A MOTHER EARTH NEWS E-book exclusive

Natural Building Methods

Creating a Home from Natural and Eco-friendly Materials



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Cover photo by Bill Steen

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YOUR GREEN DREAM HOME: FIRST THINGS TO CONSIDER

By Clarke Snell



STEVE MAXWELL

Before you hire a contractor or start building, read this expert advice.

In 12 years of home construction, I have never talked to anyone who had realistic expectations about building a house. We green building types usually are even worse because our goals are so high. We don't simply want a good house, we want to transform our lives and save the planet in the process. These are wonderful aspirations. I have no desire to denigrate them, but I would like to inoculate the dream with a bit of realism while also providing tips for grabbing that dream by the horns and dragging it into the light of day.

The first hard lesson is that you — and only you — are responsible for your house. You may need the help of professionals, but ultimately only you can figure out how to integrate your idiosyncratic personal needs with your exact spit of land.

The point is that a good house is the symbiosis between specific people and a specific place. If you agree with that sentiment, then you have no choice but to get involved in the creation of your house. The only question is, how far should you go? Build it yourself, or write checks and watch from the sidelines? To me, the only imperative is that the house comes from you. The number of people you get to help with the building is unimportant. Even the most rugged individualist with only a few hand tools and a pickup that hauls soil and straw (for making cob) has enlisted the help of hundreds of people — those who designed and built the truck, manufactured the tools or grew the straw. Enlisting the help of architects and builders is no different — we all need help. The important thing to realize is that the building buck stops with you — the house is your dream, and it's your money.

LEARN THE BASICS

None of us are indigenous builders with an intuitive understanding of the materials we'll be using and how they can come together to create a complete entity called a house. (If you are, then stop reading and start building!) It's not enough to say that you're going to build a house with straw, earth or wood. You have to understand how those materials will interact with

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CLARKE SNELL (2)

There is no substitute for practical experience. If you're not familiar with construction, then learn valuable lessons by building a shed (left) or office (right) that's a small, simple version of your house.

your particular outside environment in a way that creates the inside environment that you need to be comfortable, happy and healthy. To do that, you'll need to research four basic topics and how they relate to your particular situation. Whether you're going to build it yourself or just take responsibility for the process, you need to understand:

Structure. The manner in which your building will hold itself up.

Temperature. The mechanism by which your building will maintain a basically stable interior temperature in the face of flucuating outdoor temperatures.

Separation. How you'll separate your building from the destructive forces of nature (sun, water, wind and life-forms).

Connection. The ways in which your building will keep you in constant connection to those same natural forces — air, water, sunlight — because they are precisely what you need to survive.

DON'T TRUST SUPERLATIVES

While researching the basics, you'll encounter differing opinions. In fact, if you've ever seriously researched anything, then you've learned that experts tend to disagree. In home construction, experts don't just disagree, they sometimes live in alternate universes. I can't think of one basic building topic on which I haven't read credible yet diametrically opposed opinions: venting, vapor barriers, building materials, insulation values, air exchange — the list continues. Experts debate these things, and best practices go through constant revisions and updates.

Another problem is misinformation. The fact is that many well-meaning people involved in the varied realm of green building see it as a crusade, a battle of good versus evil. In struggling to get people to listen, they can fall prey to painting a picture that's too rosy. The unfortunate result is that you have to take everything with a grain of salt. Here's just one example: Until recently, it was common to see claims that three-string straw bale walls produce insulation values of up to R-60 (R-value is a measurement of resistance to heat flow). After the excitement cleared and the science floated to the surface, it seems that the more accurate R-value for three-string straw bale walls is in the low 30s. That's wonderful insulation, but it's about half of the original claims. There are similar myths for many other green building systems and materials.

The best protection against this problem is to distrust superlatives. If someone claims that a material or system is easy, cheap or the best, exercise at least a little skepticism. On the other hand, a plethora of useful information and wonderful, knowledgeable people are out there. You have to create a balance between your superior knowledge of your exact situation and the superior experience and general knowledge of experts.

TRUST LOCAL KNOWLEDGE

Because housing has to fit both the people and the places involved, theories will only take you so far. When looking for guidance, you need to find people who share your green building point of view and have experience with your local environment, both climatic and human.

If there are any surviving indigenous building practices in your area, then that's the first place to start — find out what the old-timers are doing. Don't forget that in many ways there are more similarities than differences between green and conventional buildings. Therefore, local experience — even if it is staunchly conventional — often is quite valuable. Plastering is a good example. The ways in which different plaster mixes will perform in your area can be determined only through experience. I'd rather discuss a mix with a local building veteran than have an experienced green builder from another climate choose my mix. The best approach is to listen to both experts and then make your own decision.

CAN YOU BUILD IT

The success of your house will be measured in the details. We could build two houses side by side that look identical. One could be drafty, moldy and experience structural damage in just a few years. The other could be warm and cozy, withstanding the elements for many years without damage. The difference would be in the details. Is the flashing correctly installed around the roof, chimney, doors, windows and at the base of the walls? Where does rainwater go after it hits the roof? Is there a foundation drain? Was the passive solar thermal mass inside the house isolated from the earth and the outside air? Should it have been for your climate? The answers to these and other questions can't be easily determined after your house has been built. They require planning and careful attention to detail during construction.

Detailing is a potential downside to choosing some green building techniques because these approaches are not yet part of the construction vernacular. Where do you turn for advice when you have technical difficulties attaching wood roof framing to a monolithic cob wall; or when you are confused about flashing details for a cordwood building? Books only give general information. Text that seems clear in print can be incredibly incomplete when you are trying to carry out the operation described. Inexperience and trailblazing don't go well together. If you don't know what you are doing, then choose building alternatives that have a history in your area and lean on those experienced with them when you need help or advice.

Having said all of that, I think you can build or be very involved in building your own house. The less experience you have, the more preparation you'll have to do. The ideal approach would be to get involved in a project similar to your own with an experienced person in your area. If you plan to build with wood and straw, then look for work — whether paid or volunteer — using those materials.

If you can't find a project similar to what you have in mind, then build a small version of your house — perhaps a workshop or playhouse. Make sure it has all of the elements that your real house will need such as doors, windows,

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CLARKE SNELL

The owner-builders of this straw bale home in western North Carolina took a patient and deliberate approach: gaining experience through other projects, getting to know the site beforehand and focusing on details during construction.

heating and good ventilation. Either way you do it, the hands-on experience will teach you invaluable lessons: either that you don't want to build your own house, or specific things you'll need to do better to make the real house work. Though I'm a professional builder and consultant now, my interest in housing started with the desire to build a house for myself. I began with a lot of book learning, then I eventually quit my job to become a construction worker. I spent several years learning by making a living in the building trades. Still, when I started building my house, I was overwhelmed by the task. It took about four times longer and cost much more than I had anticipated. It all turned out fine in the end, but I wouldn't want to do it again. On the other hand, my house is my biggest achievement. I know how everything goes together, its strengths and weaknesses. Building my own home has given me skills, muscles and a perspective that I didn't have before. From that point of view, I really recommend it. I'll add this: No matter how much you prepare, in the end you won't think you prepared too much.

IF YOU DON'T WANT TO BUILD IT

You've done your research and you know what you want, but you don't want to build it yourself. What do you do? This is a difficult question because you aren't going to be the typical client — you want to be very involved in the decision-making process. There are things you definitely want to try; there are other things you want to discuss before making a final decision. Many contractors will balk at this level of involvement, often for good reason. Professional builders are paid not only to build, but also to spend large amounts of their clients' money. The fact that clients employ contractors to spend their money is often forgotten — nearly every builder has a handful of stories about bad clients. Approaching someone with such a history and saying you want your house to be a team effort can be complicated. But if you do your homework, this problem should solve itself. You'll be able to explain the theories behind different aspects of the design and why they are important. Introduce your project with enthusiasm and honesty, and it will be obvious that you're an important member of the team.

The problem of finding good people to work with is exacerbated by our modern mobile society. Probably the worst thing you can do is move to a new area and begin building right away. Not only will you be unfamiliar with local conditions, but you will have no social network on which to rely. Remember, we are social animals. You can't expect to build the kind of relationships needed to create such a masterpiece as a good house by screeching into town and waving your checkbook around. People work for money, yes, but good builders also work to build good houses for personal satisfaction and pride. If things are to go well, then your builder needs to be your friend, or at least someone who respects you as part of the community.

Once you find someone whom you trust and who is willing to work with you, make it your mantra that you will be a great client. Put yourself in the contractor's shoes and it won't be difficult to calm down at frustrating moments. At the same time, you have to hold firm to making your own decisions. This is your house and having someone else build it is a compromise that waters down its specific nature to some degree. The balance between not getting in the way and remaining the decision maker will be a graceful dance.

BOUNCE BACK FROM MISTAKES

Regardless of how much you prepare, mistakes are inevitable. The best way to minimize them is with a construction process that combines intense preparation with flexibility while building. Let's look at straw bale construction for an example. Especially in a wet climate, you need to think ahead when using straw bales. First, you need to decide how your bales are going to interact with water and water vapor. Next, you need to plan the logistics of the construction carefully. In my climate, I recommend using a skeletal framing structure and installing the bales as infill. That way, you can build a roof to shelter the bales before they ever arrive. Finally, you need to plan all of the details that will keep your bales dry for many years to come: flashing, stem wall height, gutters, drainage and plaster. Even with all of that preparation, straw bale infill allows for some flexibility during construction. Window placement, for example, can be adjusted by mocking up bales and setting windows in place to see how they work. Diligent preparation will give you the peace of mind to be creative and adaptable during construction — that's the dynamic you want.

Of course you're still going to make mistakes. You'll be in very good, or at least very large, company. But you'll have done your best to prepare, and, hey, we all make mistakes. As in life, the grace with which you bounce back will say more about you than pretty much anything else.

