There are about five hundred of them in the city of Shibam. Most of them were built sometime around the 16th century and they are still lived in by the people there today.

For modern examples of adobe buildings, just look to the American Southwest. There are adobe homes throughout the United States, but adobe has been popular in the Southwest because of its Spanish architectural influences and traditions of use there.

Advantages and Disadvantages of Adobe

Advantages:

- Low cost for materials
- Modular brick form
- Strong and durable
- Can be appropriate for building domes and vaults
- Long lasting
- High thermal mass

Disadvantages:

- Requires extra steps: molding, drying, and transporting of bricks
- More time consuming than most other earth building methods
- Need to make bricks or buy them
- Poor insulation value
- Not monolithic like cob and rammed earth

Wattle-and-Daub

Wattle-and-daub is a simple earth building technique that has been around for many millennia. Today, wattle-and-daub is found in use mostly in South Asia, and Africa. It had its time in Europe as well, but it is not used there anymore except sometimes for the infill of traditional timber frame buildings.

Wattle-and-daub walls tend to be much thinner than those of other earthen building methods. A wall basically consists of a thin lattice with mud packed onto both sides of it. This thinner wall means that it has less thermal mass.

History

Wattle-and-daub has had its place as a building technique all around the world: Europe, Africa, the Middle East, Asia, and the Americas. Ancient Mesopotamia, Rome, and many other ancient peoples used this technique for quick building. Because of its faster construction, many nomadic people also used wattle-and-daub to erect temporary dwellings.

Wattle-and-Daub Building Technique

This earthen building technique involves pressing mud into a woven lattice of sticks, bamboo, boards, or reeds. The mud can sometimes contain extra sand or fiber depending on the needs of the local soil.

The mud is mixed to a dough-like consistency and applied onto the lattice. A wattle-and-daub building can be done with just a few workers. It requires somebody to mix the mud and somebody to apply it to the walls. The process can be sped up faster with the help of a mixing machine.

Old and Recent Examples

Wattle-and-daub is not used frequently in the developed nations today. It has certain applications, but it is not often used to build whole homes with. It is more often used for interior walls or as infill between timbers. The Japanese take wattle & daub to its highest level of perfection though, and it is often used in Japan today to fill between their timber framed post and beam structures.

There are plenty of examples from the past. Wattle-and-daub has mostly been used for small buildings and privacy walls.

Advantages and Disadvantages of Wattle-and-Daub

Advantages:

- Low cost for materials
- Quicker to construct with
- Good for small structures
- Structural flexibility adds to earthquake resistance
- Lightweight

Disadvantages:

- Poor insulation value
- Low thermal mass
- Not monolithic like cob and rammed earth
- Better suited for tropical climates (warm to hot)
- Rotting can occur in the lattice if open to water exposure
- Not load-bearing for heavy roofs (needs post and beam structuring)
- Difficult to make additions or second stories

Superadobe (Earthbag)

Superadobe, also known as earthbag building, is a patented building method developed by Iranian architect Nader Khalili. It uses sand bags (polypropylene bags) filled with a soil mixture and compacted. Superadobe buildings employ arches, domes, and vaults regularly.

History

The superadobe system was developed by Nader Khalili in 1984, but similar methods have been used before that time. It was common for buildings to be constructed out of sand bags on the fields of war, starting before World War One.

Today, the superadobe system has developed into a sophisticated and modern building system fit for all types of basic needs. Interest in the system has continued to grow over the past few decades.

Superadobe Building Technique

Superadobe is built by filling polypropylene tubing or bags with a mixture of soil, sand, and sometimes cement. The bags are tamped to compression. A loop of barbed wire is placed between each layer of filled bags for tensile strength.

Old and Recent Examples

The superadobe (earthbag) method of building is a fairly recent invention, and does not have a long history. Some of the best examples of old would be the sandbag bunkers of World War One.

Today, you can find some examples of superadobe buildings all around the world.

Advantages and Disadvantages of Superadobe

Advantages:

- Low cost for materials
- High thermal mass
- Great for domes, arches, and vaults
- Strong and durable

Disadvantages:

- Poor insulation value
- Not monolithic
- Labor intensive

Now that you've had a glimpse at all of these earthen building techniques, you can begin to think about what methods you may want to use. Start by weighing the advantages and disadvantages of each method against the wants and needs for your building.

Different building techniques can be employed for different needs. For example, you could decide to build the exterior walls with cob and complete the interior (non load-bearing) walls with wattle-and-daub. There are many combinations that could be done. Use the systems to their specific advantages.

Advantages of Earthen Building

There are several important advantages to earthen building. These advantages apply across the board for: cob, adobe, rammed earth, as well as earth bag construction.

Low Raw Materials Cost

The raw materials required for earthen building are abundant around the world at little to no cost (Soil, Sand, Straw, Water). Earthen building materials also don’t require any high energy processing or manufacturing activities to be created like lumber, cement, and fired bricks do. The earth-based materials normally are created on-site, saving you money in production costs.

Please note: This is only for the cost of the materials used for the walls. This does not apply to all the other building components involved in a structure.

Costs for constructing earthen buildings can easily be the same price or higher than conventional construction. There are many reasons for this. One being the high amount of labor that goes into constructing earthen buildings. This is why it's very beneficial to be a do-it-yourself builder. You can cut the cost of constructing an earthen building in half by building

it yourself. By building yourself to save on labor costs and replacing commonly used lumber with earth, you will usually come out at a lower cost per square foot than conventional construction prices.

Indoor Temperature Regulation

Soil from the earth has proven to be a very suitable and successful building material throughout the world's many climates because of its ability to regulate indoor temperatures. Earth is a poor conductor of heat, has low thermal conductivity, and has high thermal mass.

This is one reason that animals burrow under the ground to build their homes. Even in harsh conditions, the thick layerings of earth above them regulate the temperature very well.

If you ever experience an earthen building, you will feel a dramatic difference between the inside of an earthen dwelling and a wooden one. For example, on hot days the wood building will feel miserable to be inside if there is no air conditioning running. An earthen building will feel cool and comfortable inside on the same days with no air conditioning. This is a result of the thermal mass of thick earthen walls.

Durability

When dry, earthen buildings are extremely strong and durable resembling that of stone. Fortifications used to be made with these materials because they were so strong. Monolithic earthen buildings are also more resistant to earthquakes.

The strength comes from the density of the soil under compression. This density also makes earthen walls very insulating against noise. Earthen walls have very good sound-absorbing properties that keep it quiet inside, both from exterior noises and noise generated in the same building.

We also can't forget to mention that earthen walls are termite proof and fireproof!.

Earthen buildings have lasted intact for thousands of years, and there are cob homes in the United Kingdom that are hundreds of years old. Conventional stick-framed structures generally survive only a few generations.

Healthy

Unlike conventional wall systems which are usually constructed with synthetic or industrially produced materials, earthen buildings are built primarily out of natural, non-toxic materials.

Modern conventional homes and buildings are full of indoor air pollutants and off-gassing of chemicals that come from the building materials used. Because these types of structures are normally built as sealed envelopes with plastic lining in the walls, they also trap these gases and toxins inside the indoor environment. Earthen buildings generally do not have this problem. In fact, earth walls actually "breathe" through their tiny pores and keep air fresh and clear. This

ability for walls to “breathe” and pass moisture and vapors through them is known as ***vapor permeability***. If you suffer from indoor allergies, living in an earth wall house could significantly improve your quality of life by eliminating and/or filtering out the toxins or triggers that may be causing them.

Why Cob is a Great Choice

As you can gather from the previous sections, cob is a great choice for home builders. Among the spectrum of earthen building methods, cob is relatively easy to learn and is great for do-it-yourself builders. It also has the potential to become a commercially viable skill set for building contractors.

- Cob material can easily be created on-site for a building project.
- Cob is a great choice for most climates. Only being limited out of very cold climates if the cob walls are not insulated.
- Cob has all the inherent advantages of earthen walls.

- There is an existing building code for cob. Please refer to the 2021 IRC Appendix U at www.cobcode.org

Selecting a Building Site

Analyzing site selection is a critical first step in building any type of home. It should arguably be done before any building design, layout, or construction takes place because it can have a large influence on the home design itself.

One great advantage that you have as an owner-builder is that you can take the time to acquaint yourself with your site and the character of the site's landscape and environment. Knowing how these features can interact with your building is important.

Selecting a site can get intricate with all of the variables to consider, but it's really not as difficult as it might seem. However, it's not just as simple as picking out a location that you think is the most pretty or picturesque. You will soon discover that no two sites are ever exactly the same, and each one will require an individual analysis.

Here are some of the major things to consider when selecting a site for your home.

Slope

The slope of the land will be a major factor in selecting your building site. The steepness of the slope across the site will affect how you build your foundation and what earthworks you might need to perform. Also be aware of slope in regards to water drainage over your property. You don't want to build between slopes that will collect and pool water around your building. Make sure that water will easily drain away.

It's harder to build on a steep slope for various reasons. A steep slope can require a more robust foundation be built to compensate for the grade of the slope. Slopes can also hinder road access. If you can not get trucks of materials in and out of your building site then you will have problems.

Utility lines (water and electric) can also be more challenging and expensive to run up steep slopes to a building site. Steep slopes can also block sunlight which can make your home colder and darker.

Sunlight

Whether you want sunlight on your site will depend a lot on your climate. Hot, desert climates are places where you are probably going to design to limit sunlight exposure on certain areas on and around your home. However, for temperate and cold climates you are going to be interested in strategically aligning your home to capture sunlight for warmth in the colder months.

There are a lot of things that you can change about a building, but the alignment it has to the sun is not possible to change later. Be familiar with the sun paths in the sky at your site location and come up with a solar design strategy. It's best to spend as much time as possible at your site to observe the sun patterns.

Placing your building according to your solar design strategy is one of the most important siting tasks.

For a solar design strategy, you want to know things like if there are trees or buildings that could obstruct the sunlight from getting through and causing shading on your building. In cold climates, it's not good to have sunlight obstructions to the south since you get the most daily sunlight coming from this direction.

Determining sunlight exposure is easy if you're building in flat open land. Just use a compass to orient to your building's passive solar design, but it can be more tricky when you're in the hills.

If you're in a cold climate especially look out for things that will obstruct the sunlight in the late fall, winter, and early spring when the sun path is lowest and this solar heat is most needed.

The sun's path on the winter solstice (December 21st) is the lowest that it will be for the year. Observing the sun path on this day will help you to determine if you'll get full sun all year or if you'll have obstructions. This winter solstice sun path marks the bottom of your "solar window". The top of your solar window can be observed on June 21st which is the summer solstice.

If you're in a hot climate, you can use the same principles to shade your home using trees and landscaping features. For example, you can plant deciduous trees along the southern side of your house to block the hot Summer sunlight exposure. Then when the leaves fall off, you will gain the warmth of the sunlight in the Fall and Winter seasons when you want it.

Water

Water can also play a big role in selecting an appropriate building site. Water can be a great blessing to have, but it can be a detriment to your building if you're not careful in selecting the right location.

Observe the contours of the land on and around your site. Don’t build where water will naturally flow unless you plan to make physical changes to the landscape to redirect water away from your building.

If you have high grounds or hills around your building site, also look for drainage channels or signs of erosion and water overflow. These can indicate large amounts of water drainage onto your site during heavy rainfalls.

Also, be sure not to build in a floodplain. Land that lies near to a river, stream, or other drainage route can be designated as floodplains. It's also wise to ask neighbors if there have been any floods in the area in the past 100 years and where they may have reached to in elevation.

When determining whether you want to purchase a property or build a house on a building site be sure that you can get water to that location as a resource. You will need water for use during construction and for living purposes.

If there is municipal water available at the road, make sure that you can run the water lines to your building site. If there is no city water available, speak with drilling experts to see if you can successfully dig a well at or near your building site. Water can also be accessed from bodies of water on your property or from rainwater harvesting. The most important thing is to make sure that you have a reliable source of water and that you won’t run out.

Soil

You want your building to stay in place and set on a foundation that doesn’t move. This requires that you have a stable soil structure beneath your foundation. The soil should be solid and dry with load-bearing capacity.

Determining the type of soil that you have can be determined by digging a hole where you want to build. Dense clay is a good subsoil and foundation for just about any modestly sized home that you could think of.

Loose and airy subsoil is not as adequate, but look at other buildings in the same area that are built on similar soil types and see how they are holding up. You can also see how large and heavy these buildings are and how they’re doing seated on top of this type of soil.

If you’re building a small structure then it's more than likely that the subsoil will be adequate to support your lightweight building.

However, if you are ever unsure if the soil where you want to build is safe to construct a building on, consult a geotechnical engineer and get expert advice on the situation.

Wet soil should raise a red flag. If you dig down and find water then you should find a different location that isn’t wet and saturated.

Only build on undisturbed soil. This means soil that has never been excavated, cultivated for crops, or been leveled with fill dirt. You could dig past the deepest point of cultivation or past the fill line to set your foundation but this requires more work and can make your foundation more expensive.

The main take-away is to only build where you have solid, undisturbed ground and don't settle for less. Your foundation is too important to cut corners on. And remember, if you're not sure about your soil being appropriate to build on then consult an engineer in your area for expert advice.

Access

You want to make sure that you will have road access to your building site. Also make sure that the roads are wide enough and supportive enough for heavy trucks to deliver materials. It's also a smart idea to make sure that fire trucks and emergency vehicles can get in, turn around, and exit your property roads.

Keep in mind that building up on high hills or peaks can have the most beautiful views, but remember that these are usually the most difficult places to get access to and building roads up steep hills can be very expensive work.

Access can also refer to the accessibility of municipal utility lines. City water and electricity are most easily accessed at the side of a county road. The further away from these roads you build, the more expensive and challenging it will be to get water and electricity to your buildings.

Restrictions

In general, the further out from city centers that you go the fewer restrictions there will be. Most cob homes are built in rural counties because it has been easier to get acceptance for this style of building in these areas with fewer restrictions.