THE PARADOX OF A GOOD HOUSE

For me, green building isn't about fads, right versus wrong, how things ought to be or how you wish things were. It's about how things are: How you are, how your land is and how the two can come together.

Yet the true reason most people are drawn to building their own homes is to fulfill a dream — that place where you can relax, where all the pieces of your life come together in a harmonious whole.

The paradox of building a good house is that you have to remain grounded in reality while dreaming. To do that, you have to understand and deal honestly with the realities of your situation — your skills, your finances, your site conditions, your time constraints, your personal likes and dislikes, your social network — while allowing yourself to push the envelope of your perceived limitations. It's the dance between these two poles that ultimately will lead to what will be your good house.

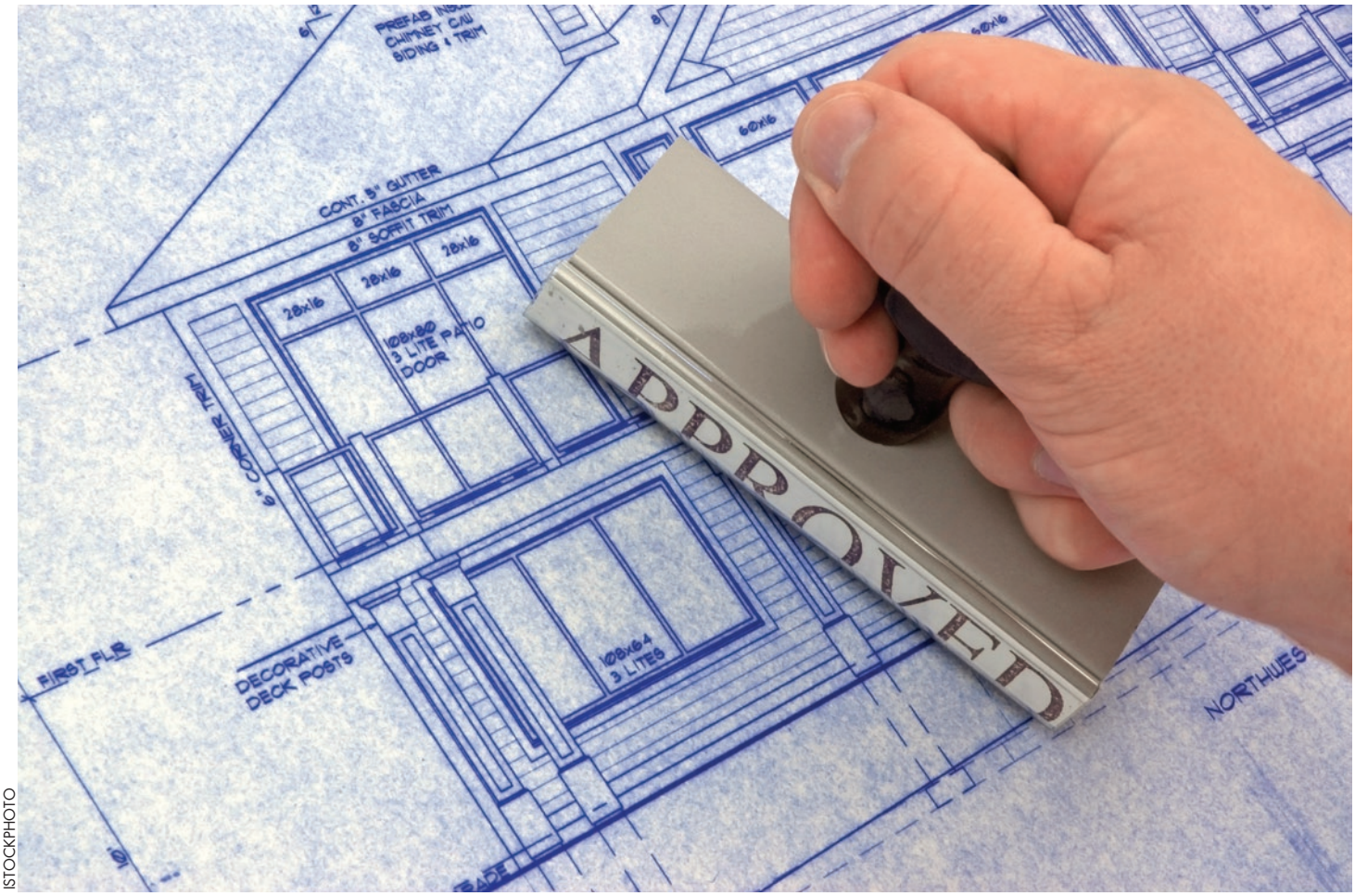
Adapted from The Good House Book: A Common-Sense Guide to Alternative Homebuilding (Lark Books).

Clarke Snell entered construction with a clear goal: to build his own good house. Twelve years later, Snell has experience with a variety of conventional and alternative building techniques, and a partially bermed, passive solar home he built in the mountains of western North Carolina. He and his wife, Lisa, plan to live there for the rest of their lives with an array of plants, some cats and tons of ladybugs. Contact Snell through his Web site, www.thinkgreenbuilding.com.

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ESSENTIAL ADVICE FOR OWNER-BUILDERS

By David Eisenberg



ISTOCKPHOTO

Here's what you need to know about building codes before you build a house.

You are about to embark on a great adventure — building your own home! Designing and building your own home gives you the freedom to build what you want, and doing the work yourself can be a rewarding experience that will save you a lot of money in the process. But for many people who dream of building, it's hard to dismiss one nagging thought: "What if they won't let me build it?"

"They," of course, are the folks at the local building department. Complying with building codes can seem intimidating. However, if you think of it as a process, much like the actual building of that dream home, you can get through it one step at a time.

Doing your homework is essential, especially if you plan to build with alternative materials or techniques. Knowing what you need to do and where to find the information you need will help you get your building approved and may even improve your home's design.

WHERE TO START

Building codes establish minimum standards for safety and health, and if you decide to build your own home, you'll need to prove that it meets these standards. There are three main phases of the process:

- Gathering information and doing the initial planning.
- Designing the house and submitting your specific plans for approval and permitting.
- Building, passing the inspections, and getting your certificate of occupancy.

Where you build matters because building, zoning and other regulations vary from place to place, as do the conditions at and around every building site. Building codes in rural areas tend to be less stringent than those in the suburbs or in town, where buildings are closer together and people are more concentrated.

Most city, county and state governments have Web sites with information about permitting processes, zoning laws and other requirements. They often answer common concerns and provide information on how to get help.

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Becky Baker, chief building official for Jefferson County, Colo., has advice for owner-builders at the beginning of their process.

"Ideally, have a conceptual meeting with the building department early on to talk about what you want to do, especially if it is unusual," she says. "You can find out what you need to do and what codes are enforced in the area." Baker says most building departments provide handouts that describe their processes, fees, minimum requirements for plans and inspections, guidelines for standard construction, and checklists for other approvals needed.

Be sure to ask about requirements specific to owner-builders. Some jurisdictions restrict what work can be done by homeowners, so knowing what the rules are where you intend to build is crucial.

"Although we know we'll have to spend more time with most owner-builders, we don't mind," Baker says. "We start with a premise of respect. We assume that owner-builders want to do the right thing and that we have the same end goals — a safe, affordable, durable, comfortable home."

Baker has one more piece of advice for those who haven't yet bought their land, especially for those who want to build with alternative materials or techniques: "Make visiting the building and zoning departments part of your routine, like checking out local schools, before deciding where you want to buy land, build and live. It makes it much more likely that you will get to build what you want to build."

GETTING THE TECHNICAL PLANS

A checklist from the building department, describing what plans and inspections are needed for a permit, also reveals what the codes cover. Whether you can produce these required plans yourself or will need help with the design or drawings will depend on the complexity of your design, your level of skill and knowledge, and local codes and rules governing when a design professional is required. At a minimum, you typically need:

- A scaled site plan showing adjacent streets, dimensions and locations of existing structures, setbacks, easements and any other significant features.
- A detailed foundation plan.
- A dimensional floor plan showing rooms and their uses with locations of plumbing fixtures.
- A roof framing plan (possibly a floor framing plan).
- Elevations (exterior views) of all sides of the building.
- Section views (views cut through the structure) to show structural details and connections.
- An electrical plan showing the location of the service entrance, lights, outlets, and special circuits for electric stove, clothes dryer and air conditioning equipment.
- A plumbing plan showing water, drain, waste and vent lines.
- A mechanical plan showing heating, cooling and ventilation equipment and duct work.
- General structural and architectural details, notes and specifications.

Some technical design questions can be answered by the building department, but don't be a nuisance. If you are new to designing houses but want to do your own plans, consider hiring an architect or professional designer for a couple of hours to have him or her review your preliminary plans. An architect will usually have insights and strategies that can save time and, frequently, more money than their fees.

Be willing to admit when you are in over your head. For example, you may need an engineer for the structural design or the septic, mechanical or plumbing systems. Better to seek help in the design phase than after your plans have been submitted and rejected, or worse, discovering what was wrong with the design after building it.

Consider this approach for any part of the process you don't feel confident tackling yourself, including once you begin building. You often can hire experienced tradespeople by the hour to help with the work and teach you how to do it at the same time.

BEYOND BUILDING CODES

It is worth noting some of the other regulatory hoops through which you may have to jump, depending on where you decide to build. The most obvious are zoning and land use codes as well as specific restrictions that may apply to your particular piece of property, such as subdivision or homeowner association CC&Rs (covenants, conditions and restrictions). Other restrictions typically relate to water, gas or electric utilities, easements, grading, erosion control

This house in Maine is being built with timber-frame construction. Building with alternative methods or materials may require some extra work to get building plans approved.