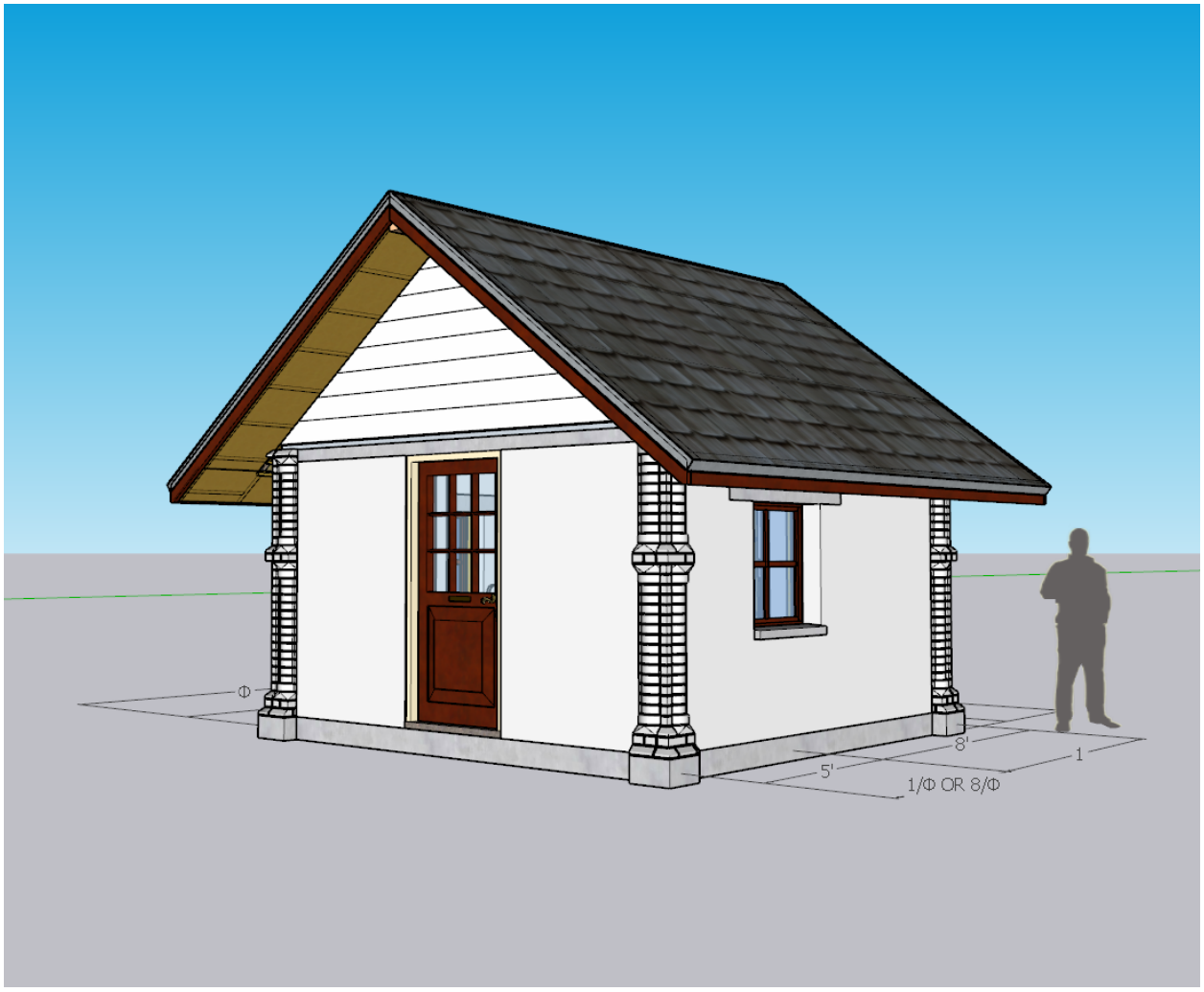
Now that there is an official building code for cob construction in the United States we have more opportunities for where we can build cob homes and get building permissions. However, if you are interested in dealing the least amount as possible with building departments, regulations, and inspections I can offer this general advice. Build in a rural county, in an unincorporated township, on a piece of property with no restrictions. This is probably your best chance of being left alone to build whatever you please without requiring permissions. However, this is not guaranteed and is only general advice.

If you decide to follow all building codes then you can, in theory, build anywhere you desire. Whether that is rural, suburban, or urban.

I still mostly recommend people build cob homes in rural counties. This happens to be where most people want to build cob homes anyway. It does make things easier in a lot of ways too.

When searching for a country property to build a cob home on, look at the restrictions on the land. A few things to look for are zoning type, HOAs, and minimum home square footage. Avoid land that is parceled into a subdivision. These properties will usually have many restrictions and homeowners associations involved. Not only will you have to pay HOA fees, but they will have regulations that push you to build to a conformed building style like everyone else in that area.

Avoid commercially zoned land. Residential and agricultural zoned land will give you the best options. Agricultural land is best if you want to set up a homestead or small farm with your home.



Designing Your Cob House

Designing a home is an art and a science in itself. It encompasses a wide variety of subjects and takes into account many different variables. Designing a home is a skill that anyone can learn and understand. However, depending on the complexity of the building design, outside experts may need to be involved such as architects and engineers.

It's very important to develop a vision for your home and to have a solid design before beginning any construction. Starting construction on a home without having everything planned out in a detailed design in advance will lead to a myriad of problems.

Possibilities and Limitations

There are many misconceptions and fanciful ideas floating around about cob homes. One of them is that a cob home must look a certain way and must adhere to a certain ideology of

construction. People like to define cob homes in many different ways. Here, I will define a cob building in the most practical and logical way. **A cob building is any building that has walls made of cob material.**

I will explain this definition a bit further now. For example, a cob building is not defined by the style of its foundation or the style of its roof. We tend to define buildings by the type of wall systems they have. A cob building does not need to have a stone foundation and a circular living roof for it to be called a cob house. A cob house can have literally any style of foundation, roof, and other components and be defined as a cob house. As long as the majority of its walls are made with cob then it's a cob house.

Something that I always tell my students is that a cob building is just the same as any other type of building except that instead of wood framed walls (for example) we are replacing them with cob walls. Almost every other component of that building stays the same whether we are building a cob house or a conventional stick-framed house. The main difference is how all of the components integrate with a cob wall system. In this book, I will teach you how everything connects and integrates with cob walls. I also hope to dispel any misconceptions about what a cob house really is and give you a realistic and practical perspective that will actually help you build a modern, long-lasting cob home.

Now that we have put some things into perspective, I will summarize the possibilities and limitations for cob buildings. If anything, there can be some height limitations for cob structures. Most do not go above two or three stories tall. Overall, the possibilities are endless for the design and style of cob buildings.

Building Components

In this section, we will describe the main building components as they pertain to cob buildings.

Foundation

The foundation is one of the most critical components to a building. This is the solid base upon which a building sits. The entire building depends on the strength and support of the foundation to stand. A building foundation can be constructed in many different ways with many different materials. Foundations are generally made with either stone or concrete. The latter being used in most cases today.

Windows and Doors

Windows and doorways are obvious components to almost any building. They serve the general purposes of letting light into the building, fresh airflow, and providing passageways into and out from the structure.

Walls

The walls make up a major part of any building. Walls can be made from a wide variety of materials. In this book, we are concerned with earthen wall systems. Within this component there can also be additional components, such as metal reinforcing. Codes have wall reinforcement requirements depending on seismic zones and wind zones.

Bond Beam

The bond beam is a concrete horizontal structural component that stretches along the top perimeter of the wall system. A bond beam braces the walls together and can help prevent shifting in seismic activity. The bond beam also serves as a good attachment point for roofing materials.

Roofing

The roof is a critical component that covers the top of a building and protects the structure and its inhabitants from the environment. A good roof is very important for earthen building systems because they direct rainfall away from the walls. A roof can be made with several conventional materials, such as wood or metal. Roof finishes can also be done in several different materials, such as: shingles, tiles, or metal sheeting.

Electrical & Plumbing

To access water and electricity within the building requires a series of electrical and plumbing systems. These components carry water and electricity from the source and distribute them through the building to any desired points of use.

Indoor Temperature Regulation

Soil has proven to be a very suitable and successful building material throughout the world’s many climates. Consider that nearly half the world’s population lives in earthen dwellings. Whether the climate is harsh and arid or temperate with seasonal changes, earthen buildings are winners because of their thermal mass and heat-cool retention.

Have you ever been in your garden on a hot day and started digging down into the soil and felt the coolness beneath the ground? The temperature beneath the ground is drastically cooler on a hot summer day than above ground where you’re standing. Also, when it's cold outside you will discover warmth beneath the ground. This is why many animals live underground. They can survive the heat and winter freezes by burrowing and living underground.

An earthen home can provide very similar benefits to humans as underground burrows can do for animals. Let's discuss how an earthen building can regulate the indoor temperature and keep us comfortable inside during the seasons.

Insulation

One of the few downsides to all earthen building materials is that they are poor insulators.

The two main ingredients in cob, soil and sand, have little conductive heat loss resistance (low R-value). The other highly insulative ingredient, straw, is included in such small amounts that it doesn't increase the R-value of the cob in its regular amounts. Straw-heavy mixes can be created for high insulation value, but they do not have the load bearing capacity with the amount of fiber needed to get an adequate R-value.

According to the Cob Code Appendix U on Cob Construction, the unit R-value for cob walls is R-0.22 per inch of cob thickness. This comes out to about R-2.64 per foot thick of cob wall. Meaning, your cob walls would have to be several feet thick to compare to a strawbale wall which can be R-35 for the thickness of one bale.

What earthen materials lack in insulation properties they make up for with thermal mass.

Thermal Mass

Earthen building materials are very poor conductors of heat and have very low thermal conductivity. This means that heat from outside the building has a much harder and longer time to transfer through your walls and inside your home. Earthen materials will absorb heat, retain it, and then dissipate it back out slowly. Most modern, conventional building materials have the opposite attributes. However, materials such as concrete and fired brick have some thermal properties like earth, but they absorb and release heat quicker than earth materials do.

Cob homes have an amazing ability to regulate the indoor air temperature. Compare the indoor temperature fluctuations between a cob home and a concrete or cinder block home and you may be astonished at the results. Cob is a suitable building material for hot or cold climates due to its ability to keep indoor temperatures stable. Depending on your climate and comfort levels, this can eliminate the need for centralized heating systems and air conditioning. That's some great energy saving potential right there!

"A mud house with walls 2 ft (0.6 m) thick, a well-insulated roof, and minimum-heat-gain doors and windows would have an indoor temperature range varying no more than about 6° – 8° F (3.3° – 4.4° C) year-round in most of the USA without central heating and air conditioning!"
- Glorious Mud, Gus W. Van Beek

Cob's high thermal mass makes it possible for your walls to actually absorb sunlight heat, retain it throughout the day, and then release that heat to the inside of the home as outdoor temperatures lower. Thermal mass plays a big part in setting up a passive solar design.

Thermal mass which is a heat battery in the winter months acts as a cold storage in the Summer months. Thick mass walls like cob help to buffer the inside temperature. Hot air from the outside will slowly move through the walls during the day, but it will reverse its direction back to the outside as night comes on. The cool outdoor temperature of the night will force the hot air to vent out.

Many people wonder if they can build a cob home where the winters are cold and frigid. I would not truthfully say that cob is your best option for a cold climate if you're worried about your home getting too cold, but I would also not tell you to rule cob out as a viable option either. If you're building with cob in a cold climate, the building's indoor temperature performance will depend on proper solar siting and passive solar design. We will also discuss further on in the book how to insulate cob walls so you can build even in very cold climates.

So in conclusion, earthen building materials have some amazing temperature regulating properties. They have poor insulation value but in many cases they make up for it with thermal mass.

Passive Solar Design

Passive solar design is a concept that is beneficial to understand for building an earthen home. It's about designing a building so that it can effectively use the sunlight energy to create warmth inside the structure in the colder seasons and also not overheat in the hotter seasons. To benefit from the sun's radiation for heating, we have to site and orient our homes so that sunlight enters.

Now that we understand the basics of thermal mass we can understand that thermal mass is what allows the walls to absorb the sun's radiant heat throughout the day and then transmit it back out into the interior space to regulate the indoor temperature. 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.

Passive solar design basics are easy to learn, and these basic principles and concepts can bring you large benefits. By the end of this lesson, you should have a good understanding of passive solar and how to apply it to your building design.

There's only one working part in this mechanism for passive solar energy. That is the Sun's rotation. Passive solar design is something to work into your overall design with thoughtful consideration, but once your building is up you just leave the rest of the work to the Sun.

Facing South

Just by simply orienting the long side of a home to the south (in the Northern Hemisphere), without thought to any other solar design points, can cut your energy bills for heating by 30 percent in some cases. You can further increase your energy savings with proper window placements and thermal mass walls. This is why passive solar design is important to apply with an earth wall building.

Going back to site selection for a moment here, you want to choose a south-facing site for your building. A south, southeast, east, or southwest downward slope will also open up more “solar window” for sunlight exposure to your structure.

The point is to make sure that your site has an unobstructed sky view mainly to the south. Choose a site with unobstructed sunlight exposure from about 10 A.M. to 3 P.M. for as many days of the year as possible. More sunlight will increase your passive solar potential. It's most important that there are not obstructions that will block the sun in the cold months of the year when you need the heat.

For the most optimal solar gain, orient the long axis of your home as perpendicular as possible to the South. The southern direction should be where the longest wall of your building is placed and aligned to.

From this direction, extend your arms straight out, at right angles to each other. Your hands will point southeast and southwest. Within your arms, you want about 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.

This might all sound complicated, and if it does just stick to the basic premise that your south facing wall should point relatively southward (it does not need to be exactly to True South) and that you want to have an open view for the sunlight to shine on your south facing wall as much as possible in the winter months.

Window Placement

The orientation of the building and the placement of windows are important design elements that should be taken into consideration when using passive solar. The intelligent placement of windows is important so that you can get the right amount of 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. If you’re in the Southern Hemisphere, you would put the windows on the north side instead.

With passive solar design you want to situate your main living spaces of the building between solar south and southwest, with larger and predominant windows placed between the southeast and southwest walls.

Also keep in mind that the sun rises and sets in different locations as the sun moves throughout the year. During the winter, the sun rises in the southeast and sets in the southwest. In the summer, the sun will rise more to the northeast and set to the northwest.

Here are a few points for placing windows:

- Don't place your windows too high. This prevents overheating in the summer, when the sun is high in the sky, and it ensures that low winter sunlight enters the building.
- Don't place many windows in the north wall as this will provide a point for heat to escape from inside your building. You don't get the same passive solar benefits on the north wall since the sun is not shining from that direction.
- Some windows can be placed in the east wall to allow morning sunlight in.
- Only add small windows in the west wall and don't add too many. Big windows in the west facing walls can create overheating in the summer time as the sun goes down.
- Be more stingy with adding 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 the inside warm. Glass is also constantly adding heat to your building when it's very hot outside.
- At the winter solstice, when the sun is at its lowest point in the year, sunlight can penetrate more than twenty feet inside of a building. Keep this in mind when designing. You may opt for a more open floor plan because of this.
- Skylights are nice, but not very intelligent for passive solar design. They let in a lot of sunlight during the summers and also let precious heat escape during the winters.

More things to consider with passive solar design:

- Build roof overhangs to prevent excess sunlight penetration during the hotter months of the year. Since the sun is higher in the sky, the overhangs will block most of the sun rays from entering inside.
- It makes sense to design the inside of your house according to the sun's orientation throughout the day. You can place your bedroom and/or breakfast area on the east/southeast side to capture the morning sunlight. You can place your workspace or living space to the south to capture the most daylight sun exposure, and then, for example, you can put a small nook on the west side to relax in during the evenings. Be aware that sunlight creates a bad glare on computer screens though. It might be good to have a sun-free room for things like this.