SCOTT VLAUN

Building Codes, Old and New

The first known written building code was enacted by Hammurabi in Babylon in 1758 B.C. Literally written in stone, the harsh penalties of the code established that people who are designing and building for others are accountable for the quality of their work. Though the code provided no guidance on how to build, it stated, "If a builder has built a house for a man and his work is not strong, and if the house he has built falls in and kills the householder, that builder shall be slain." Such penalties surely inhibited innovation, but they also kept most builders honest without licensing, detailed codes or permits. Also noteworthy is that this code did not apply to people building for themselves or their own families.

After the great fires in London in 1666 and Chicago in 1871, codes started addressing the risks one building posed to adjacent buildings and the public. Denser development in cities, and hazards associated with close proximity and taller buildings, led to regulations for the construction of common walls between buildings and outlawing dangerous practices like wooden chimneys. Problems in existing buildings led to codes for light and ventilation, fire escapes, water supply, toilets and sanitary drains, and stairs and railings.

In 1905, a U.S. insurance group, the National Board of Fire Underwriters, created the National Building Code to minimize risks to property and building occupants. The existence of this code led to the formation of organizations of building officials. By 1940, the United States had three regional code organizations, each with its own code. These three organizations and their codes were consolidated into the International Code Council, (ICC) and the first set of "I-codes" was published in 2000. These codes include the International Building Code (IBC), the International Residential Code (IRC), the International Energy Conservation Code (IECC), as well as mechanical, plumbing, fire and other codes.

Though the international codes are becoming the most widely adopted building codes in the United States, the consolidation didn't mean that everyone is now using the same codes. Unlike countries with codes developed by the national government and adopted nationwide, the United States has local or state codes. Some jurisdictions still enforce older codes, some have their own unique codes, and some have no code enforcement at all. All these variables make clear the importance of finding out which codes, if any, will apply at your building site.

There is no substitute for getting the applicable codes and spending some time reading through them. Look for copies at your public library.

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Ten Steps for Getting Unconventional Projects Approved

1. Start early – it's a process.
2. Gather information about the jurisdiction and applicable codes.
3. Gather information about the specific alternatives.
4. If needed, find and enlist the help of allies and sources of expertise. Maintain a positive attitude and take the high road.
5. Meet and share information with the building officials.
6. Get specific feedback from the building officials — listen carefully; get it in writing. This is a process of building trust — pay attention to the relationships.
7. Address concerns and objections as directly, factually and reasonably as you can. Demonstrate patience and persistence.
8. Carefully consider all your options — appeals, special agreements, political pressure.
9. Acknowledge and thank those who helped.
10. Share the lessons you've learned with others.



BILL STEEN

and highway or street right of way considerations. In historic districts, you may have to comply with architectural rules governing what can be done with both new and existing buildings, and many places have ordinances protecting indigenous plants and wildlife.

Don't be discouraged by these restrictions. You probably won't have to deal with them all, and most are fairly routine matters. The folks who administer these requirements usually are well versed in helping people through the process.

USING ALTERNATIVE MATERIALS

If anything in your plans might pose a problem for the building department, address it as early as possible. Laura Bartels, now a natural building consultant for GreenWeaver, in Carbondale, Colo., was an environmental educator when she and her husband built their pioneering straw bale home in Eagle County, Colo., in 1995.

"I realized the building officials would not have time to research alternatives on my behalf," Bartels says. "So I went in as an educator, with a binder of all the information I could find about straw bale construction, and talked informally about what I wanted to do. I left the binder with them, giving them lots of time to study it. When questions came up, I did the legwork and got the information to satisfy their concerns." She kept a positive attitude through the whole process, got the permit and built their home without needing an architect or engineer.

Don't be surprised if your plans are not approved as submitted, even if you're building with conventional materials. There usually are details that need to be clarified, added or corrected. The plans should come back with notations explaining deficiencies and citing specific code sections that must be met. Be sure you understand what is required to satisfy the plan reviewer. Don't be afraid to ask questions.

If something significant has been questioned or rejected, ask for a meeting with the building official to seek a resolution that gives you what you want and also satisfies the building department's obligations. In the end, if you can't reach a satisfactory solution, you have the right to an appeal process. See the list (left) for more ideas about getting alternatives approved.

PASSING THE INSPECTIONS

Once your plans are approved, you will receive a permit with a list of required inspections. Let the work begin! The inspections are sequenced to make it as easy as possible for work to flow naturally and still allow the building inspector access to all work that needs to be inspected. Don't inadvertently cover up work that has yet to be inspected, because you will be required to re-expose it.

Remember that inspectors have many sites to visit in a day and a large territory to cover. Not everyone is happy to see them. Make your job site an exception. Most inspectors have worked in the building trades; respect them for what they know.

If you fail an inspection and don't understand why, ask for the specific code requirement so you know what needs to be done. If the problem is that the work doesn't match what is called for on the plans, find out if the work as done still meets the code. If so, you may choose to go to the building department and get approval for the change rather than redo the work. If inspectors want you to do something that differs from the approved plans, they will need to resolve the issue with the plans examiner. If it is the inspector's personal opinion or preference rather than the code, you should point this out and if necessary, bring it to the attention of the building official.

In most cases, when something needs to be corrected, just do it gladly and move on to the next thing. There will be lots of minor items that need to be changed or fixed, and a good relationship with the inspector will speed the whole process.

After you pass your final inspection, you will get a certificate of occupancy, meaning you can move into your new house! The final inspection doesn't cover certain aspects of the finish work such as paint, trim, floor and window coverings, interior doors (except a door into a garage, which is required for fire separation), and some other minor work that does not require a permit or inspection. You may even choose to move into your new home before it is totally finished, though most owner-builders will tell you that it's much easier if you finish it all before you move in. On the other hand, they'll also tell you that a house is never really finished anyway.

David Eisenberg, director of the Development Center for Appropriate Technology in Tucson, Ariz., is co-author of The Straw Bale House. He writes a column for *Building Safety Journal*, "Building Codes for a Small Planet," is a contributing editor to *Natural Home* and speaks frequently on alternative construction, green building, appropriate technology and building codes.

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GO SOLAR AND SAVE BIG!

By Clark Snell



CATHERINE WANEK

Passive solar design results in huge savings on energy bills.

Great news! You have free access to a source of energy that can save you thousands of dollars on your home's heating and cooling bills. You can harness this eco-friendly energy source using inexpensive, readily available technology, and it comes with a lifetime guarantee.

The energy source is the sun, and the technology is *passive solar design* — the conscious manipulation of building temperature by using the sun's direct energy. If you are planning to buy a new home or remodel your current residence, put passive solar design on your "must-have" list.

Everyone is already aware of some of the advantages of solar design: We all appreciate the coolness of a shady porch or patio in the summer, or the warmth of a sunny window in the winter. But most people are not aware of the huge difference solar design can make in the amount of energy needed to heat and cool our homes. In most situations, a well-designed passive solar home stays cool in the summer without air conditioning, and in the winter it requires much less energy to heat. The combination of a woodstove and solar design is often enough to keep a house comfortably warm, even in very cold climates.

The best aspect of solar design is that if you're building or remodeling a home, you can incorporate it at little or no extra expense. With oil and natural gas prices rising, and power blackouts becoming more common, it now makes more sense than ever to take advantage of natural heating and cooling rather than depending on fossil fuels.

After all, we already heat and cool our homes with solar energy. That's because the fossil fuels we burn today are nothing more than stored solar energy. Plants captured that solar energy through photosynthesis, and then — over millions of years — heat and pressure transformed dead plants and animals into deposits of coal, oil and natural gas. I wish I had the biggest bullhorn ever made (solar-powered, of course) to broadcast this message: *There's a better way! Everyone should use solar design to save energy, save money and reduce pollution.*

LOCATION, LOCATION

In nearly every kind of climate, heating and cooling a building is a challenge. Maintaining a stable temperature for a tiny air mass (the inside of your house) is a difficult undertaking because of the constantly fluctuating temperature of a much larger surrounding air mass (the great outdoors). Unlike most other approaches, though, solar design makes the sun an ally rather than an adversary in this task; the key is adapting the design to the specific location where you live.

Building site. Two facts about the sun make solar design possible. First, the sun's path through the sky changes throughout the year. Second, this path repeats the same cycle every year. That's why for any given building site we

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know exactly where the sun will be during every season, so we can design our homes to capture the sun's heat in the winter and block it during the summer.

In northern climates where winter heating is necessary, the winter sun is conveniently lower in the sky, so we can point the majority of the building's windows toward that free heat source. The low angle of the sun allows a maximum of solar heat into the building through windows, which will then be absorbed by the floor and walls. In the summer, the sun will be higher overhead, so the roof can be designed to block much of the unwanted solar heat. (See "Solar Design for Cold Climates.")

In southern climates, where cooling is the main concern, the sun is higher in the sky year-round. This makes it even easier to use building elements such as roof overhangs or porches to block the sun and keep the building cooler. If you are choosing a piece of property to build on, you also can take advantage of hills, trees and other buildings to block unwanted summer sun and winter winds.

Building shape. The right shape also is important. In a climate with cold winters, houses that are long and thin on their east-west axis are best because they expose more wall surface to the south, where it will be warmed by the sun in winter. This building shape also helps houses stay cool in the summer, when the sun is higher in the sky, because it has little wall surface on the east or west sides, which will be most exposed to the sun's heat at this time of year.

But in a warm climate where summer cooling is the main concern, houses that are compact in shape are easier to cool than long, thin houses, because they expose less interior area to direct sun from any direction. (See "Solar Design for Warm Climates".) In the absence of natural features such as hills or shade trees, you also can use the shape of the house to shade living space by building an interior courtyard or covered north veranda.

THERMAL MASS AND GLASS

Designing to take advantage of the sun's position during the year has a huge effect on a building's temperature while the sun is out, but you'll also benefit from building a house with materials that store solar energy effectively.

Thermal Mass. Everything stores temperature, but some things store it better than others. Dense materials—such as stone, concrete, bricks and earth—are known as thermal mass, and they excel at heat storage. Walls and floors built with these materials act as heat sinks that help maintain a comfortable interior temperature throughout the year. This works because in any environment, heat will move from warmer to cooler objects.