Ventilation and Ceiling Insulation

You need to have adequate ventilation and insulation to keep your building cool during the hotter times of the year. The cooling effect should be kept in mind when designing insulation and ventilation systems. They should both work together to reinforce the other.
The basic rule of thumb is to keep air flow circulating through your building. Ventilate roofs and attics so that air doesn't become trapped in them. You can install soffit vents or cupulas to let hot air flow up and out of your building. Allowing hot, humid air to flow freely out the peaks of your building will prevent overheating on the inside, and will also prevent most mold and mildew issues.

As a general rule, don't use a black rooftop. It absorbs a lot of heat and can make the surface of your roof reach over 150 degrees Fahrenheit on a bright summer day in most of the United States. In contrast, a white or other light colored roof can reflect up to 70 percent of the sun's heat onto your roof. You can also insulate your ceilings for summer cooling. This prevents heat from coming in through the roof.

Decrease Summer Solar Gain

By understanding the principles of passive solar design, we know that the sun is high in the sky in the Summer so roof overhangs should be long enough to keep the sun from penetrating into the building.

Limit the number of windows on the east and west sides of your structure. They let in a lot of sunlight that can overheat your building. Be mindful of putting large windows or sliding glass doors on these sides. You can install shutters or curtains on these windows if you need to though.

Another option is to build patios on the east and west sides and cover them with arbors. The vegetation on the arbors will then shade these sides of your building from the sun.

Hybrid Buildings

Cob is a very versatile and adaptive building material. It has a long list of advantages for home building. Cob does not have to be a standalone building material though. It integrates very well with other materials and systems. If you want to use cob to its greater advantages and replace cob where it falls short, you can build a hybrid building system.

A Disadvantage of Cob

Probably the most noted disadvantage of cob and earthen building materials is their lack of insulation value. The insulation value for earthen building materials is around R3 per 12 inches of wall thickness. This is very low and insignificant. Compare the R-value of cob to that of a strawbale wall, which comes in somewhere at around R35 for the thickness of one bale. That’s a huge difference!

Insulation value is not always the be-all-end-all to a comfortable living space though. It depends on your location and climate. If you experience cold winters then you can consider a hybrid building design.

High Insulation Alternatives

There are a lot of highly insulative building materials that you can choose from if you decide to build a hybrid cob home. In this lesson, we’ll look at a few non-toxic building materials that you can use for insulating walls.

Strawbale

Strawbale has been a commonly used natural building material to complement a cob structure. Strawbale walls are thick and highly insulating. You get the highest R value for natural materials with strawbale, and the thermal retention properties of cob all in one building.

Straw-Clay
Straw-clay, also referred to as light-straw-clay, is a mixture of straw and mud slip that is packed into forms to create infill for walls. A 12 inch thick straw-clay wall has an R-value of about 26.

Hempcrete
Hempcrete is a combination of hemp cores and lime binder that is both lightweight and insulating. It has a cement-like consistency but hempcrete weighs about a seventh of the weight of concrete.

Hempcrete is not a structural building material, as with straw-clay, and is used as infill between framing. It is either compacted into forms or built in brick form. A 12 inch thick hempcrete wall has an R-value of about 25.

Hybrid Building Design

A hybrid building design is actually quite simple after you understand passive solar design principles. The purpose of creating a hybrid design is to keep the inside of the building warmer during the cold seasons.

We know that we get the most sunlight exposure from the south and the east. For this reason, it's best to keep both the south and the east walls as cob. This way, they are able to absorb maximum sunlight into their thermal mass to heat the inside of the building.

The north side is the coldest side and does not receive any direct sunlight exposure. This is the primary wall that you would want to change the building material on. Put a high insulation material on the northern side of the building. This will prevent colder air from coming in and your indoor heat from escaping.

It's also common in hybrid design to replace the west wall with a high insulating material as well. This side of the building received little sunlight in the Winter months and can be a cold spot. The most important side to keep as cob is the southern side though. This is where you can take full advantage of cob’s thermal mass properties. You might lose some heat because of cob’s poor insulation value, but you gain back more heat through the thermal mass advantages if you’ve designed according to passive solar design.

Cob Ingredients

Cob can’t be purchased in bags at the hardware store so you have to process the materials and make it yourself. The first step in making cob will be to find the proper ingredients.

You will need four basic ingredients to make cob:

1. Soil
2. Aggregate
3. Fiber
4. Water

All of these materials are widely available throughout the United States, Canada, the UK, Australia, New Zealand, Europe, and most of the world. There is a good reason that people have built with earthen materials all over the world since the dawn of civilization.

Soil

Cob is made from the soil right beneath your feet. Excavate the subsoil that lies beneath the thin layer of topsoil. This is one of the main ingredients for cob. The topsoil is the thin layer of dark dirt that contains mostly organic matter. The subsoil beneath has very little organic material and is where you’ll find the clay-rich soil suitable for cob. You will usually notice a very distinct change of color between the topsoil and the subsoil.

Many people have the misconception that you need to have clay to make cob. This is true, but you only need a soil that is roughly composed of 15-25% clay content. This is considered clay-rich soil. The rest of the soil is made up of sand, silt, and other aggregates. Using a pure clay would require you to add back in the 75-85% aggregate. It would not be practical and would require buying more sand to adjust it to the correct ratio. A heavy amount of clay in the soil is actually less desirable because it shrinks and cracks when it dries out and is unsatisfactory for earthen construction.

Soil for cob is generally easy to find in abundance and can generally be found all around the world. One good way to acquire the soil you need is to use what’s excavated from your foundation trenches. You can also look at construction sites where this excavated soil is considered a waste product and is hauled off to be dumped in landfills. This costs them a lot of money and they might just be happy enough to deliver it to you for free! You can also purchase truckloads of soil from soil depots or landscaping supply shops.

The clay is a binder and its purpose is to hold the sand (aggregate) together. The clay is composed of microscopic platelets that act as suctions between the aggregate particles when they’re made wet. Something important to understand is that clay expands when it's made wet

and it contracts when it's dried out. This is why you can’t build a house out of pure clay. It needs the aggregate and straw fibers to give it stability and to prevent cracking.

This is also why, in reality, a cob house is more like a giant sand castle that is bound together in a unified mass by the clay particles.

Note: Some grassland areas of the Midwestern United States and sandy areas of the Florida peninsula have a lack of clay in their soils. These soils can be too loose and crumbly for optimal cob. This does not mean that you can’t find appropriate soils in these regions, but you may have to look harder than most. You can also have appropriate soil shipped in. Sandy soils in these regions can sometimes do well for rammed earth though.

Aggregate

The terms sand and aggregate can be used interchangeably, but most people refer to this ingredient as sand. The majority of your cob mixture is actually composed of sand and other aggregates found in the soil. It usually hovers somewhere around 80%. The other 20% is your clay. This ratio will differ depending on where you get your subsoil from though. That’s why the vast majority of times it's going to be essential to add additional aggregate into your cob mixture. There are some rare areas where you will find soil that naturally contains the right amount of aggregate-to-clay ratio to make cob, but this is not usually the case.

One of the main guidelines for choosing sand for your cob mixture is to use a rough and coarse sand that has many different particle sizes included in it. A rough-edged sand helps the particles to lock together better and will prevent serious cracking. You may also opt for gravel aggregate as long as the gravel rocks are not bigger than about ¼ inch. Road base gravel, sometimes called *crusher run gravel*, also works very well for cob aggregate.

Rounded sand that is sometimes found on beach shores is not appropriate for cob because the particles don’t bond together with any strength. It's like trying to stack a bunch of beach balls on top of each other, but they just keep rolling away.

If you live in the United States you will find sand for sale under many different names. Some common sands that you might encounter are masonry sand and concrete sand. These are typically used as ingredients for cement and are widely available. Sometimes they fall under different names by region of the country though.

Concrete sand is a great choice for cob. It is rough and holds a variety of particle sizes even including some small pebbles. Using this sand will help prevent serious cracking. Masonry sand is a finer version of concrete sand and is usually a bit too finely sifted for large cob constructions. I recommend either concrete sand or crusher run gravel.

You can buy sand or gravel inexpensively in large quantities by the truck load. You might spend a few hundred dollars for a truck load of sand plus the cost to transport it to your site, but the cost is still low considering that sand is one of the main ingredients in cob. The actual delivery charge can easily cost you more than the sand itself so it's a good idea to order in bulk. You may have extra sand left over depending on what you're building, but you can always use the extra sand for other projects. If you're building a small cob house of a couple hundred square feet you might as well get a full dump truck load, which is usually between 6 to 10 cubic yards. Anything larger will require more than one truck load.

You can purchase sand and gravel at landscape supply depots and gravel yards. There is usually at least one for every small town or city in the United States so these businesses are easy to find.

Fiber

Straw is the component of cob referred to as the fiber. It acts as a natural rebar in a similar way that metal rebar would function in concrete. It adds tensile and shear strength to cob walls and holds a cob structure more together as a single monolithic piece.

Use straw that is fresh and not brittle or rotten. Make sure that it has been kept dry before purchasing it too. Sometimes a bale of straw might look okay on the outside, but it's a good idea to examine some of the stock for mold or mildew by opening up a bale to see the inside portions. Look for bales of straw that have long strands. Six to twelve inches is an appropriate length. If it's too short you are losing out on the benefits of this ingredient for cob.

Test the quality of straw by taking a strand in your hands and bending and pulling it to check it's strength or brittleness. You can also take a couple more strands, put them all together, and try to tug the pieces of straw apart. Straw is much stronger when put together and it should be very difficult to break them with your own strength.

Many people are worried that the straw will rot inside of their cob walls over time. Straw and other similar fibers have been used in cob and there are many buildings that have lasted for hundreds of years without any decomposition of the fibers inside. Even after this much time, it's still yellow and strong because there is very little oxygen or moisture available inside of dried cob for microorganisms to cause rotting and the straw is thus preserved inside.

Another important point to make here is that you should never use hay as a substitute for straw. They are very different things. Hay is a pre-harvest food product such as grass, alfalfa, or clover for livestock animals to eat. Straw is the post-harvest product that does not contain any food value. It is usually the stem left over from oats, wheat, or barley. Wheat stems are hollow and have great tensile strength.

On the other hand, hay has lower tensile strength and will quickly 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. As they say, “hay is for horses.” Don’t use it for cob!

Wheat straw is a great option for your fiber ingredient. It is widely available in the United States and many other countries. It usually costs between $3 to $5 for a bale. Oat and rye straws also make for strong cob fibers. 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 locally.

Always try to store straw indoors. 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 your straw with tarps is good, but tarps usually leak and build up condensation underneath them. Store your straw underneath some leak-proof roofing material if you have it available. If you have sheets of plywood or steel roofing you can lay that on top to cover it. It's very important to keep the straw dry to maintain its integrity.

Water

Water is the final ingredient that you will need for making cob. There’s nothing particularly special about the kind of water that you use though. If you’re getting it from your water lines then you have nothing to worry about. But if you’re collecting it from a pond or open body of water then perhaps just make sure that you remove any leaves or other organic matter from it first.

The water is a crucial ingredient in cob because it is what turns your soil, aggregate, and fiber into a doughy, thick building material. You may also remember that the clay first needs to be made wet in order to coat the aggregate particles and create the suction and binding.

Selecting Soil and Testing Your Cob Mix

A good building soil has approximately 15-25% clay content and less than 30% silt. There are many kinds of suitable soil types: clay, sandy clay, sandy clay loam, clay loam, and loam. There can be a lot of complexity and things to think about with finding a good soil, and it can be overwhelming to those who are new to earthen building. But just take a deep breath and relax!

In the end, it's all very intuitive and you will learn to distinguish suitable soil for cob mostly by sight and feel. With some experience, all of the categories, numbers, and percentages won’t even pass through your mind. You can usually judge its quality with your senses of touch and sight.

The aggregate (sand) and silt portions of soil will stay the same size whether they are wet or dry. These tiny aggregates need the clay to bind them together like a mortar. The clay by itself

expands when it's wet and contracts when it's dry, thus making it unstable on its own. This is why you have to test your soils and determine their composition. You have to find a soil that will allow you to create the right balanced ratio.

To find clay-rich soil, first check the soil at your building site. The closer you can source your soil the more efficient you will be. Soil can be a lot of work to transport from one point to another. Do soil tests in different locations around your property. Generally, you can just dig beneath the topsoil to find subsoils that can work for cob.

If you can not access any suitable subsoil from your property, it can easily be purchased from a local soil depot, landscaping center, or even from construction sites who need to get rid of excess soil. Before purchasing a large amount from an outside source, do some small cob mixture tests with a sample amount.

Creating and Analyzing Test Blocks

There are many ways to test soil and analyze its suitability for cob. There are many simple field tests that you can perform, such as the: snake test, ribbon test, arm test, and jar test However, these tests are of very little benefit, and I have stopped teaching these over the years. You will eventually gain a sensory discernment for what good soil is and you won't even need to use these tests.

Instead of going through these basic field tests, find subsoils that you want to try and simply make test mixes of cob. Use the chosen subsoil and test it with different ratios of aggregate. For each small cob batch that you mix, create small test bricks and let them dry out for 24-48 hours outside. You can let them dry in the shade or in the sun. The bricks must be at least the size of a standard red brick. For later reference, mark the bricks with the ratio of how much soil and aggregate was used.

Once all your bricks are completely dried through, observe the bricks for any issues. If the bricks are sandy and brittle, you probably added too much aggregate to your mixture. If the bricks are cracking then you probably added too much soil or water to your mixture. The bricks should be

rock solid and you should not be able to scratch them deeply or break them in your hands. In the end, find a test batch that turned out strong and step up your tests with that mixture from there.

Once you have created a set of good test bricks, I recommend that you make a test wall. This might seem like a lot of extra work, but it will uncover any weaknesses in your cob mixture that small bricks will not reveal. A small test brick can look perfect with a given cob mixture, but sometimes when you start to build large portions of cob wall, problems can start to appear that you didn't see with the bricks. The main problem that can be revealed is cracks. We mostly want to avoid long vertical cracks in our cob walls. These can be structural issues and decrease the monolithic aspect of a cob wall.

To build a test cob wall, construct a section of wall to the desired thickness you will be building your walls on your real project. This is usually between 18 and 24 inches thick. Next, build the wall section at least 5 feet long and 3 feet high. Let this section of wall dry for 2 to 3 weeks to observe its integrity. If there are any large vertical cracks that appear, you will want to adjust your cob mixture and start over. Vertical cracks in cob walls can be the result of several variables, but they are usually a result of not enough aggregate in the mix or too much water being added to the mix.

Pro tip: It's easier to sculpt and work with a wet, pliable cob mixture in your hands, but wet cob has a higher tendency to crack as it dries. The clay soil will expand with water and then leave a void as that water dissipates out of the cob. Try to create a stiffer cob mix that you can work with.

How to Make Cob

There are several different methods for mixing cob. In this book, I will instruct you on how to mix cob manually and mechanically. I always recommend that people learn how to mix cob manually first. It gives you a better feel for the material and you will quickly understand what to look for when you are mixing cob with machinery.

Tarp Method

One of the most common and regularly-practiced techniques for manual cob mixing is called the *tarp method* of cob mixing. This is one of the most basic and most labor intensive ways of

making cob. You can create very consistent, well-mixed batches of cob using this method, but you will also burn the most human energy and time as well.
The tarp method can be done by yourself or with one other person. Whether you do it solo or with a partner is up to personal preference. You will need a large tarp and a few buckets for soil and aggregate. Always use buckets of the same size, whether they are 5 gallon or 3 gallon buckets. Fill them up flush to the top of the rim. You want to be using the same sized containers so you have a standardization for measuring material volumes.

1. Organize all of your materials and tools close to your building site. Soil, aggregate, straw, water, tarp, and buckets.

2. Lay out your tarp on a flat space. This is where you'll be mixing. Since you will likely be mixing with bare feet, make sure that any sticks or rocks are out from underneath the tarp since these will hurt to step on.

3. Put your dry ingredients (subsoil and aggregate) in the middle of your tarp in a pile in accordance with the cob ratio that you have decided to use.

Here are some common ratios to start testing with:

Sand 1: Soil 1 (Starting with an equal balance is a good place to begin.)
Sand 2: Soil 1 (If your cob cracks a lot, add more sand.)
Sand 1: Soil 2 (If your cob is too sandy and brittle, add more soil.)

4. Now you will mix the dry materials together on the tarp. Grab two corners of the tarp and walk forward to the center of the mix, folding the tarp in half. The dry materials 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 4 to 5 times or until the dry materials are mixed thoroughly together. 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 spray some water over the top of it. Be careful not to add too much water as you mix. It's always best to add too little water than too much! It's much easier to add little bits of water as you go than to try and fix adding too much from the start. You will have to experiment to determine how much water you will need in your mix. You'll figure out how much water to add through experience making cob. 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 it will slump. Overly wet cob is also more susceptible to cracking 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. Begin mixing by using your feet to smear the materials together with the water. You can do this 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. The goal is to make sure that all the dry materials are

mixed together well with the water and that all the clay and sand are smeared together thoroughly.

7. Once the mixture has been stopped flat and spread out, you will pull the corners of the tarp to fold the mix on top of itself again. Stomp the mix again, and repeat this as many times as it takes to get the right consistency. You can continue to add some water to your mix as you go. 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 ready for adding straw.

8. Take some handfuls of straw and sprinkle it over the cob mixture. 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 as needed. There is no exact amount of straw to use. You will need to decide how much straw you want in your cob. Some people like straw-heavy cob, some like less straw in their cob. Continue repeating the mixing process until all of the straw is thoroughly distributed and mixed into the cob. You've just made cob!

Mortar Mixer

My preferred machine for mixing cob is a mortar mixer. The first thing to know about the mortar mixer is to not get it mixed up with a concrete mixer. They are very different machines. A concrete mixer will only tumble the materials round and round. This works for mixing very wet material such as concrete and some earthen plasters. A concrete mixer will not mix cob. On the other hand, a mortar mixer has paddles inside that actually smear and mix the material together, much like how you would do it with foot mixing on a tarp.

The mortar mixer is at least ten times faster than mixing cob by foot and it will save you a tremendous amount of human energy and time. I recommend the mortar mixer for almost any size project, and for groups of workers ranging from one to twenty five people. A mortar mixer is probably all you will ever need as far as cob mixing machinery goes. If you have extra labor and want to mix more cob, use two mortar mixers. There are larger machines that you can use to mix cob, which I'll touch on here soon, but you likely will never need to use these other options.

Mixing cob with a mortar mixer is quite easy, and follows the same concepts as mixing cob with the tarp. Once the machine is running, add your soil, aggregate, and water. The machine will

mix it up within a few minutes. You will notice the cob “clumping” together on the mixing paddles. At this point, sprinkle your straw into the mixer as the paddles continue to spin. You may need to spray in bits of water throughout the mixing process. Once everything is thoroughly mixed together, dump the material from the mixer into a wheelbarrow and take it to the building site.

Mortar mixers are reasonably easy to find for rental. They range in cost from $150 to $400 per week depending on the size of the mixer and where you rent from. You can purchase a new mortar mixer usually somewhere in the range of $3,000 to $4,500. Used mixers can be bought at much cheaper prices too.

When you rent or purchase a new mortar mixer, always check to make sure that it's in good shape. All the pins and safety mechanisms should be solid and in good working order. There should not be any bent or loose pieces on any of the metal framing. Most of the mechanical malfunctions you will encounter with a mortar mixer are a result of worn out belts and clogged air filters, which are easily replaced.

Safety Note: When operating a mortar mixer, **never** put your hands inside the mixing bucket. Whether the paddles are on or switched off. As long as the motor is running, **never** put your hands or arms inside the mixing bucket. If you need to clean or unclog the bucket, **always** turn off the engine entirely first. When sprinkling straw into the mixing bucket, keep your hands at least a foot above the mixing paddles for optimal safety. There is no need to put the straw in as close to the bucket as possible.

Tractor or Skid-Steer

When we talk about using a tractor or skid-steer, we understand that it has a front-end loader with a bucket equipped to it. A few things to note about using these machines to mix cob:

1. You will need at least a 20 foot by 20 foot concrete mixing pad to mix the cob on.
2. Do not mix without a mixing pad unless you have no choice. You will pick up too much surface material and dirty-up your cob mix without a clean mixing pad.
3. Using one of these machines makes very large batches of cob per mix. The size of your machine and its bucket will determine the size of the batch. A large batch of cob can sit still and last for several days (depending on the environmental conditions), but it's best if you can use the newly created material on the same day or the next morning. This requires a team.
4. You can make one large batch of tractor cob in one hour that would take a group of 10 people one or two full days to make by foot. Machines are a tremendous time saver.
5. You can more easily transport the mixed cob from the mixing station to the building site. You can sometimes even drop the fresh cob right onto the wall being built. Then the workers only need to form it into place. This can save a lot of time and labor this way.

I only recommend mixing with a tractor or skid-steer if you are building a large cob house and have a team of at least 10 people working. There is usually just more investment involved with using a tractor or skid-steer. The machines are more expensive to rent and you should have a dedicated concrete mixing pad.

How to Mix Cob with a Tractor or Skid-Steer

1. Determine your cob mixing ratio. Read the chapter on Selecting Soil and Testing Your Cob Mix to learn how to do this.

2. Use the tractor and scoop up a bucket full of soil and place it in the middle of your mixing pad. Then pick up a bucket full of aggregate and place it on the mixing pad. The front-end bucket is your measuring device. Just like how you would use standard sized buckets as a measurement tool if you were mixing by foot. Continue to alternate between soil and sand. This will speed up your dry mixing process by getting them together in one big layered pile. If my ratio was 1 part soil to 1 part sand and I wanted to make a quadruple batch I would use 4 buckets of soil and 4 buckets of sand. Alternate between the two materials as you add them to your mixing pad.

3. Once you have all of your materials piled up in the middle of your mixing pad you will need to dry-mix them together. This is the same process you would follow if you were mixing on a tarp. You're just doing it on a larger scale now with a tractor. There are many techniques as to how exactly you use your tractor to mix. A lot of it will just come with experience. Use your tractor bucket to push, pull, and smear your pile of ingredients. When it starts to flatten or spread out too much, push it all back together into a pile. I've found that it's not efficient to run over your materials back and forth with the tires. The weight of the machine mixes and mashes your cob ingredients down, but it just tends to make more of a mess. Mash the materials down with your tractor bucket instead. This way you have more control over your pile and you don't have to spend nearly as much time cleaning your pile up.

4. Once your dry ingredients are thoroughly mixed together it's time to add plenty of water. The amount of water that you add will depend on how large your cob batch is. Keep adding water until your mix starts to get muddy and thick. It's best to have a person or two on the side adding water while the tractor operator mixes.

5. Continue to thoroughly mix your cob ingredients and add water. When everything is smeared and mixed together it's time to add straw. If you have experience with making cob then you will know when your mix is done and it's ready for the straw to be added.

6. Add the straw. Have your helpers on the side continue to add straw as the tractor

operator mixes the pile.

7. Remember that it's more difficult to get tractor mixed cob as consistently mixed as foot-mixed cob. So, continue to mix your batch a little extra.

8. Once you judge your cob to be thoroughly mixed, gather your pile of cob up into one big pile. It's time to transport it to your building site.

Backhoe

Mixing cob with a backhoe is probably the largest scale method for creating cob onsite. I don't usually recommend this method for people unless they already have a backhoe available to them.

In a nutshell, to mix cob using a backhoe you will first need to dig a big pit in the ground. This pit will be your mixing "bowl" of sorts. Drop all of your cob ingredients into the hole. Again, use the backhoe's bucket as a measuring device. Once all the materials are in the pit, stick the dipper into the hole and scoop, drop, and smash the materials with the bucket.

When the cob is complete, pick it up and set it outside the pit. You can either drop the cob into the back of a truck to deliver the material, or drive the backhoe with the cob over to the building site.

Cob Mixing – Problem and Solution

Here are a few tips and points of review that may help you with mixing cob to the right consistency and the best ratio.

- If your cob mix is very slick and sticks to your feet or to the tarp then it is probably too wet. Either add more soil and aggregate to dilute the overall water volume, or let the mix dry out for some time.
- If your mix continues to crumble and it won't hold together then add more clay to your ratio and/or more water to your mix. You might also have too much straw in your mix, which can make cob very dry and brittle.
- If your cobs pull apart too 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.

Foundations

What is the Foundation?

The first part of building your home will be the foundation. This is the first major component to consider when building any structure, and the information presented in this chapter will be relevant to most types of buildings. The foundation is a unified, stable base which holds the weight of your walls, upper floors, roof, and any live loads. It also distributes the weight of the house over a larger area and helps prevent the building from sinking into the ground, which can be catastrophic to a structure. You must build on solid, dry ground with good soil drainage.

Foundations can be built using a variety of materials, but they are mostly built with solid, non-corroding materials like concrete or stone. A good foundation is vital to the life of your building and it should be given the thorough consideration it deserves as a critical piece of the structure.

Foundations for cob buildings can include the footers below ground and the above-ground stem wall that holds the cob walls above grade. The footers below ground level work with the stem wall to further distribute the weight of the building evenly and to anchor the building into the ground.

The stem wall, which extends above ground on top of the footers, stands at least 1 ½ feet above ground level. The stem wall acts as protection for the earthen walls from water damage. It acts as a moisture break so that water does not seep up from the ground into the walls. Water runoff along the ground is also not able to touch the cob portion of the walls, and water splash-back from rainfall cannot reach the height of the cob walls.

It's important for your foundation to protect your walls from water since cob walls will deteriorate if they are exposed to water. Even in arid climates, it is not recommended to build the cob walls starting at the ground level as this shortens the life of the structure. You still want to have a raised stem wall.

Especially for earthen building, the importance of foundations cannot be overemphasized. Do your due diligence and plan for a solid, strong foundation. If your foundation is well designed, your building will enjoy a much longer life.

Foundation Components

There are a few main components that will make up the foundation for a house.

Footers

Foundation footers are the deepest part of your foundation and sit underground beneath the foundation stem walls. Footers support the foundation and help prevent it from settling. They are wider than the actual width of the foundation stem walls.

Stem Walls

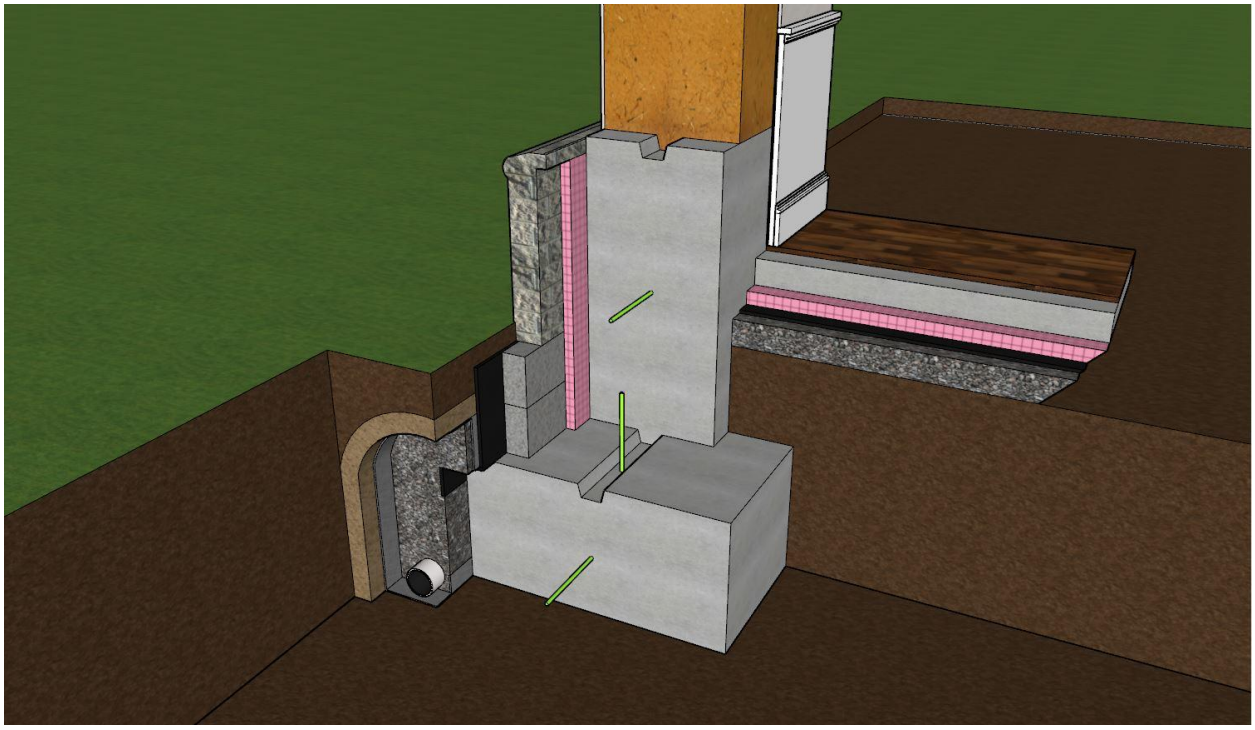
The stem wall sits on top of the underground foundation footers and they extend above-ground. Stem walls for earthen buildings should generally rise between 1.5 to 2 feet above ground level. This portion of the foundation acts as a moisture break between the ground and the walls, and further integrates the building into the solid ground beneath it.