In the winter, thermal mass located inside the house in front of south-facing windows will absorb and store the direct heat of the sun. After sunset, the mass slowly releases heat into the air to warm the building. During the summer, that same mass stays cooler because it is shaded by the roof and overhangs, and it pulls heat out of the interior air during the day. At night, when windows are open to allow cooler air inside, the mass releases that heat back to the air. A 4-inch thick concrete slab floor is a good option for thermal mass if you don't cover it with insulating materials such as carpet. Earthen floors also work well. Additional mass also can be added to interior walls, with the first 2 inches in depth from the

Solar Design for Cold Climates

These solar design strategies can be effective in a climate with cold winters and moderate summers. The greatest need here is winter heating, and the building will be oriented to the south.

1. Choose a building site with **no obstructions to the south** for complete access to the low angle of the winter sun. Another plus is a site with trees that can block prevailing winter winds, which are usually from the north.
2. Chose a design with **a long south wall** facing within 15 degrees of true south.
3. The house should include **ample thermal mass** (dense, heat-storing materials such as concrete or earthen floors). Consider building an **earth berm** on the north side for more thermal mass.
4. **Most of the windows should be to the south** for access to the winter sun. Minimize windows on the east and west sides and place very few in north walls.
5. Use **shorter overhangs over south windows** for better winter heat gain and ample overhangs over other windows for shading.
6. Cover windows and glass doors at night with **insulating shutters or insulated drapes** to prevent heat loss.
7. **Maximize insulation** in walls and ceiling. Use rigid insulation under the floor and around its edges.
8. Consider using a **dark roof surface** to pick up solar gain in winter.
9. **Mechanical ventilation** will probably be needed in winter; a heat recovery ventilator, which preheats incoming air, is a good option.
10. Consider a **porch or plantings to the west** to block afternoon sun in summer.



OLIVIER ROLLIN (2)

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surface doing the most good. Interior brick or cob walls, thick plaster on straw bales, or plastered drywall are all possibilities for interior thermal mass.

In some warm climates, thermal mass also can be used as a kind of dynamic insulation in exterior walls. In the desert, where it is very hot during the day and significantly cooler at night, many homes are built from adobe, cob, rammed earth or concrete. Heat absorbed by the dense walls of these homes slowly moves inward during the day. But before it has a chance to reach the interior, the sun goes down, and exterior temperatures begin to drop. When the outside temperature drops below the inside temperature, the heat stops pushing inward. This happens because heat always moves toward cold. The heat then moves back toward the outside, causing the wall to cool down.

On the other hand, thermal mass isn't always useful. For example, in a tropical climate where it is breezy, humid and shaded by forests, direct sunlight isn't the issue, so thermal mass wouldn't be an effective way to cool your home. In this case, solar design would focus on ventilation.

Windows and glass doors. The careful placement of glass doors and windows is the next step in tapping solar energy. To capture heat, you'll want to place windows and glass doors along the long south wall to allow the low winter sun to shine in. Be conscious that glass on the east, west and north sides will let more heat escape than it will collect from the sun during the winter. The most common passive solar design mistake is to use too much southern glass and not enough mass. Fortunately, a lot of information is available about how to compensate for variations of climate and design. Do your research and enlist the help of experts.

NATURAL COOLING

For summer cooling, you'll want to block direct sunlight, but open doors and windows to let in wind. Using air movement for cooling can be difficult to fine-tune because wind is the natural element that varies most from site to site. The most effective research you can do when building a home is to spend a lot of time on-site during different seasons to understand how the wind moves there, then place windows and doors accordingly. Still, many generalities apply. For example, window screens reduce air flow by up to 50 percent!

In the summer, the more shade you can create, the cooler your breezes will be. Large porches and roof overhangs over windows and doors are a good way to create shade. Of course, trees and other vegetation also create shade.

Plants around the house also provide evaporative cooling, a process by which hot air is cooled by taking on water vapor, in this case from the constant transpiration of water by plants. Various studies have shown that a large hardwood tree can evaporate 100 or more gallons of water a day, creating a cooling effect equivalent to 10 window-unit air conditioners running for 20 hours. This, too, is tapping solar power, which is fueling photosynthesis in the tree.

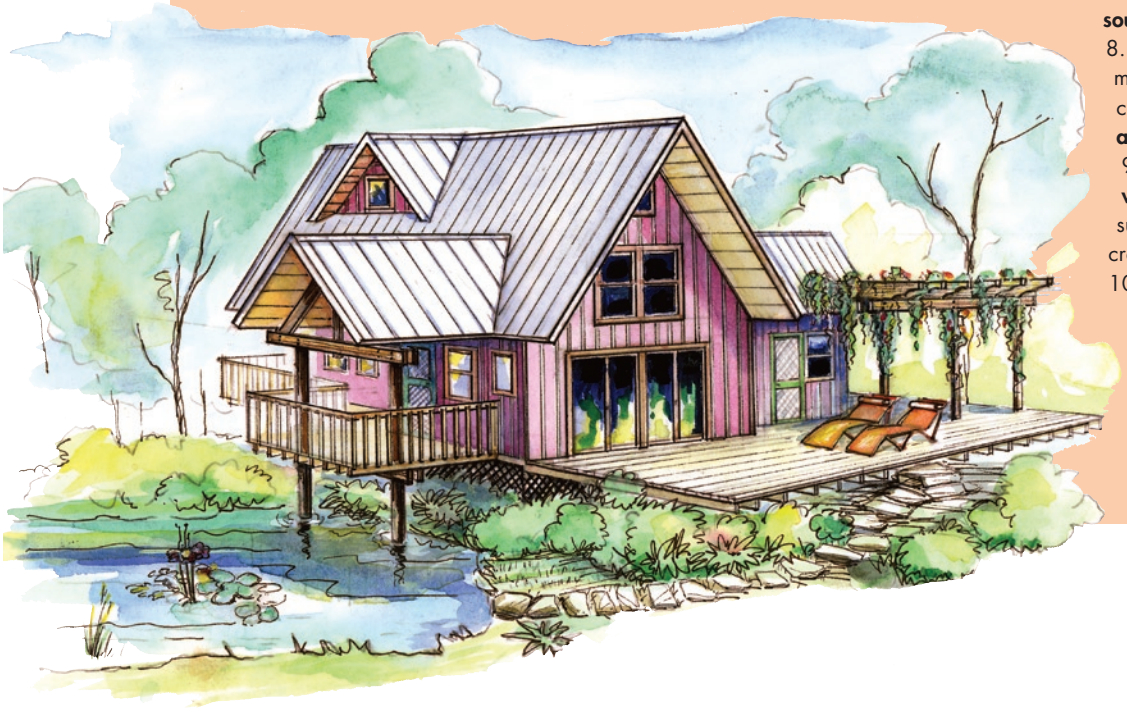
SLOWING HEAT MOVEMENT

To maintain temperature, we have to slow the inevitable movement of heat. Materials

Solar Design for Warm Climates

These solar design strategies can be effective in a climate with mild winters and hot summers. Cooling is the main need, and more of the living space should be oriented to the north.

1. Look for a site where the house can be positioned with plenty of **outdoor living space to the north**. Another plus is a site with **trees to the east and west** to block morning and afternoon sun.
2. The house should be **compact in shape**, with less wall area exposed to the sun. Build shaded porches and patios.
3. Focus on outdoor living space to the north and east for cooking, sleeping and relaxing. Comfortable **shaded verandas** are inexpensive additions that make a house feel luxurious.
4. Take advantage of the cooling effects of vegetation by planning for **plenty of trees**, vines and garden space. Established shade trees are an invaluable resource — protect them!
5. Maximize **insulation** in the walls and in the ceiling.
6. For the roof, use a radiant barrier and **reflective metal or light-colored roof tile** and create air space between the roof surface and the sheathing.
7. If some winter heating is required, thermal mass, such as a concrete floor, and **windows to the south** can be used.
8. If using south-facing thermal mass for winter heating, use deciduous trees or a **vine-covered arbor** to shade it in summer.
9. **In arid climates, use thick walls** as a buffer against the sun. Minimize windows to increase this effect.
10. **In hot, humid climates with no winter, don't worry about thermal mass.** Lift the building off the ground over open crawl space to encourage air flow. Maximize window and door openings on all sides.



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placed to slow the movement of heat are generically called insulation. However, heat moves in different ways, so insulation needs to be chosen based on the type of heat movement you're trying to prevent.

Light, airy materials such as fiberglass and straw bales slow conduction. Conduction is the transfer of heat from molecule to molecule through a material, such as the metal in a pot on a stove. It is best slowed by materials that form a complicated web that the heat must traverse. This is the principle behind most materials we normally label as insulation, including fiberglass, polystyrene foam and forms of organic cellulose such as cotton, straw bales and shredded newspapers.

Stopping air leaks slows convection. Convection is the transfer of heat by physically moving molecules from one place to another, such as the air that rises in a fireplace chimney. Many materials won't let air move through them: Wood, concrete and plaster, to name a few, allow basically no convective heat loss through their volume. Problems often arise, however, at joints between and breaks in these and other materials. Windows, doors, plumbing vents and electrical boxes are all potential convective weak points. Once identified, though, they can be sealed effectively. One huge source of convective air loss is opening the front door. This can be greatly reduced by creating an entry room, sometimes called an airlock or mudroom, that isolates the living space from the outside.

Reflective surfaces slow radiation. Radiation is the direct transfer of heat by means of electromagnetic energy: The sun heats the Earth through space with radiant energy. Heat absorption from radiation is best slowed by using reflective materials. How reflective a surface is depends on its color. A white surface is an effective reflector of light, but a poor reflector of heat. On the other hand, a shiny metallic surface is a good reflector of light and heat, but a poor emitter of heat. If you're trying to cool a home in the summer, a shiny metal roof does a good job of reflecting the light and heat of a sunny summer day away from the building, but at night a white roof will release the heat trapped in the attic more rapidly than a shiny metal roof.

MORE BENEFITS OF PASSIVE SOLAR

We've quickly outlined some of the basics of solar design, but they only begin to describe the benefits of living in a passive solar home. Here are a few other advantages of using solar design strategies.

Long-term savings. Ron Judkoff, director of the Center for Buildings and Thermal Systems at the National Renewable Energy Laboratory, says, "There is nothing intrinsically more expensive about passive solar construction. In fact, basically the same materials used to construct many modern homes can simply be rearranged to make a passive solar building."

Once built, passive solar buildings are cheaper to operate, so they will save you money — and lots of it — over the life of the building. "It's relatively easy in most climates to create a passive solar building that will use 30 percent to 70 percent less energy than a comparable nonsolar design," Judkoff says.

Attractive home designs. A common misconception about passive solar homes is that they are designed like space-aged cubicles. Older books on passive solar homes are full of wild, complex designs, including such things as retractable exterior walls and roof pond storage masses with movable nighttime covers. *Forget that stuff!* Passive solar homes can be designed to fit almost any style or aesthetic.

"Far from being limiting, passive solar design gives you a wealth of building elements to work with," says Greg Jackson, an architect and adjunct professor of sustainable design at the University of Kentucky. "Overhangs, roof articulation and a focus on the relationship between sunlight and glass all add visual interest to a building."

Buildings can be retrofitted. You don't need to have the perfect site or the opportunity to build a new home to take advantage of passive solar design, because you can make meaningful adjustments to an existing building. Any of the following can have significant effects on the thermal performance of your house: major work such as a complete solar retrofit; intermediate actions such as adding windows and an interior mass wall facing the winter sun; or simple do-it-yourself changes such as adding arbors with deciduous vines over windows and doors.

"Passive solar additions to existing buildings bring an excellent return on your initial investment," says builder and educator Marcus Renner of Appropriate Building Solutions. "A well-designed sunspace addition, for example, will cut energy bills by providing both solar heat and illumination. It will also create a cozy room that increases floor space and provides a great environment for plants. As if that weren't enough, all of these features add value to your house."

The bottom line. As heating and cooling costs rise and the scramble for dwindling fossil fuels escalates, it's time to tap the elegant, common-sense principles of passive solar. As corny as it may sound, we really can build a better world. The sun is shining down on us with the answer; all we have to do is soak it up.

Clarke Snell is a builder, consultant, writer and educator. He is the author of *The Good House Book: A Common-Sense Guide to Alternative Homebuilding*, and, with contractor and master builder Tim Callahan, *Building Green: A Complete How-to Guide to Alternative Building Methods*. You can contact him through his Web site, www.thinkgreenbuilding.com

BOOKS

The Good House Book
By Clarke Snell

The Passive Solar House
By James Kachadorian

The Solar House
By Dan Chiras

WEB RESOURCES

Passive Solar Design
An overview of passive solar design strategies from the California Energy Commission.

Sustainable by Design
Advanced tools for calculating sun position, the impact of window overhangs and more.

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BUILD WITH STRAW BALES

By Catherine Wanek



DAVID VAN CLEVE

Anyone can build a straw bale home — thanks to the community spirit associated with this Earth-friendly building technique.

Singly, stalks of straw are fragile, but hundreds together, compressed and baled, make a solid building block. Stack a bunch of these blocks together and you have a sturdy wall. Roof and plaster these walls, and you can have a beautiful, superinsulated and energy-efficient home.

Popular for its sustainable qualities, straw bale building also is a great way to build community. Building and plastering is labor-intensive but fun, and similar to barn-raising — for these giant mud-pie parties, the more helping hands, the merrier. Owner-built projects enlist anyone willing — family, neighbors and friends, new and old. In the end, everyone takes pride in the building; plus, the owner gets free labor and the volunteers learn all about straw bale building. It may then be just a matter of time before the group builds again, all the wiser from the previous experience.

Straw bale veteran Judy Knox saw this empowering spirit spread after leading 160 inexperienced builders in a particularly intense straw bale wall raising: "Around the walls I heard, 'I can do this!' People were literally starting to talk about that possibility in their own lives — that they could build their own house."

A wall raising also sold Texas architect and owner/builder Ben Obregon on straw bale. "We saw people of all ethnic, economic and religious backgrounds working together for a common goal," he says. "In a society where we normally build barriers between ourselves, something that brings people together was so refreshing and unusual, that we wanted to do it ourselves."

Straw bale building originally was conceived more than a century ago out of necessity — homesteaders in the Nebraska Sandhills, a rolling grassland largely devoid of trees, built their houses' walls from load-bearing straw bales, preserving precious trees for the roof structures. But during the last decade, modern pioneers have rediscovered this humble material and begun building with bales, creating affordable, sustainable and beautiful homes all over the world. (To find a straw bale workshop near you, go to www.thelaststraw.org.)

Aesthetically, straw bales create wide, shapeable walls that can satisfy any design preference. On the outside, straw bale homes can be beautiful and eye-catching without looking like the odd house on the block.

Practically, superthick straw bale walls can reduce heating and cooling bills by 30 percent to 80 percent over conventional construction, saving homeowners tons of money. And replacing conventional stick-frame walls with bales can cut the amount of timber needed for construction in half, reducing demand on forest resources. Straw bales commonly are available wherever grain crops are grown, and straw is even considered an agricultural "waste product" in some regions. In many parts of the world, straw is simply burned in the field — the millions of tons that go up in smoke every year would be better used as an energy-efficient building resource.

Natural and nontoxic, straw bales provide healthy indoor air quality, especially when combined with clay-based plaster. Compressed and sealed with plaster, bales are extremely resistant to combustion. Yet another

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CATHERINE WANEK

A well-prepared straw bale wall is a pleasure to plaster, and good flashing details will pay off in the first hard rain. As with any home, poor detailing will lead to more maintenance.

advantage is that thick bale walls cut down on noise — some people describe the feel of these solid, organic walls as an ultra-snug home that surrounds you like a warm embrace.

TWO DESIGN OPTIONS

Building a house with bale walls is not so different from traditional new-home construction — it requires a foundation and roof, doors and windows, mechanical systems and a lot of hard work.

An important early decision is which of two common wall systems to construct: load-bearing or post-and-beam. In load-bearing construction, the bale walls bear the weight of the roof. In this system, bales are stacked like giant LEGOs, overlapped as in brick construction and capped with a wide wooden "bond beam," to which the roof is attached. A modest, single-story rectangular building lends itself to load-bearing design, and generally is cheaper to build than a post-and-beam bale structure, primarily because of reduced lumber costs. Load-bearing bale walls usually can be erected faster, too.

In post-and-beam-and-bale construction, builders erect a wood, steel, concrete or adobe structure and use straw bales as infill insulation; the roof loads are carried by the posts and beams, so the bales are not structural. Larger, taller and more complicated floor plans generally require this strategy.

One advantage of the post-and-beam method is that the roof can be finished before the bales are delivered to the site. This provides a handy place to store bales out of the weather.

FINISHING TOUCHES

The simplicity of building with bales is inviting to novices and, indeed, many a straw bale wall has been erected by an exuberant, inexperienced work party. But constructing a home is neither easy nor cheap; after the walls are up, there is plenty of finishing work to do.

Water is straw's No. 1 nemesis and must be a priority concern during construction. Exposed to more than 20 percent moisture content (about 80 percent relative humidity), bales will support fungal growth and begin to decompose. Conversely, if kept perfectly dry, they can remain intact for centuries.

A well-designed foundation and roof will prevent most moisture problems in bale structures. Raising straw bales 6 to 10 inches above grade and installing a moisture barrier between the stem wall and first course of bales should prevent moisture from wicking up from the ground. And creating an indoor "toe-up" or curb, which supports the bales a couple of inches above the final floor surface, protects your straw walls in the event of interior flooding. To seal your walls from invasive critters and rodents, meticulously plaster the foundation-to-bales junction.

A roof design that incorporates wide eaves will shed rain and snow far from bale walls and protect plasters from becoming water-saturated. Flat roofs and parapet walls are not recommended because of the possibility of leaks. Good window detailing also is critical to avoid moisture infiltration. Windows commonly are set to the outside of an opening, leaving a bale-wide shelf or nifty window seat on the inside. Where window ledges are exposed, proper flashing is essential, and a drip edge is recommended.

Finish plasters serve multiple functions: They protect straw bale walls from wind and rain, seal bales from birds and rodents, and add structural strength to walls. In laboratory tests, compression strength, wind resistance and shear strength were all significantly enhanced after plaster was applied. Plastering both sides of a straw bale wall seals out oxygen and provides fire resistance. A well-plastered bale wall also is critical to energy efficiency, as even minor gaps will allow air infiltration, reducing the insulation value of the wall.

Renowned for their beauty, earthen plasters (primarily made of clay and sand) are the most permeable and have the advantage of being hydrophilic, which means they will wick moisture away from straw and wood, protecting these materials from rot. Praised for absorbing odors and softening sounds, earthen plasters also can be made from onsite soil and applied safely with bare hands. The finished surface can be smooth or textured, and tinted with mineral pigments. Earthen plasters also moderate humidity inside homes, improving indoor air quality.

Straw bale buildings mostly are known for their beauty, durability, and resource-and energy-efficiency. But the good feeling that emerges when people come together to help each other is probably the most satisfying aspect of building with bales. As we work, sweat and laugh together, we develop a community which, like the straw bale compared to a piece of straw, is stronger than each of us individually.



CATHERINE WANEK

Electrical wires can go right through straw bales, though it's wise to limit plumbing to interior walls. The wooden framework will support future kitchen cabinets.