Reinforcing

Steel reinforcing, also called rebar, is used throughout any concrete foundation components, such as the footers and stem walls. Rebar strengthens concrete and holds it in tension, similar to how straw fiber acts within cob.

Drainage

A good foundation will also have a drainage system along the outside perimeter. The drainage system should keep excess water away from the foundation components. Water collection around foundations can cause leaks and frost heave.



Foundation Materials

There are many kinds of materials and alternative materials that are used for foundations. In this section, I'm going to categorize them very distinctly as either good or bad materials for foundations. I have seen too many very poor examples of foundations for earthen buildings that have led to a myriad of problems for them. I would be doing you a disservice if I tried to sell you a fantasy that many other people try to do that you can build strong foundations with recycled or alternative materials. These alternatives only work in isolated instances. Let's begin with the materials you do want to use for foundations.

Stone

To be honest, I'm only putting stone in the "good" category because it has been used successfully for foundations throughout time. Even with this being the case, I very rarely recommend that anyone attempt to build a traditional stone foundation for their home these days. They are expensive, the vast majority of masons don't know how to build stone foundations anymore, and getting a building permit for one is nearly impossible.

With all that being said, stone has a place in foundations and you might be able to use it for yours. Stone is a good natural option if you are not interested in using concrete. Stone also has an appealing aesthetic look to it when put together properly, and it nicely complements the earthen tones and organic shapes of cob.

Building a stone foundation is a labor intensive process and can take a long time. It also requires some skill. If you are going to build your own stone foundation, please get proper training from a skilled stone mason. Stone foundations are not slapped together. They are carefully crafted.

Stone is a decent choice for stem walls. It would be a good idea to place a stone stem wall on top of concrete footers though.

Concrete

Concrete is a mixture of aggregates (like we use in cob) and cement binder. Concrete is my top recommendation for foundation material. Any competent builder in the modern age will not gripe with the fact that concrete works the best for foundations in the vast majority of cases.

A few people decide not to use concrete because of cement's high embodied energy. This means that it requires a high amount of energy and fossil fuels to be burned for its production, transport, and application. This is true, but don't rule out using concrete because of this. For the embodied energy of the concrete you use, you will save more embodied energy and timber overall by building your walls with earthen material. It's still a net positive as far as embodied energy goes.

Concrete has been used for thousands of years by builders for good reasons. It is a

great material for foundations. It's monolithic, very strong, widely available, it uses 99% natural ingredients, and it can be poured into almost any shape that you want.

Concrete is a great choice for footers and stem walls!

Bricks or Blocks

Fired bricks or concrete blocks can be used for stem wall construction. They have been used for thousands of years for this purpose all over the world. They are easily stackable and go up quickly. However, bricks and blocks are not monolithic and you will have to build them out to whatever the thickness of your earth walls will be. Again, this will not be an easy option for getting building approvals on. If you want the brick-look for a foundation, you can always add a brick veneer to the side of a concrete stem wall.

Bricks and blocks might be an option for stem walls on top of a concrete footer.

Polypropylene Bags

Woven polypropylene bags are sometimes used for foundations on alternative buildings, such as superadobe structures. These types of structures are systems that work in very dry, arid climates. I do not ever recommend polypropylene bags for foundations though.

The concept is to fill the bags with gravel and stack them up into a foundation. This will most definitely lead to a weak foundation that won't last long. The bags easily tear and they also degrade under sunlight. You will have a foundation full of spilling holes by the time you are halfway complete building your walls, and the whole structure will need to be torn down at that point.

Avoid polypropylene bags like the plague for foundations.

Tires

Another popular alternative material that's sometimes used for foundations is tires. The tires are stacked together and each tire is filled with compressed soil. This system is used successfully for the Earthship system. Again, the Earthship buildings are designed mostly for dry, desert climates. Please do not attempt to build a tire foundation in any climate with normal rainfall. Water will leak through the foundation and saturate the compressed soil inside them.

Tires might only be a good option if you're building a cob pig pen.

Urbanite

Urbanite is salvaged pieces of broken up concrete (usually sidewalks) that can be used to stack like stones. Urbanite has all the downsides of bricks, blocks, stones, and more. The pieces are un-uniform and you will never get building permits to use it for a home foundation.

Urbanite may be a decent option for a small shed foundation if you really want to go this route.

Building Cob Walls

When your foundation is completed, you can begin to build the cob walls. They will sit directly on top of the stem wall foundation and extend up to the bond beam.

Monolithic Building

Cob walls are intended to be monolithic. Instead of the walls being composed of thousands of individual bricks, a cob wall is more like one single giant brick. Ideally, each piece of cob is connected to its adjacent pieces, and each layer of cob is attached to the layer above and beneath it. The bonding between layers and the weight of gravity are important for giving cob walls strength.

Each piece of cob is interconnected with its surrounding pieces, and you also have a three-dimensional texture of interwoven straw between each individual piece of cob. Using the hands and feet, each piece of cob is smeared, pinched, and stomped together as they are applied to the walls. Stomp or smear together any cracks or gaps between cob pieces so they don’t come apart when dry.

In reality, most cob walls never turn out to be completely monolithic. There can be areas of disconnect between layers, or where vertical cracks form. Always strive for the most monolithic cob wall possible, but don't feel that it has to be perfect. I like to think of a cob wall more as thick monolithic layers. This is usually the way a cob wall is, unless you can manage to build the walls from start to finish with very little pause in between the process. As one layer dries, there will never be a way to completely bond the next layer on top. You will only be able to "key into" a layer if it's already dry.

Connecting Layers

A cob wall is technically not monolithic if its layers are disconnected. Placing a fresh layer of cob on top of a dry layer of cob will create this type of disconnect. One way to help integrate a dry layer of cob with a freshly placed layer of cob is to use a "key."

You will discover some misinformation on how to best attach fresh cob to dry cob layers. Some people will tell you to just spray some water over the dry layer before placing the new, fresh layer. This will do absolutely nothing and will not bond the two layers together.

One of the more popular new techniques for integrating fresh to dry cob is to use a "spine and ribs" over the top of the cob wall. This is a method of keying into the next layer. This needs to be done when you are planning to let the cob wall sit for an amount of time that the cob will be dry by the time you return to build more. If you will be gone for two or more days, this is a good idea to do.

When you're done with a layer of cob and need to let it set for a while, 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 top of the wall. On both sides of the ridge, attach cob loaves to it at right angles going from the ridge to the edge of the wall on the interior and exterior. Between each rib, leave about one foot of space. When you start the next layer, you simply continue to add cob to the wall covering the spine and ribs and building higher.

The spine and ribs technique works for helping to integrate a fresh cob layer to a dry cob layer. I've found that it has some faults though. The main one being that the spine and ribs are usually not attached thoroughly enough to the top of the cob wall to begin with. I've seen so many spine and ribs simply come right off the top of the wall when they dry because they have very little or no integration to the wall. This could be a matter of just putting more time and labor into better integrating the spine and ribs. But at this point, I think it's becoming an inefficient task and there are better ways to "key" layers together that take less time and labor.

Instead of building a key by adding cob material, it's much easier to carve out a key. There is no need to create such a complex keying system like the spine and ribs. Instead, when you complete your layer of cob go to the top of the wall and carve out a 4 to 6 inch wide channel

down the middle. Carve it into the top of the wall about 3 to 4 inches. This is a very good key system and will take far less time.

The Basic Process: Place, Kneed, Stomp, Trim

Building with cob is a fairly intuitive skill and you can learn to build cob walls very quickly. Of course, as with anything, practice makes perfect. But you won't have to get over a steep learning curve before you can successfully build a cob wall. I've broken down the process of building cob walls into four simple steps.

Place

The first step is to take a cob and place it on your wall. When you first begin your wall, you will be placing the cob right on top of the stem wall foundation. The pieces of cob that you apply to your wall can be any size. It usually works to add pieces that are most manageable for you to carry. Sizes usually vary from handfuls to small watermelon sizes.

Add the pieces of cob next to each other. You can push each piece up against the next. They'll already begin to form into one piece. Add enough pieces so that you cover the full width of the wall, and it's best to add a little excess over the edges. If you don't put enough cob to cover the full width of your wall you will end up with your walls being too narrow and potentially tapering in as they rise. Any excess cob will "ooze" off the sides and be trimmed off later. So it's better to add too much than too little.

Knead

Once you have placed your pieces of cob onto the wall, work them together a little bit with your hands. Knead one piece into the adjacent pieces. If there are gaps between pieces, smear them together to get a little more integration. You don't have to be very thorough with this step though because we'll get most of the pieces compressed together in the next step. This step is especially helpful in connecting the pieces together lightly so that they don't fall apart and off the wall when stomping.

Stomp

Now that you've added the cob and lightly kneaded it together, it's time to stomp it. Stomping will compact the cob together and build its strength. Get on top of the cob and stomp it down with your feet. Many people compress the cob with their hands instead of using their feet. This is not an efficient way to perform this step when you can easily use your body weight and gravity to assist you. Stomp from the top and you can hit the sides of the wall with the side of your foot. Just make sure that you are well balanced if you decide to stand on the wall to stomp.

Trim

After stomping the cob, you will have some cob "oozing" off the sides of the wall. This might seem like a waste of cob material, but it can easily be trimmed off and reapplied onto the wall. Trim off the excess cob with your trimming tool. I prefer to use a hay saw, but you can use a hand saw or a machete if you don't have one. Again, stand on the top of the wall if you're using a hay saw and trim the sides of the wall flush with the stem wall or the layer of cob beneath you.

A fresh layer of cob is going to still be soft and malleable making it easy to trim and shape. Depending on the weather conditions, you should be able to easily trim the cob for a few days. Once it gets too dry though it will be impossible to trim. I recommend adding your daily layer of cob and then trimming that layer first thing the next day. It helps to let the cob settle and slightly dry before trimming it.

Trimming is important for keeping your walls vertical, or as close to vertical as possible. As you trim the walls, hold a level against the side. Trim and level until you get as close to vertical as you can get. If you are more concerned about keeping your cob walls perfectly vertical then I recommend using the slipform cob building method.

Slipform Cob

Slipform cob, also known as shuttered cob, is a way to build cob walls by placing the cob mixture inside a formwork of “shuttering” which contains the cob. It is a great way to keep the walls straight and vertically plumb as you build upward without the need for trimming or molding the sides later.

It has been discovered that shuttered cob was employed as a building technique in Britain in the nineteenth century to build a variety of cob structures. Apart from this, shuttered cob has not been a widely used method to build cob walls with. However, it's becoming more popular now and a lot of testing and research is being done using this method.

Advantages of Slipform Cob Building

- Perfectly vertical walls.
- No wall trimming is required. This saves a large amount of time and labor.
- Drastically reduces amounts of wasted cob trimmings.

- You can easily create a dual wall system inside forms. Half cob, half high-insulation mix.
- You can easily add insulation inside the middle of a cob wall when building inside forms.
- Less wall cracking. It's easier to use a drier, stiffer cob mix when building inside forms.
- You can attach conduits, outlets, pipes, etc to the formwork and build cob around them.

How thick should cob walls be?

The thinner that cob walls are the less load bearing capacity and thermal mass that they will have. I recommend the width of cob walls be between 18 to 24 inches as a standard. This gives plenty of load bearing capacity for a one story building and plenty of thermal mass.

If your structure is not relying on the load bearing capacity of the cob walls to hold it up then you might consider going for a thinner wall. Especially if they are non-load bearing interior walls. The thinnest I would go with a cob wall is 12 inches wide.

How High Can You Build a Cob Wall?

Cob homes are typically one or two stories tall. It’s rare to see a cob house go up more than two levels in height. In the country of Yemen, there are earthen structures that reach up to seven stories tall. The bases of the walls are built very thick and taper in as they go up.

Another thing to consider if you want to build high walls is that building slows down once you get on scaffolding. You are more limited in your movement and materials have to be delivered up from the ground.

If you are building a cob wall over 8 feet tall, consider the seismic activity and winds in your area. You may want to use metal reinforcement in the walls according to the cob building code (2021 IRC Appendix U).

How Much Cob Can You Build Each Day?

It’s a general practice to build up about one foot of cob per day. However, this is only a guideline and does not have to be strictly adhered to. How far up you can or should go in a day will depend on certain factors.

In good weather conditions with lots of sunlight and breezes you can easily build up one or more feet per day. The truth is that in most cases you won’t have the time or labor to go higher than one foot per day anyway. Just keep in mind how high you’re building each day and give each layer sufficient time to dry.

Each layer does not have to dry completely before you can add the next layer. Generally, you can apply one layer, let it sit overnight, and then apply the next layer the following morning.

The rate of cob construction will also depend a lot on how much water you are putting into your cob mixture. Wet cob will take longer to dry and will reduce the speed of building. Drier cob is more challenging to work with in the hands, but it stacks and dries faster. This is another advantage that slipform cob building has over hand-sculpted and trimmed walls. Slipform cob works best with a drier, stiffer cob mixture, and you can build in the forms at a very steady rate.

Scaffolding

When working with cob, always remember that it's best to be working just below your waist level. If you try to work too far below or above your waist level you will put unnecessary strain on your lower back or upper body by leaning down or extending too high.

As you work higher on your walls you will come to a point where you will need some form of scaffolding. Always use safe and secure scaffolds when working above ground level. Makeshift scaffolds can work in many instances, but it's always better to have approved scaffolds when you can.

Working up high increases the chances for worksite accidents and injuries. By using safe scaffolding systems, being aware of surroundings, and communicating with other workers on the building site you can drastically lower the chances of any problems happening.

Windows and Doors

Windows and doors open up your home to the world outside. Windows provide many different functions: they light our homes, show outside views, ventilate our homes, and let in heat from the sun.

You can install any type of door or window into a cob wall. In this chapter, I will explain the components you'll need and how to integrate windows and doors with cob.

Sills

A sill is the durable surface that a window sits upon. Doors usually have what is called a threshold, which serves much the same purpose as a window sill. We will mostly be referring to how this component works with windows though.

A sill can be made of any durable material, such as: stone, concrete, or sometimes wood. The sill acts as a durable surface for your window opening to prevent erosion on the cob wall. A sill should have a drip line on the exterior, and should be sloped not less than 1 unit vertical in 12 units horizontal to drain water away from the cob walls and the window.

Sills can be very heavy, depending on their thickness and type of material used. It's best to let the cob dry for two or three weeks before setting any sills onto the cob walls. This will prevent your sills from settling out of level and your fresh cob walls from oozing out due to too much top weight.

Frames

For each door and window that you install, you will create a wooden frame or "box" that attaches to the cob wall. The windows and doors will fasten inside of these wooden frames.

In a conventional stick-framed building, the doors and windows attach into frames just like these. When working with cob walls, the frames are attached into the cob instead of being nailed to the adjacent framing in a wooden structure.

Any standard dimensional lumber will work for building window and door frames. There are actually many different ways that you can construct your frames. Make sure that all of your corners are squared at ninety degrees, and attach cross-bracing to keep the frames sturdy and squared. As the cob dries, there will be a lot of pressure and pulling by the cob walls on the frames. You will also want to brace the frames to the ground or some other solid surface.

Also build your frames about an inch and a half wider on all sides than your actual window or door will be. This will give you plenty of room to insert and adjust them into the frame. Use wooden shims to fill these gaps and align your windows and doors.

Anchors

To actually connect the window and door frames to the cob you will need to use anchors. There are a few options that you can use. One of the most simple methods is to put nails into the outside of the frames with the heads exposed an inch or two. The nails provide a grip for the cob to hold onto.

For big windows and doors it's a better idea to use a stiff piece of wood which is buried into the cob, sometimes referred to as a “deadman.” These can easily be made out of dimensional lumber.

You will attach the anchors to your window and door frames first and then cob around them. You can also build these type of anchors into the cob walls and have one face left exposed on the side of the wall. Make sure that the exposed face sits flush to the wall. 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 heavy to the wall in the future.

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

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. These tend to be areas where doors take more pressure.

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

Lintels

Wherever you plan to install a door or window you are creating an opening in the cob wall at that location. The cob wall usually needs to extend over the top of this opening. Building a lintel is the way to support the mass of the cob over top of the window and door openings.

Lintels are typically made using strong, stiff materials such as: wood, stone, or concrete. I recommend using concrete for lintels. A concrete lintel needs to be 6 inches in thickness, and will usually have

three #4 rebars laying through it horizontally. Any rebar should be installed 2 inches clear from the bottom of the lintel and 2 inches clear from the sides. This prevents the rebar from rusting out over time. The sides of any lintels should extend one foot beyond the opening sides of windows and doors.

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 install your lintel. This is the same concept as with installing heavy sills.

Roofing

A good roof will be a large factor in how long your cob building lasts. Learning how to build a roof is beyond the scope of this book. However, I will show you the basic concepts and components you'll need to attach a strong roof to your cob home. You can build any type of roof that you want for a cob

house. The main point of confusion for people is how to actually attach a roof to a cob wall. I will explain how to do that in this chapter.

A roof should meet a few basic qualifications:

- A good roof should keep the rain and precipitation out of the building and direct it away from the cob walls. This is especially important for cob homes since the earthen walls are vulnerable to water damage.
- The roof should shelter the people inside the building from the outside weather elements and hot sun rays.
- The roof and ceiling should be properly insulated to prevent heat loss and heat gain. It should keep heat inside during cold weather and keep unwanted heat out during hot weather.
- The roof should be securely fastened to the walls to withstand heavy storms and hurricanes.
- The roof should also be strong enough to carry extra loads from snow, ice, fallen branches, and workers.

Basic Roofing Components

Roofs consist of two main components:

• The timber frame structure which gives the roof its strength and shape.
• The outer covering attached to the framed structure, which protects the building from water and the elements.

There are a few basic parts that make up these components. There are many different styles of roofs, but they usually consist of these same basic pieces.

Rafters

The rafters are set diagonally to the pitch of the roof and support the sheathing and membrane above them.

Ridge Beam

This supports the highest point of the rafters and runs down the centerline peak of the roof.

Trusses

A truss eliminates the need for a ridge beam. It is a pair of rafters, a collar tie, and cross bracing that is assembled on the ground and lifted onto the walls. This system replaces the ridge beam and rafters system.

Eaves

This is the part of the roof that overhangs past the walls. A long eave is good on a cob house to protect from driving rains. Roof overhangs (eaves) should extend out two to three feet from the walls for earth wall buildings.

Sheathing

This component attaches to the rafters and supports the membrane above. The sheathing is typically constructed with plywood or OSB (oriented strand board).

Membrane

This is the outermost covering on top of your roof sheathing. Roofing fabric is nailed on top of the sheathing. This membrane is then covered and protected with a finish such as: shingles, tiles, shakes, or metal roofing.

Bond Beam

The bond beam is the point of attachment for the roof of the building. The bond beam has anchor bolts
(J-bolts) embedded into the top surface, which are used for attaching the top plate (sill plate). The top plate is what the roof is then attached to. The bond beam acts as a flat, level surface to easily attach your top plate to. The bond beam also acts as a tension ring that helps to further tie all of the walls together into one monolithic piece. A bond beam creates a stronger wall system and is good for earthquake prone areas as well.

The roof can also help tie the walls together by its strength and connection to the bond beam. This creates a uniform distribution of earthquake loads onto all of the walls of the building rather than just to those which are perpendicular to the direction of the ground movement. The bond beam is made of concrete and reinforced with rebar as per the cob building code. Concrete bond beams shall be not less than 6 inches high, and should be the width of your cob wall. They will be reinforced with two #4 rebars, 2 inches clear from the bottom and 2 inches clear from the sides.

Note: You must also integrate the bond beam to the cob wall underneath it. Refer to the cob code for specifics on how you can do this. In a nutshell, you want to have metal reinforcement embedded into the cob wall that will extend out the top of the wall, and you will pour the concrete bond beam around.

Here are some guidelines for attaching the top plate to the bond beam:

- Use a 2 inch by 6 inch, or larger, dimensional lumber for top plates.
- Use 5/8 inch diameter J-bolts/anchor bolts.
- Embed the anchor bolts 5 inches into the bond beam.
- Space the anchor bolts 2 feet on center.

You can also have rebar attached from the foundation and going up through the walls and ending inside the bond beam. This better secures the bond beam to the wall and can also help prevent uplift of the roof by high winds. Please refer to the cob building code (2021 IRC Appendix U) for further details on metal reinforcing options in cob walls.

Gable Roof

The gable roof is a good style of roof for cob homes and they are easy to design.

Some advantages to gable roofs are:

- Simple design structure
- They are good for rainy climates since they can provide plenty of protection to the earth walls from driving rainfall.
- Load bearing cob walls distribute the weight of a gable roof evenly.
- Gable roofs can create more space inside the building with higher ceilings.

A basic gable roof consists of a ridge beam spanning the length of the building with paired rafters connected on each side of it. The rafters extend from the ridge beam and set down onto the walls. This leaves space in the roof open for a “cathedral ceiling” and can also give you the ability to add in lofts and storage spaces. You can also create a gable roof using trusses, but you won’t have an open ceiling in this case.

Roof Ventilation and Insulation

A well-designed roof will have a good ventilation path worked into its structure. Insulation can also be added into the roof to decrease the loss of desired heating and cooling from the inside. Most buildings will want to incorporate both of these systems into their roofing.

The more humid and wet your environment is, the more importance you’ll want to place on roof ventilation. Hot air rises and will either find a way to escape through your ceiling and roof, or that hot

air will build up inside of your structure causing more discomfort to the residents in hotter times of the year.

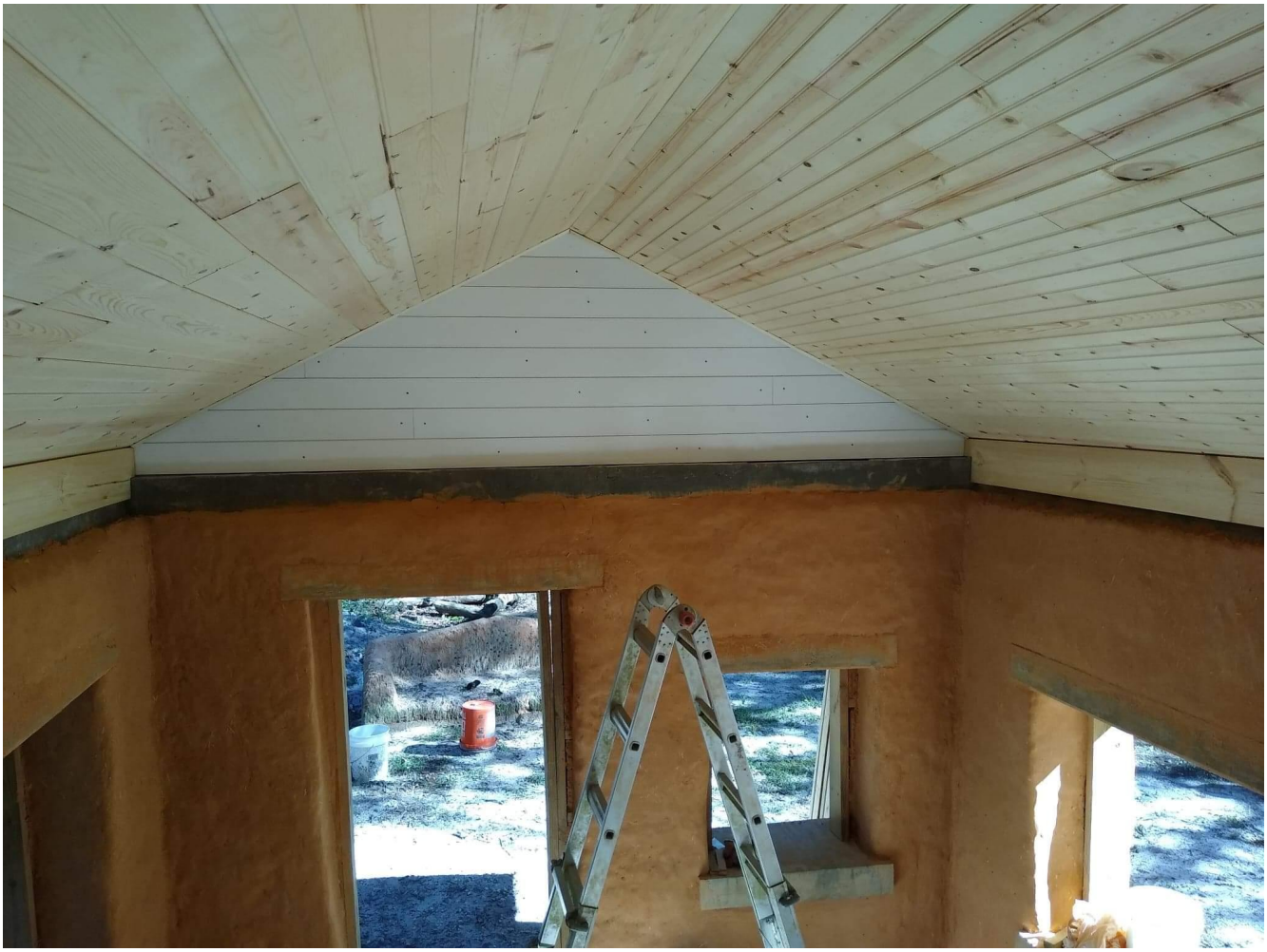
One of the main things to do for roof ventilation is to make sure that you leave enough of a gap at the top of your ridge beam. This is the highest point of your roof, and this is where the most hot air will be trying to rise and escape from. If your ridge vent is too narrow, the hot air rising will struggle to escape out of your building. Ridge gaps vary in size by region so check your local codes for best guidance in your area.

A basic roof ventilation system will be composed of outdoor soffits under the roof eaves and a ridge vent at the top of the rafters. Air will circulate through the open soffits and channel up and out the ridge vent, helping to carry hot interior air out of the structure.

If you notice areas inside or outside of your building that are humid and wet because of poor ventilation, you may also notice that wasps and insects are attracted to these areas. Having a good ventilation system can help prevent insects from nesting inside and around your roof.

Ceiling insulation is another way to help regulate the indoor temperature of your building. With insulation in the ceiling, you can prevent heat from entering through your hot roof in the Summertime, and you can better prevent heat from escaping through your roof in the Wintertime.

Insulation can be placed between the roof rafters. Just make sure to leave as big a gap above the insulation as possible between the insulation and the roof sheathing. This is the ventilation pathway and should not be blocked. A blocked ventilation path inside your roof can cause moisture buildup and it can saturate and ruin your insulation over time.



Ceilings

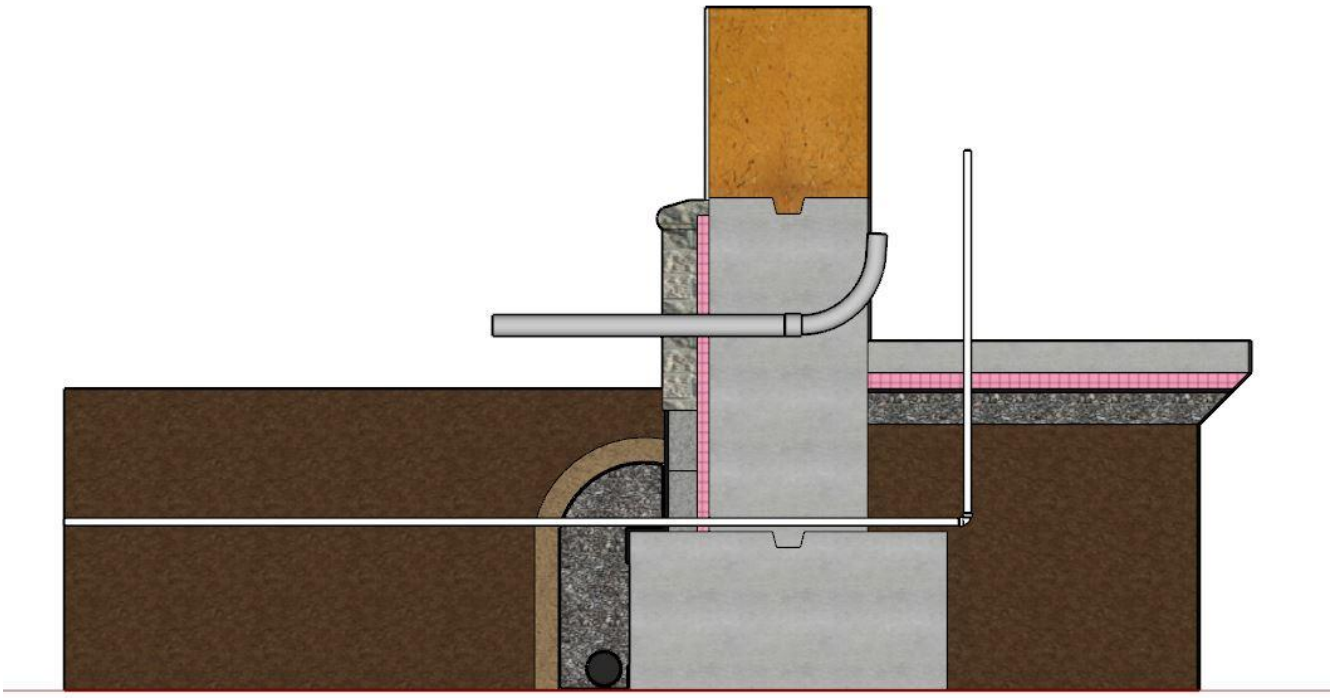
Your indoor ceiling acts as a support for your roofing insulation and provides an attractive surface over the interior structure of your roof. There are a lot of ways to do a ceiling. It's mostly an aesthetic detail. You can put the ceiling in strips between rafters, attached directly beneath rafters, on top of rafters (so the rafters still show), between trusses, or suspended down from the rafters for more insulation space and ventilation gap.