Author, photographer and filmmaker Catherine Wanek has been at the forefront of the straw bale movement for more than 10 years.

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EXPERT ADVICE ON STRAW BALE BUILDING

By Chris Magwood, Peter Mack and Tina Therrien



LAURA TAYLOR

Surprising answers to common questions about this popular alternative building method.

Houses made from straw bales are attractive, affordable, energy efficient, environmentally friendly and can be designed to match the owners' personal needs, aesthetics and budget. These homes are made by stacking rectangular bales of straw and covering them with a plaster shell. Straw bale walls are at least twice as energy efficient as those from conventional stick-frame construction and will save you money on heating and cooling bills. Such savings are among many reasons why straw bale building is no longer a fringe idea, but one that has spread throughout North America and the rest of the world. Other attractions include its adaptability, hands-on building satisfaction and the cozy atmosphere created inside these homes.

With this recent surge in popularity, the collective knowledge built from the successes and mistakes in this grass-roots movement has helped the technique evolve — we now know much more about what works and what doesn't. So before you decide if straw bales are right for your dream home, here's expert insight into common questions about fire resistance, moisture, pests, building costs, mortgages, insurance and resale value.

FIRE RESISTANCE

Straw bale walls are naturally fire resistant. Loose, dry straw is combustible, but when it is compacted into bales, there's not enough air for the straw to burn well. For a good analogy, compare the combustibility of a single sheet of newsprint to that of an entire telephone directory. A single sheet will burn quickly, but a phone book will just smolder. Combining plaster with the compactness of a bale wall enhances fire resistance. The plaster coating effectively seals the already fire-resistant bales inside a noncombustible casing. According to fire safety tests conducted by the National Research Council of Canada, bale walls withstood temperatures up to 1,850 degrees F for two hours.

MOISTURE

Regardless of which materials you use to build your house, moisture is an enemy, and this topic is hotly debated among bale builders. When built correctly, straw bale homes don't pose any greater moisture risk than conventional buildings. According to the 2000 Strawbale Moisture Monitoring Report, submitted to the Canada Mortgage and Housing Corp., "straw bale walls do not exhibit any unique propensity for moisture retention."

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LILKER HECHT DESIGN STUDIO WITH STONES THROW DESIGN

The walls of this unique passive solar home, located outside of Huntsville, Ontario, are made with straw bales, demonstrating one of the many ways bales can be incorporated into home design.

The main source of potential moisture problems is liquid penetrating into the wall cavity. This can happen in many ways such as windblown rain, drifting snow, splash-back from a dripping roof, plumbing leaks, floods, holes and breaches of the wall's protective layers in leaky roofs and window sills. Many simple, effective building techniques are used to protect bales from exposure to moisture. Generous roof overhangs and proper eave troughs will eliminate most direct rainfall and splash-back from reaching the walls. A bale wall that is raised on a wooden curb on the foundation or floor will ensure that any spills or floods inside the house will not soak into the walls. Plastic or tar paper placed along the top of walls will protect against any water that may come through your roof. Windows and doors also can be installed with proper flashing and drip edges that shed water away from the walls.

The other way moisture can damage a building is vapor migration through walls. Think about blowing up a balloon. You force warm, moist air from your lungs into the balloon, creating an air-tight container with a higher pressure than what exists outside the balloon. The moist air will do its best to leave the balloon and join the surrounding atmosphere. During the heating season, your house functions similarly to the balloon: When heat is added to your living space, your relatively airtight house is filled with warm, moisture-laden air. Extra moisture is added by breathing, cooking, bathing, etc., and that air will naturally search for a way out of the house and into the cold, dry air outside.

As the warm, moist air tries to travel outdoors, it will begin to cool. As it cools, the water vapor it carries will condense back to liquid. If liquid is deposited in your walls and allowed to remain there without drying, it will reduce the efficiency of your insulation and eventually lead to mold and rot. In hot climates, the process can happen in reverse, especially if you use air conditioning.

The plaster coating on straw bale walls is an effective barrier against moist air leakage. If properly tied in with conventional polyethylene vapor barriers installed in the ceiling and under the floor, a bale house can be made almost airtight. In conventional building practice, moisture is prevented from migrating into the wall cavity through the use of plastic vapor barriers. This addresses the real concern of air leakage in stud-framed homes, but it is unnecessary in bale walls.

PESTS

We share this planet with billions of creatures both large and small. To say that a particular house or style of construction is pest-proof is to ignore the instinct and persistence of our little neighbors.

The ideal homes for pests offer openings, nests and food. Plastered bale walls do not offer any of these three because their coating seals the bales from foundation to roof with a difficult-to-chew barrier. Should a gap be left open in the plaster, the bales themselves are too densely packed to make comfortable housing for mice and other rodents. All those comfy spaces in your neighbor's frame walls, lightly packed with batt insulation, make a much more inviting home for pests.

Not much food is available for any living creature in a straw bale wall — even termites dislike straw. However, an inordinate amount of seed in the straw could provide a source of food, which is why you should check your bales for excess seed content before purchasing them. But make sure — as with any style of construction — to keep pests out during the building process.

BUILDING COSTS

Most contractors estimate the cost of a wall system will be 10 percent to 15 percent of the total budget. Because of this, your straw bales (as a building material) are going to directly affect only that percentage of the total cost. That said, straw bale buildings can offer a small cost advantage over conventional homes, mostly in the form of less expensive building materials and sweat equity. By replacing both wall-framing lumber and insulation — plus plastic vapor barriers, nails, glues and more — with straw (a single inexpensive material), you can lower material costs. The interior and exterior plaster cladding, depending on the choice of ingredients and application method, can be comparable in price to that of other cladding systems such as drywall, brick, vinyl or wood siding.

You also might save money on framing labor. Because bales are more "user-friendly" than other wall systems, many people save on labor costs by doing the work themselves. The cost of hiring labor for frame homes and bale homes is about the same, so the amount you will save depends on how much sweat equity you put into the house. Most people combine hired help with their own labor and that of volunteers — family, friends and neighbors.

Remember that if you build the house yourself, you will have to make a significant time commitment. While you may not be paying for labor, you may be losing earnings from missed time at your job. You should mix and match your talents and interests with those of local professionals to find a good balance between your budget, time and level of expertise.

With the exception of the exterior, other construction costs for a straw bale house can be identical to those of any other building style. You can buy cheap materials to save money on other aspects of your house, such as the foundation, roof, windows, mechanical systems and interior finishings, but make sure you weigh the initial savings against long-term benefits. More money spent upfront on better building materials can lead to energy savings and lower maintenance expenses in the long run.





CATHERINE WANEK (2)

Straw bale houses are cozy, attractive, affordable, energy efficient and can be designed in different architectural styles. Here are examples of straw bale homes in Steamboat Springs, Colo. (above); Kanata, Ontario (top).

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MORTGAGES, INSURANCE AND RESALE VALUE

Perhaps the most difficult part of building with straw (or any other alternative building material) is presenting your project to the various institutions that must be involved. Lenders and insurers are conservative and averse to risks, and any construction method that is perceived as new or experimental can seem like a risk they'd rather avoid.

Sufficient evidence exists to convince lenders and insurers that your proposed straw bale house will be a safe prospect, but you will have to educate them. The U.S. Department of Energy has published positive findings about straw bale construction (go to www.eere.energy.gov and search for "straw bale"). The Canada Mortgage and Housing Corp. (www.cmhc-schl.gc.ca), which helps set many of the standards used by lending institutions in Canada, is supportive of straw bale construction, and its data can help you when negotiating for a loan.

Potential lenders also must have confidence in your financial situation. You can make a compelling case for a straw bale home project by bringing the lender a good set of professionally drawn building plans and a realistic budget and timeline. Ensure your budget contains guaranteed quotes for materials and services you'll require. If you are a first-time builder, you may need to hire professional consultants to prove to the bank that good help is available should problems arise. If you are hiring a general contractor to build your home, he or she will have to fill out paperwork for the bank, too. Hiring someone with a good local reputation will help.

It takes thoughtful preparation and patience to explain straw bale construction to a lender. Before they secured funding, many bale builders had to approach numerous lending institutions to find the right combination of personality and corporate culture. Don't let a rejection deter you. If you truly are a "good risk," you will eventually find the money.

As the number of straw bale homes continues to increase, it becomes more likely that a financial institution in your area has already approved funds for one. Do some research into existing bale homes near you to find out if their builders received loans.

Insurance companies are concerned with facts and figures that indicate levels of risk. The existing research for straw bale homes scores positively with most insurers, especially the excellent fire ratings. Many insurance companies already have these test results on file; others will consider the ratings and results if you submit them with your application.

Building code approval is usually the only structural requirement of insurers, so with a permit and fire test ratings, you can usually obtain insurance. Some straw bale homes have been insured at rates lower than similarly sized conventional homes. However, it may take determination to find the right insurer. Your role as educator, builder, well-informed client and confident planner cannot be underestimated.

In current real estate markets, chances are good that a straw bale home will receive a lower resale value estimate than a stick-frame equivalent. However, low appraisals do not necessarily guarantee low resale prices. Those looking for a strong, unique and superinsulated house may decide that the attractions of straw bale are worth more to them than the home's appraisal indicates. (As a side benefit, lower appraisals often mean lower property taxes.)



JAN COHEN

If you decide that a straw bale home is what you want, plunge in and do it. You will open doors to a new and lively community that will spring up around your efforts. Friends you didn't know you had will emerge to help, and connections will be fostered with other like-minded people.

Adapted from More Straw Bale Building, a Mother Earth News "Book for Wiser Living" by New Society Publishers.

Chris Magwood is the lead instructor for Fleming College's sustainable building program in Ontario and the former editor of *The Last Straw*, a straw bale-building newsletter (www.strawhomes.com). Peter Mack and Tina Therrien met on a straw-bale job site ten years ago. They now operate Camel's Back Construction (www.strawhomes.ca) in Warsaw, Ontario.