Ceilings can be made of:

- Boards
- Plywood
- Plaster over lath
- Drywall
- Bamboo

Electrical and Plumbing

It's important to give careful consideration to how your electrical and water systems will be integrated with an earth wall building. Unlike a hollow stud-framed wall to run your wires and pipes through, an earthen wall is a solid mass that can not be opened up. A plan for how you will install and integrate your utilities needs to be done in the design and planning stage and should not be left to figure out once your structure is built.



Electricity

One advantage to earth walls is that they don’t catch fire. This doesn't mean that you can cut corners on how your electrical system is installed though. Always install electrical systems as close to code as possible, and hire a certified electrician whenever necessary.

There are a few strategies for how to integrate electrical wiring systems into an earthen building.

One strategy is to install conduit pipes through your earth walls that you can easily run your wires through. The method for installing conduits varies depending on the type of earthen construction you

use. Conduits can be attached to the formwork if you're doing rammed earth or slipform cob. Then the earthen material is added around the conduits as you build the wall up inside the forms. Conduits can also be attached to the outside of earth walls for an exposed conduit.

Another strategy for electrical installation that works well for small homes is to have a conventional stud frame wall between the kitchen and bathroom that contains all of your major electrical and water lines through it. Since it's a hollow stud-frame wall, you can more easily install and access these utilities.

Water

Leaky water pipes inside of earth walls is a dangerous situation. If a leaky pipe is installed inside of an earth wall, you might not be able to see the leak and you won't have access to it even if you do. So it's important to think about how you will safely and efficiently set up your water utilities system.

Leaky pipes inside of earthen walls can cause significant structural damage. The general rule of thumb to avoid this situation is to never install water pipes inside or through cob walls. Especially, do not install pipe joints inside of earth walls since these are most likely to be your points of leaking.

In most cases, water lines should run into your building underneath the foundation and come up through the foundation at any points of access. Water lines should always be buried beneath the frost line so they don't freeze and crack in cold times. If you need assistance with setting up a water utility system, consult a professional plumber.


FRIGIDAIRE

Natural Finishes

Natural plasters and finishes are a great non-toxic alternative to the conventional finishing products that are available on the market today. Natural finishes are a beautiful, and often cost-savings, way to render and paint your earthen walls. One of their greatest benefits is actually for our own health. Most people don't even realize the negative effects that synthetic finishing products have on their wellbeing. Indoor air pollution and toxic off gassing is a whole subject unto itself. But by using natural plasters and paints, you avoid the added toxicity of drywall and chemical paints.

Natural plasters and finishes can be applied to all types of earthen walls! The majority of natural plasters and finishes are made from a combination of these simple ingredients: soil, sand, fiber, lime, kaolin clay, wheat paste, pigments, and water.

Plastering your cob home is like putting the icing on the cake. Once you have built your walls, built your roof, and installed the windows and doors then you can begin to plaster your building. The plaster will protect your walls from rain on the outside, and it will protect your earth walls from any erosion or crumbling off on the inside.

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, but you may get some deterioration on your walls over time. 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 with light and pale colors can brighten your home by reflecting natural light inside. Use darker colors to set a certain mood. With natural finishes, you can create almost any color possible. It's up to you how you color your home so get creative!

Vapor Permeable Finishes

It's critically important that you only use vapor permeable finishes on any earthen walls. A vapor permeable finish is one that allows air and moisture to freely pass through it. You need to let your earth walls “breathe” freely. Cement-based finishes and synthetic paints block the ability for air and moisture to pass freely through the tiny pores of earthen walls.

Do not use any impermeable cement-based stuccos, moisture barriers, tar, oil-based paints, or latex-based paints on cob structures or earthen walls. 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 one way or another.

Moisture will condense behind cement stucco, or any kind of vapor barrier, and soak your cob walls. This will completely destroy the strength and integrity of your earthen structure. This is why it is so important to never use these types of coverings over your cob walls. Always use vapor permeable natural plasters and paints. They are usually cheaper, more beautiful, and always better for your health.

Earthen Plaster

Earthen plaster is made with a highly processed 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. The ingredients for earthen plasters are low-cost. However, creating this sort of plaster takes a lot of manual labor and processing to create.

There are a few other notable disadvantages to earthen plasters. They tend to be dusty and sandy, and are not great choices for home interiors if they are like this. These plasters will also erode and degrade faster than lime-based plasters. I usually recommend earthen plasters be used for exterior walls, and to protect them with a high stem wall and long roof overhangs. If your foundation and roof don't shelter the earthen plaster finish, you might need to re-apply a new coat every few years for maintenance. These plasters do not hold up well to rain. You can also stabilize earthen plasters by adding lime to them. This will give them much better water resistance.

Creating earthen plaster can be a lot of work. It's a matter of finely processing all of your ingredients into a smooth mixture.

- Soak your soil for at least 2 to 7 days depending on how hard your soil is. The longer you soak the soil the better though.
- Thoroughly mix the soaked soil with a bit of water. The soil will become a thin mud slip at this point.
- Sift the mixed soil through at least a ¼ inch screen. Further sifting the soil through a bug screen is ideal.
- Sift the sand through a bug screen, or purchase pre-sifted sand. You want to use fine grade sand for plaster. Bags of sandbox “play sand” also work well for this.
- Shop up the straw into small bits and pieces, under 1 inch in length.
- Combine the sifted soil and sifted sand into a container and mix them together with a bit of extra water, as needed. You will need to determine your ratio the same way you do with cob. Make tes patches of plaster to find your best ratio.
- Mix in the chopped straw to the container.
- The finished plaster should be around the consistency of a thick cake batter. It should be easy to spread onto your walls.

Earthen plaster and lime plaster are both traditionally applied to walls using a hawk and trowel. I like to use a drywall taping knife for plaster application. You can use various sized knives to work in different areas. The other tool I prefer to use for plaster application is a small, round piece of flexible plastic (about the size of the palm of a hand). This simple tool is great for working plaster into rounded and uneven parts of cob walls. They are also great for compressing and polishing plasters to a smooth finish.

Lime Plaster

Lime plasters have been used for thousands of years. Lime is a vapor permeable material that works very well with earth walls. 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 or structure. Lime plaster is a mixture of lime putty (or lime powder), sand, and water.

I prefer to use lime-based plasters for interior surfaces and exterior surfaces. Firstly, they are a base white (or light grey) color so they are easy to pigment to any color you want. They are much cleaner and more sanitary than earthen plasters. If you rub your hand across lime finishes, sand doesn't come off your wall as it does with many earthen plasters. Lime plaster is also fungicidal and anti-bacterial. Lime plaster is also very resilient to water and requires much less maintenance than earthen plasters do. Overall, it's more costly to purchase lime but it has so many advantages over earthen plasters.

Lime can come in many different forms. Ready-made lime putty is one of the best types of lime that you can have for plastering a building. However, this is not readily available in the United States. It's widely used in the UK though. Bagged, hydrated lime (Type S) and hydraulic lime powder are available in the United States and are still effective. You can even soak powdered

lime in water for long lengths of time to make your own lime putty.

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.

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's like 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 plasters dry and re-calcify back into limestone.

When working with lime, you should consider wearing a respirator to prevent breathing in any lime dust. Like cement, lime is caustic and can burn your skin if it's exposed to lime for too

long. Its recommended to wear gloves if you will be handling lime material for long periods of time. If lime gets on your hands or skin just rinse it off in water. You may find that working with lime dries out your hands by the end of the day. Apply moisturizer to your hands if this occurs. If you feel like your skin is burning from the lime you can rub your hands or skin with vinegar to neutralize the alkalinity of the lime. If lime gets in your eyes, wash them out with water immediately. Wear eye protection to prevent this from happening.

Lime Wash

Applying lime wash is one of the cheaper ways to cover and protect your earth walls. Lime wash is just a lime putty watered down to the consistency of milky paint. It can be applied to your walls with a paint brush. It can also be made with hydrated lime and hydraulic lime. NHL 2 power will provide you with great results for a lime wash.

For added protection to your walls, you can apply an earthen plaster as a first coating. Apply the lime wash over this. You may need several coats of lime wash to get a white finish over a dark earth color. Mist your walls with water before applying any lime wash, and always wait at least 24 hours before applying the next coat of lime wash.

Try not to apply lime wash in direct sunlight or in the rain. A cloudy day is the best kind of day! If you can, cover your lime wash with sheets for 24 hours to protect it from sunlight exposure.

Tadelakt

Tadelakt is a lime-based finishing technique used to beautify and add waterproof properties to surfaces in your building. It's a water resistant finish that can be applied to sinks, showers, pools, spas, baths, or to decorate a wall. Tadelakt is permeable to air but impermeable to liquid water making it vapor permeable like other natural finishes.

This technique originates from Marrakech, Morocco and has been used by the Berber people of North Africa for centuries on their adobe and rammed earth buildings and casbahs. Tadelakt is believed to have first been used to waterproof their ancient cisterns and traditional bathhouses.

Tadelakt is a lime-based plaster finish. Olive oil soap is applied onto the fresh lime, which creates calcium stearate (the same thing as soap scum).

Lime + Olive oil soap = Calcium Stearate

Tadelakt is like very beautiful soap scum (calcium stearate), and it almost never needs to be cleaned. Lime’s high pH value means that tadelakt is both fungicidal and anti-bacterial. It's actually a very clean product!

The tadelakt surface is finalized and polished with a black olive oil soap, which reacts with the lime plaster to create the waterproof surface. A final coat of beeswax can be applied to give it even further luster!

How to Get Started

Many people envision building their own cob house one day. Some people hire an experienced builder, but most of the time they build it themselves. Building any kind of house or building on your own can seem like an overwhelming challenge for most people. Especially for those who have little or no construction experience.

There is no single path to constructing a house. Every building situation will be at least a little bit different for everyone. You will need to set your mind on your goal and pursue it from many angles. Everything is within reach for you. You just need to set your goal, make a detailed plan, and continue to educate yourself.

Set a Goal, Make a Plan, and Educate Yourself

Determine what your goal is and create a step-by-step plan as you continue to educate yourself. Your plans, and even your goals, might change during the process. Modify things as you continue to learn, and refine everything as much as you can until you have everything laid out with a clear plan of progression.

Consult experts in specific fields if you need help: architects, engineers, building departments, general contractors, electricians, plumbers, etc. Draw up a detailed building design using 3D software, such as SketchUp. Having computer designed drawings at your fingertips will be invaluable to you and any outside experts working with you on your project. You will be able to modify plans and visualize every detail of your construction before, during, and after your construction.

Continue to educate yourself. The field of construction is multifaceted and you will never know everything there is to know about building. If you can, take your time in the learning process before jumping into building your home or building. The more you know and understand about different aspects of construction the better your design and skill at building will be. Learning about how to construct a home is a lifelong continuous process. Knowing how to build cob and earthen walls is only one step in the process. Depending on who is designing and building with you, you may be able to skip some areas of learning, but I would suggest empowering yourself with as much knowledge and oversight as you can for your project through self-education.

The last piece of advice here is that you must immediately begin to take action. Take what you have learned from this book and start to apply the information in some way. Building a house is a step-by-step process. Go take the first step!

Beginner Cob Building Projects

To get started with cob building, I recommend starting with a small project first before jumping into something large like a building. There are several small projects that you can do at home in your backyard to get your hands dirty and acquire a little experience.

Cob Oven

Building a cob oven is a good first project for new cob builders. There are some technical details that need to be paid attention to in construction of an earthen oven, but there is far less cob that has to be mixed overall for this project.

With this project, you will get hands-on experience with mixing cob, building a foundation, sculpting cob into shape, and applying natural plaster. With a cob oven you will also learn how to make insulation-cob mixes.

Note: For details on how to build a cob oven, please refer to *Build Your Own Earth Oven*, by Kiko Denzer.

Cob Wall

A small cob wall is a great project to begin with. For starters, it's a good way to test your cob mix on a larger scale project to see if your mix ratios have any problems. Small test bricks many times hide underlying issues.

With this project you will get experience in building a foundation, mixing and applying cob to form a wall, finishing with natural plaster, creating a bond beam, and attaching a roofing structure (to protect the wall if you’re in a wet climate).

A cob wall can be as long and as high as you want it to be (within reason, of course). There are all kinds of places where you can build one. You could build a cob wall to spruce up your garden or yard, for example.

Cob Dog House

Another good project that you might want to start with is a cob dog house. This project is slightly more advanced than the other two listed above, but it's very doable for beginners. It's a lot like building a miniature version of a cob house. Except with this, you have more room for errors and forgiveness if you make mistakes. You will also not need any permits to construct a cob dog house.

Want to Learn More? Get Over 16 Hours of Video Lessons

One of the first recommendations that I make to anyone who is interested in building a cob house is to **get some training**. Whether you will be physically building the house yourself or having someone else do the construction, knowing the details of cob construction will guarantee you a **better design** and **fewer mistakes** along the way. In building, mistakes can cost you a lot of money and time so they are best to be avoided whenever possible.

I recommend that people get as much training and experience as possible before taking on a large building project. It's best to take a comprehensive cob building workshop and any additional construction and design classes to supplement the workshop.

However, I also understand that getting training can be difficult for a lot of reasons. Most people who want to take a cob workshop and get the skills they need to design and build their own cob home tend to run into **three main problems**.

- Workshops are **too expensive** and not affordable for the value gained.
- **Not enough time** available, and no time to be away from work.
- Workshops are **too far away** and travel time and costs add to the burden.

These three things are preventing a lot of interested people from participating in cob workshops, but I'm going to offer you my solution to these problems right here.

I've created an exclusive online classroom where you can login and download a virtual learning experience from the comfort and convenience of your home. You will receive **over 16 hours of video lessons** in this course. The program is self-study and you can learn at your own pace without any stress of travel or deadlines.

If you found this book helpful and you want to take your learning to the next step then I recommend you to **join the online cob building academy**.

Click here to learn more about the online school.

Every topic that you've read about in this book will be covered in detail in the video lessons. As well as many more to further educate you in general construction.