CATHERINE WANEK



DAVID PATTERSON PHOTOGRAPHY

Above: In this straw bale home, a half-wall has been creatively placed to provide divisions of space without spoiling the room's spaciousness.
Left: Lines of this Ontario straw bale home echo the churches and schools of the area's early settlers. Top: The traditional "truth" window reveals a straw bale, providing evidence of the home's building material.

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OUR STRAW BALE DREAM HOME

By Catherine Wanek



CATHERINE WANEK

A central Washington couple explores sustainable straw bale construction and builds a beautiful, comfortable home.

David and Margie Van Cleve did their homework when it came time to build their dream house near Yakima, Wash. As civil and chemical engineers, respectively, they knew early decisions would have lasting influences on their home's comfort, durability and energy efficiency. With that interest in mind, they analyzed every design choice for its effect on their pocketbook — and the planet.

For several years, the Van Cleves had been thinking about building their dream home. David's work as a civil engineer brought them to central Washington state, where they happily settled "for the duration." They knew they wanted their home to resemble a country farmhouse and blend in with the region, which is famous for its fruit orchards. Based on their research, David had drawn a floor plan they liked, but they could not visualize how the outside would look.

Committed to energy conservation, the Van Cleves also wanted a well-insulated house that was not of standard "stick-built" construction. "We had looked into straw bale, but it seemed too exotic," Margie says. "We were actually thinking of going with foam-insulated concrete forms or stress-skin panels."

Then they found Washington architect Terry Phelan of Living Shelter Design, who specializes in sustainable design. Phelan told the Van Cleves that the central Washington climate, with its low annual rainfall and extreme seasonal temperature swings, was perfect for straw bale, and that she could give them pointers on building with straw. And "Margie's face lit up," Phelan says.

Having previously lived in New Mexico, Margie loves the look and feel of the thick-walled adobe buildings that are Southwestern hallmarks. She imagined their cats lounging on wide, sunny windowsills with the curved edges that are so easily created with straw bales. And because her job allows her to telecommute, she needed a quiet workroom. In discussions with Phelan, they came up with the idea of creating a loft office, to utilize space under the tall, gabled roof.

"Terry took our layout and came back with a house of reasonable size," David says. "The design looked livable, and the outside looked like a nice, friendly house that would fit in with our neighborhood."

INVESTING FOR THE FUTURE

The approximately 2,400-square-foot home cost about $130 per square foot. The total cost was slightly higher than a standard "stick-frame" home because of the many high-quality features the Van Cleves incorporated into the design, including double-glazed wood-frame windows, hardwood floors, wool carpets and

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custom maple cabinets. They also chose commercial-grade materials for the plumbing and electrical systems, trading a "higher capital cost for lower maintenance." Margie says, "As engineers, we chose to put extra quality into the infrastructure." The result is a home that should have a much longer life than a conventionally constructed house.

Through a landscaped front yard, a path curves to an inviting arched entry. Just inside the door, custom shelving, cleverly integrated under a stairway to the second floor, displays the Van Cleves' collection of Native American arts and crafts. To the left of the main entry, the kitchen, dining and living rooms are integrated into a spacious great room with a cathedral ceiling and views to the south and west. To the right of the entry are the master bedroom and guest suite, both designed with 36-inch-wide "zero-step" doorways.

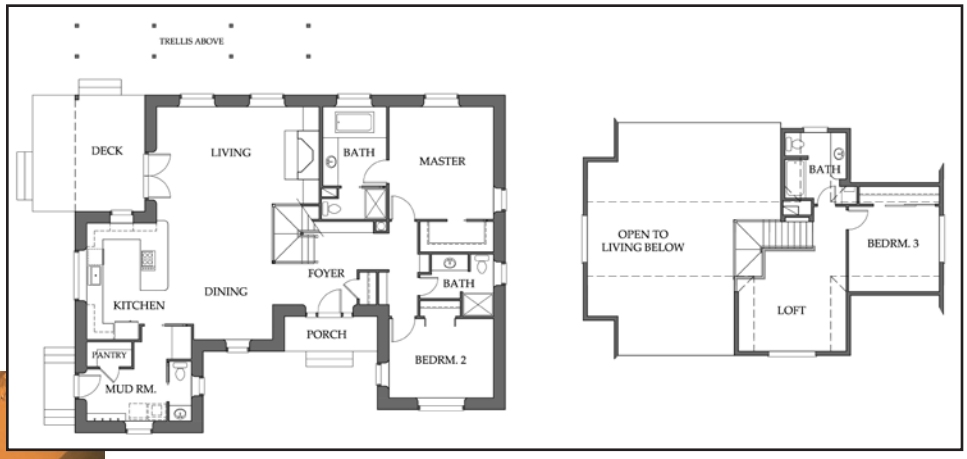
"We want to grow old in this house, so the ground floor is pretty much wheelchair accessible," David says. "And we created a separate suite that's also accessible in case Margie's mother needs to live with us."

Through the more frequently used door on the south side of the house is one of the home's more unique rooms, the multipurpose mudroom. Given central Washington's dry climate, Phelan designed the mudroom to be a central collection point for dirt and dust. The mudroom also contains a clothes washer and dryer, pantry and recycling center inspired by the book *The Not So Big House*. In a space the width of a large closet, Ken Schiffelbein of Artistic Cabinets built a base cabinet that houses three deep drawers, each with three 10-gallon trash cans. The trash cans hold recyclables and store bulk cat food. The Van Cleves also open their mail here and readily send junk mail to the recycling bins.



DAVID VAN CLEVE

The Van Cleves and their straw bale building crew. David Van Cleve is at right in the front row; architect Terry Phelan is fourth from left (in straw hat) in the center row; and Margie Van Cleve is second from left in the back row.







DAVID VAN CLEVE (2)

Top: Margie Van Cleve's home office, from which she telecommutes via a high-speed Internet connection. Above: The great room consists of living and dining areas.

The mudroom has another handy feature for the four Van Cleve cats: Buzzy, Little Bit, Monster and Patches. Margie and David wanted to keep their upright freezer in the mudroom so it would be near the kitchen. To create space for both freezer and the cats' litter box, Schiffelbein built an 18-inch-high wheeled platform, which raises the freezer for easier access and leaves plenty of room underneath for the litter box. This innovation accommodates humans, felines and appliance.

Upstairs is Margie's home office, where she telecommutes via a high-speed Internet connection. Her spacious office has a lovely view to the east, toward Yakima Canyon, and is open to the great room below. The upstairs loft also could be enclosed to create a third bedroom should the need arise, and it is already plumbed for another bathroom. As an avid amateur photographer, David had the attic space fitted with a built-in storage system for his slides and photographs. "We like our floor plan a lot — the only change I would make is to make the sliding patio door larger, so it would open wider," Margie says.

SWEAT EQUITY

When the time came to build the straw bale walls, Phelan led a volunteer work party of the Van Cleves' friends and neighbors. This was the first straw bale building for all involved.

"We were Terry's first straw bale design that actually got built," Margie says. "What we knew about straw bale was from two books, *Build It With Bales* and *The Straw Bale House*."

From the beginning, the Van Cleves learned to adapt to unforeseen situations. "Our house was designed for 36-inch bales but we got 48-inch bales," Margie says. "We had to make lots of custom bales, which became a real pain." Plus, the contractor put in more posts

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DAVID VAN CLEVE

The south walls of the house, left, and the garage, prior to the first stucco coat. Eventually, the garage roof will be fitted with a photovoltaic solar-power system.

than the design called for, which meant more notching. Still, the wall-raising was a rewarding and bonding experience. Whenever something tricky came up, the crew would stop, talk it through and figure it out. "It's not rocket science," David says. Since then, two of the volunteer couples have built their own straw bale homes, with the Van Cleves on hand to assist.

To help control costs and the quality of their home, David and Margie acted as their own general contractor. Living next to the building site, in a house they sold after the new home was finished, made the work easier, but it still was a challenge.

"We'd change clothes after work, go over and work on the house until 10 p.m.," Margie says. "We worked 95 percent of nights and weekends. After about six months, we were really frazzled. It was hard, but I would do it again."

As the general contractor, they had more control over the building process, including hiring subcontractors and occasionally firing those who didn't perform professionally. They also were on-site to supervise and make the myriad decisions required along the way. "I'd go to sleep at night with a pad of paper by the bed in case I thought of something, or had a problem bugging me," Margie says.

"Because we were on our own construction schedule, when we got to the electrical system we could take our time picking out fixtures and thinking things through," David says. "So our switches and lights are just what we wanted." David did all the plumbing and electricity, including wiring the fixtures, which were designed to accommodate energy-efficient, compact-fluorescent bulbs. He kept electrical runs in the interior walls as much as possible and avoided running plumbing through the straw bale walls.

David and Margie also did the interior painting, stucco prep and the rock work surrounding the fireplace, but subcontracted the plastering. They turned to Rich Radoslovich, who chose a cement/lime exterior stucco, and a gypsum plaster for the interior finishes.

David and Margie chose red oak hardwood floors rather than a concrete slab (traditional for passive solar and geothermal designs) for their floor surface. Atop the stem wall — the perimeter foundation wall that supports the post-and-beam structure — they installed truss joists. This allowed them to insulate the floor below the plywood subfloor and hardwood finish floor. The red oak flooring is made of pieces called "shorts." These 10- to 24-inch pieces are the leftovers after full-length oak pieces are cut; consequently, they are relatively less expensive.

For the structure, 4-by-4 wood posts connect to 3-by-9-inch laminated beams above, which support standard wooden trusses. A brick-red, standing-seam metal roof tops the structure. With an apple orchard next door, the red roof with green trim fits in with the neighborhood.