Check out some of these other interesting topics covered in the course:

- How to build a traditional stone foundation
- How to square your site for building using the Pythagorean Theorem
- Tools to build a cob house
- Stone masonry tools and how to collect stones
- How to layout a round foundation
- How to build cob archways
- How to build on a timetable
- How to trim cob walls
- How to make and apply earthen plaster
- How to mix and apply lime plaster
- How to mix and apply tadelakt (Moroccan waterproof finish)
- How to protect a cob building from moisture
- Plaster and finishing tools
- How to integrate cob and strawbale walls together
- How to construct a concrete bond beam
- Introduction to 3D design with SketchUp
- How to perform a cob toss
- Introduction to living roofs
- Mechanized cob mixing
- How to build the roof before the cob walls
- How to find and work with architects and contractors
- Cob builder's property purchase checklist

The online video course has been made **very affordable** and **convenient** for you to enjoy and experience. Take the next step in your cob building education today. Click here to get all the course details.

Appendix

Please refer to the sections in the appendix for more important information and knowledge about earthen construction and building a cob house. The appendix has answers to many frequently asked questions.

Cob Building Codes

The Cob Research Institute's proposed cob building code for the 2021 International Residential Code (IRC) was approved at the International Code Council's Public Comment Hearings on October 26th, 2019. It's currently referred to as IRC Appendix U: Cob Construction (Monolithic Adobe).

This new building code will allow people the opportunity to build code-approved cob homes much easier and at a much lower cost than before. The cob code has had extensive research put into it that the average person could not do, or it would be outside of their financial possibility to have done. The new cob building code is a big step in a positive direction for more cob homes being built throughout the United States.

Before the cob code, many people were barred from building cob homes due to very limited understanding of the material by local building departments. Some people were able to build code-approved cob homes before the code was developed, but the chances were much smaller. Having the code greatly increases our chances of being permitted to build cob homes in the United States now.

You can read and download the cob code by visiting the Cob Research Institute's website. https://www.cobcode.org/code-download

How much does a cob home cost?

The cost of a cob home is as variable as for any other type of building. There are so many different variables that go into the cost of building a home. A cob home is no different in this regard. You can really spend as little or as much as you want to build a cob house. (Note: You get what you pay for.)

The raw materials required to make cob walls are very cheap, but remember that a cob house has many more components than just earth walls. Everything together will add up to a significant amount of money by the time you finish the construction.

There is a misconception that cob homes are cheap to build. This is rarely the case. A cob house, in our current construction market, is generally more expensive to build than a conventional house. A rough average cost-per-square-foot estimate for building a cob house is between $200 and $250. About half the cost of building a cob house goes into the labor. If you can build your cob home yourself and save that labor cost, you can build a cob home for roughly the same price as a conventional home or sometimes much lower.

Every home construction will be different and costs will vary. You can build a cob house for a few thousand dollars if you want to, or you can spend tens of thousands, hundreds of thousands, or even millions of dollars to build one. This is up to you, your plan, and your finances.

How do cob homes do in wet, humid climates?

Cob homes actually do very well in wet, humid climates. Vapor permeable earth walls do not stay wet if the building is properly built. Wet climates are only a problem when cob buildings have basic design flaws, such as short roof overhangs and low foundation stem walls. A 1.5 foot high stem wall and 3 foot long roof overhangs should be enough to protect any one-story cob home in the wettest of climates. If water does get onto cob walls, the water will dry out or pass out of the wall quickly.

Do cob homes have mold and mildew problems?

There is a misconception that cob homes have mold and mildew problems. Again, when you see these issues in cob homes it stems from basic design flaws and poor construction quality. Earth walls will easily dry out if they get wet, eliminating any chances for mold and mildew to flourish. Putting things into more perspective, conventional wood and drywall buildings are notorious for molding and mildew. These materials are excellent breeding grounds for molds, and mold is very hard to eliminate once it's taken hold in these types of structures.

Are insects and rodents a problem with cob?

Cob walls are not generally known to be burrowing grounds for rodents or animals. However, there are some varieties of bees that like to burrow holes into cob walls. You may encounter such a thing when

you build a cob structure. If you have this problem, I would recommend rendering the exterior walls with a lime plaster. Insects will not eat through this layer.

You should also be aware of ants and make sure that they do not burrow into your cob walls. Other insects and animals will not attempt to burrow into hard cob walls.

Can you build a cob house in a cold climate?

There are ways to insulate your cob walls for a cold climate. I would always try to avoid attaching insulation directly onto the cob walls though. This can cause problems with moisture build-up between the insulation and the cob wall. I would recommend either a dual-wall system or sandwiching rigid board insulation in the middle of the cob walls.

A dual wall can be created by building your cob walls using a slipforming system. Do half of your walls as high insulation mix, and the other half of your walls as load-bearing cob. Please research the CobBauge Project for more details on this type of dual-wall system.

Using a forming system, you can also sandwich rigid foam insulation in the center of your cob walls. The interior and exterior walls are generally tied together through the middle with rebar. Please research SireWall for more details on this type of insulated earth wall.

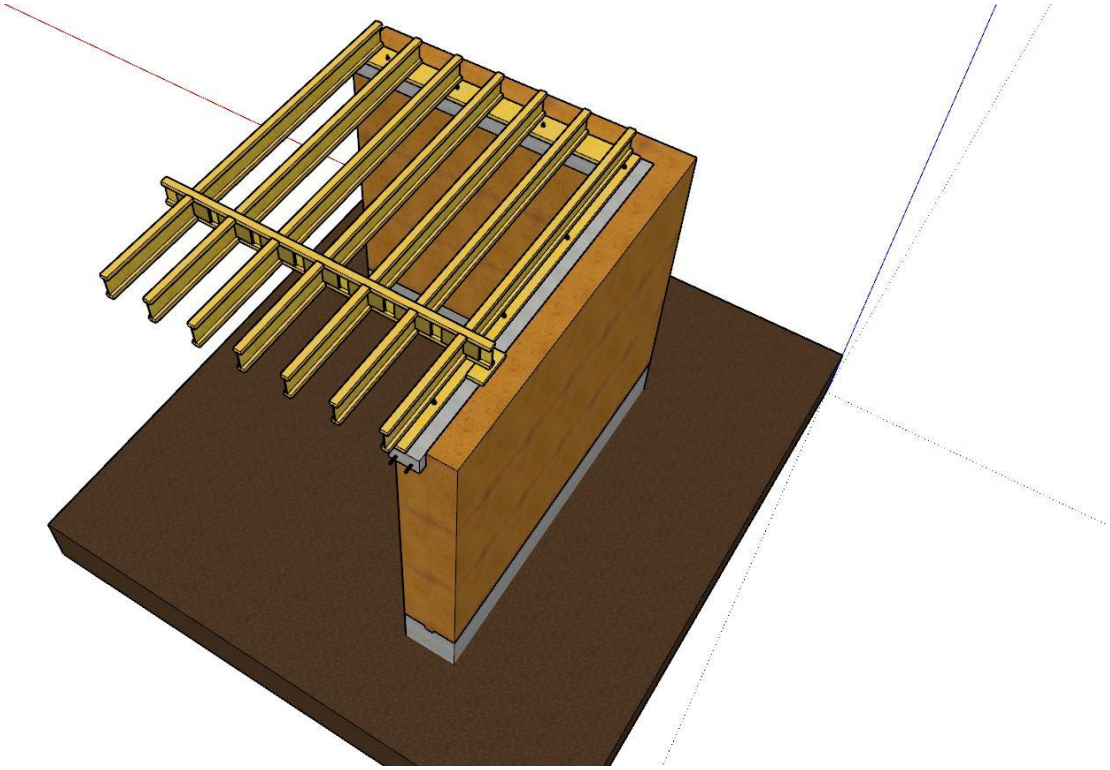
Floor Options

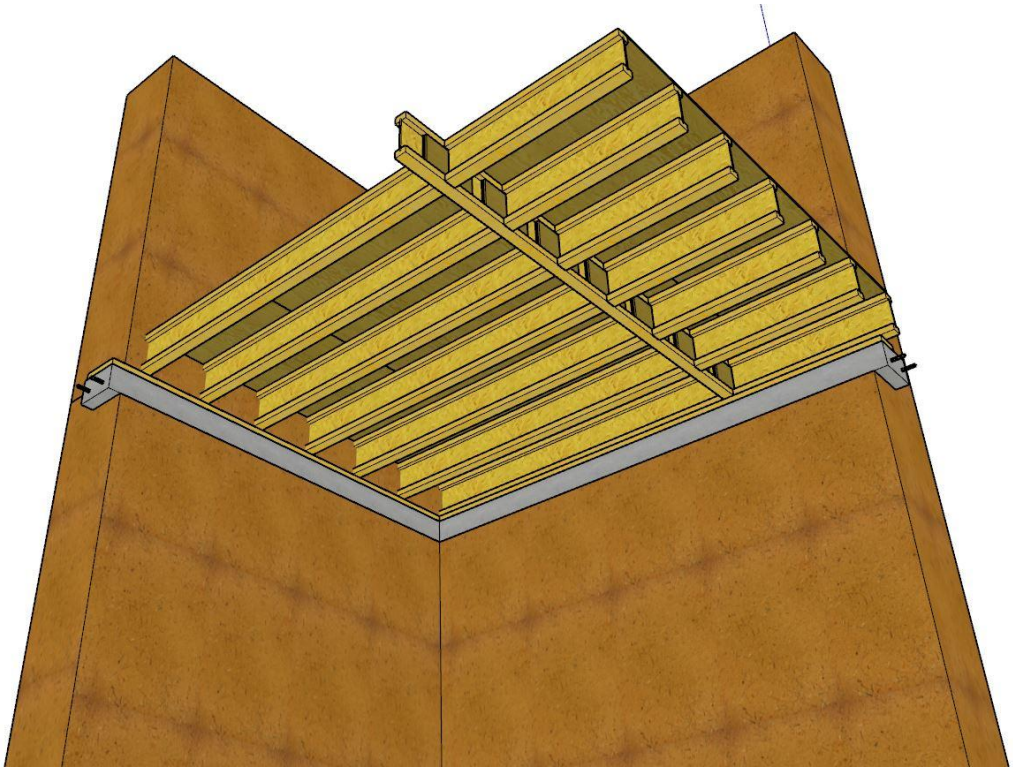
You can have any type of floor in a cob building. There are really no limitations here. Some typical floor options for cob homes are: concrete slab, wood, tile, and earthen floor.

You can use the same ingredients for cob and earthen plaster to make an earthen floor. The floor mix is spread out, set to dry, and then coated in several coats of linseed oil. Please refer to the book *Earthen Floors* by Sukita Crimmel for a comprehensive resource on earthen floor construction.

Second Story Floors

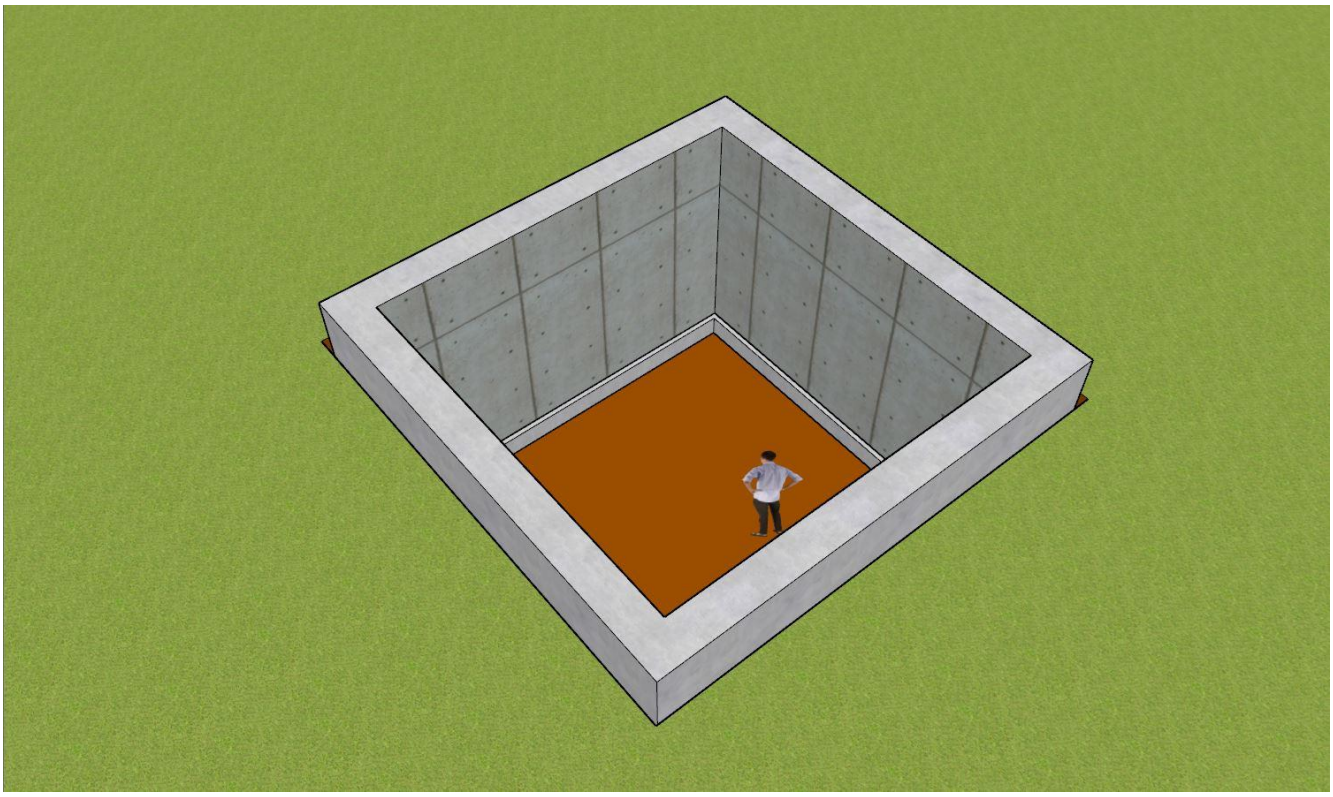
You can install second story floors (or higher) by embedding your floor joists into the cob walls. Install either a full bond beam or a half bond beam at the level you want your floor joists to rest. Set the floor joists in place, and continue to build the cob walls up and over the joist ends.





Basements

You can have a basement under a cob home. You will basically be digging a really deep foundation in this case. Instead of your footers being only a few feet underground, they will be beneath the floor level of your basement. Your stem walls will extend upwards from these footers to about a foot or two above ground. The stem walls still need to be as wide as your cob walls will be. This makes for a very big and expensive foundation! I recommend using concrete for all basement foundation components.



Can you build cob walls underground?

No. Please do not attempt to build cob or any type of earthen wall underground. This is not even advisable in dry, desert climates. If you have earthen walls underground, they have no protection from water. I recommend concrete for any type of underground wall.

Window and Door Buck Installation Process