GEOTHERMAL & SUPERINSULATION

For heating and cooling, the Van Cleves installed a closed-loop, ground-source heat exchanger that taps into the constant 55 degree temperature of the Earth below the frost line. In this "geo-thermal" system, ethylene-glycol (anti-freeze) solution circulates in pipes buried beneath the house. The antifreeze passes through a heat exchanger, which a heat pump uses to warm or cool air distributed in ductwork running throughout the house. Whenever the heat pump compressor comes on, it preheats the home's hot water. The closed-loop, geothermal heat pump system has an estimated payback of 10 years at current Northwest energy prices, which are some of the lowest in the United States. "Geothermal is the most energy-efficient way to heat a home, period," David says.

The Van Cleves decided to site the house to maximize the expansive views to the west. This is not the ideal orientation for passive solar design, which calls for mostly south-facing windows. But the house design does follow two other tenets of energy-efficiency: an air-tight envelope and high R-value insulation. ("R-value" measures resistance to heat flow; the higher the number, the better.)

David and Margie's superinsulated envelope has proven effective. The straw bales provide an R-value of 38 for the 18-inch-thick walls, almost twice the code requirement in Washington. Floor trusses insulated to R-30, ceilings insulated to R-45 and insulating shades on double-paned windows also increase the house's energy efficiency. The Van Cleves' energy bills remain low — much less than those of similarly sized stick-frame houses.

To prevent overheating from west-facing windows in the summer, the Van Cleves developed a strategy to passively cool their home. On warm afternoons, Margie closes the shades on the west side of the house. After dark, she and David open the east/west windows, and the cool night air rushes in, flushing any remaining warm air out the upstairs windows. In the morning, they close the windows again, trapping the cool air inside for the day. Thanks to this strategy and the straw bale walls, the Van Cleves only need to cool the house with their geothermal system about two weeks out of each summer. And since the home's completion in 1999, they've only used their backup propane fireplace once — last winter, when temperatures dipped to 20 degrees below zero. The couple also built a three-car garage with straw bale walls using a wood pole-barn design. The garage roof is oriented due south, to accommodate a future photovoltaic solar-power system to provide electricity.

LIVING HAPPILY EVER AFTER

After 13 months of construction, David and Margie finally moved into their nearly finished home. They remember well the wonderful feeling of sitting at last in their great room, in awe of their accomplishment. "Our house turned out great!" they say, noting the best part is "the thick walls and the resulting warm, quiet home."

By virtue of their deep involvement in building their home, the Van Cleves are now the local straw bale experts, and they get a lot of visitors wanting to experience a straw bale house for themselves. "We love to show our home," David says. "People's first reaction usually is, 'Wow! What a nice house!'"

The Van Cleves have surrounded their country home with a perennial landscape of native and drought-tolerant plants, many ordered from a Santa Fe, N.M., nursery. They also spread a thick wood-chip mulch to hold in moisture and help stop noxious "cheat grass" from invading their garden. Last year, they splurged, installing a gazebo and a pond with a waterfall that now attracts a diversity of wildlife. And the couple's four cats, who have the run of the house, lounge most afternoons on cozy, bale-wide windowsills, watching the birds that gather in the garden.

Writer and photographer Catherine Wanek has been on a straw bale soapbox since building a straw bale greenhouse in 1992. Her most recent book is *The New Strawbale Home*.

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WAITRESS BUILDS FORTRESS

Story and Photos by Dorothy Ainsworth



A gutsy homesteader builds her post-and-beam dream home for just $15 a square foot.

I wanted a big log house. Never mind that I had no building experience, no fat bank account and no helpmate. What I did have was a piece of land, an old pickup truck and a high threshold for pain.

My long-smoldering desire for a rustic home had ignited into passion when I turned 40 — "Ripeness is all," Shakespeare wrote. I moved to Ashland, Ore., found an affordable piece of land and secured financing. With a federal loan, I bought 10 acres for $40,000 at 6.5 percent interest. The property had two outbuildings that I remodeled into storage and temporary living space. Now, I just had to come up with a practical plan for my dream home on my waitress's frayed-shoestring budget. Vertical-log construction was the practical choice for a 125-pound woman with a strong back and a sturdy chain saw.

With a pole permit from the U.S. Forest Service, logs were available for only 3 cents a foot, and I could get them just 20 miles away. Short logs would fit in my pickup; they would require minimal notching, so the walls would go up fast. Shrinkage in length is negligible, so settling wouldn't be a problem. Besides, Davy Crockett was my great-great-great-great-uncle, and that's how he did it. Forts back then were erected in a day, stockade style. Why not now?

CUPID COMES TO OREGON

With enthusiasm and newfound confidence, I forged ahead. In and out of the forest, and back and forth to work I went. Like a squirrel, preoccupied with survival and security, I was oblivious to anything but "acorns."

Until I met Kirt. Somewhere between doing sit-ups at the fitness center and serving two eggs over-greasy at the restaurant, I fell in love.

Kirt was quiet and good-natured, and had the most satisfying shoulders I'd ever seen — not to mention arms and legs like tree trunks. Hercules! He also had blonde curls, blue eyes, sparkling teeth and a dimple in his chin. (Excuse me while I faint.) Never mind that he was half my age. We adored each other, and time stood still.

The year we met, 1989, was spent giggling like children at recess while stockpiling 300 logs from the forest. A conventional courtship it was not. Gossipers called us Jock and Jill. I called us lucky. If this rough-hewn figure in a flannel shirt and Levi's wasn't the marryin' man, he certainly was the carryin' man! (See photo, Page 26.)

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Kirt was wise beyond his years, and authentic. He respected my wishes and nurtured my dreams. Equality was a given. Our similarities far outweighed our differences — the age gap didn't matter. Just out of college, he was pursuing his own goals, but was unobtrusively there if I needed him.

ECCENTRIC BY DESIGN

I designed the house — structure, form and content. First of all, it wouldn't be too "precious" to live in or live it up in; I wanted dogs and cats. It would be spacious, well-lit and functional. Simplicity and natural aesthetic would prevail, with plenty of room to get fancy in the finishing touches.

Commensurate with my level of craftsmanship, I needed a straightforward, hilltop design, like a Panama hat, to direct the winds up and over. I opted for the unpretentious grace of a lofty gabled barn with sweeping shed wings. (If a tornado hits, I'll see you in Kansas!)

I constructed a scale model to get the feel of my plans. From years of forethought and soul-searching, I knew exactly what I wanted, but how was a bothersome technicality. With waitressing tips from the cafe, I'd pay as I go, and go 'til I dropped. Labor cost time, but energy was my renewable resource. Except for big-ticket items like appliances, fixtures and a woodburning stove, I would make everything from scratch, including deep windowsills and cedar frames for the glass. Planning ahead was essential.

Inside, ambient light would stream through a bank of large south-facing windows. At eye level, the spectacular views of snow-capped mountains by day and city lights at night would be given their proper status. Never to take my views for granted, I would settle for nothing less than a round portrait window to gaze out of for visual refreshment.



In winter, the living room is full of light and heat, thanks to large windows and a woodstove. Cotton duck curtains help insulate but let light filter through. Note the hanging-chain knee braces.

French doors would open out onto a huge front deck with steps leading down to a wood-fired hot tub.

On the north side of my model, I pretended to be up in the loft with its knotty pine walls, a huge bed and a river-rock shower. My imagination slid down the fireman's pole into the den below. Every home needs a hermetically sealed enclave, where one can escape the capricious distractions of life. My cave, with its porthole window and hobbit door, would be my place to run away to without leaving home. I would cherish my time to read, listen to music and watch the Discovery Channel.

An easterly kitchen would be the bright spot in the morning, and the first rays of sunrise would meet me for coffee in the breakfast nook. One of my life's most profoundly simple pleasures is to sip coffee and contemplate the universe.

When I designed the house, I gave myself permission to satisfy — not deny — my eccentricities. So what if the inspector raises one eyebrow when he signs the checklist — just as long as I'm legal. I also wanted low-maintenance housekeeping. Let moss grow on the river rocks in the shower. Lichens and mushrooms are charming!

I love to cook, but not within the confines of a cramped kitchen. The kitchen is where my personality takes up a lot of space. Give me a massive butcher block and a cleaver, and I'll get serious about dinner. Fresh vegetables are a must and so is a big sink for washing them. I want to throw spinach in the built-in "pond" and let the silt fall several feet to the bottom.

The dining-room table is the most popular place in any home. Everything happens there. Mine would be a colossal 4 by 8 feet and made with planks thick enough to support hungry relatives in a feeding frenzy.

Doors are symbolic. As a shelter defines our living spaces and controls the atmosphere, a door determines who enters that private realm of being. I wanted a front door that would break Hitler's toe if he tried to kick it in! Massive and medieval, it must creak with hand-forged hinges and black hardware.



Dorothy in action. The ledger board clamped to the rafter ensures a clean hole when the drill bit breaks through the other side of the rafter.

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Each kind of door has its own character. The quaint Dutch door in a country kitchen will cool an aromatic apple pie resting on the door's mantelpiece. A little cat door in the bottom will let Foo-foo bring a mouse in. Sophisticated French doors make a woman feel like a princess in gossamer, even when clad in blue jeans and a T-shirt. There's something about a large view chopped up into little pieces that makes it easier to take in. Smaller French doors in the loft would open onto a cantilevered deck, for sipping mint juleps in the cooler north light of a hot summer day.

Mandatory for decoration, mirrors are magic. They're a poor man's way to double the square footage and keep an eye on things. They repeat architectural patterns for visual appeal and keep you company when no one's home.

Yes, my humble abode would be my castle, and I reserve the right to keep the Internal Revenue Service out with a moat and drawbridge if necessary, or let the whole Mormon Tabernacle Choir in, if I so desire.



Kirt Meyer carries an "Oregon toothpick" with relative ease. (Don't try this at home.)

FORTRESS JOINTS

"I am giddy; expectation whirls me 'round." (Shakespeare again.) It was time to roll up my sleeves, flex my little biceps and grab the drawknife. I peeled and stained 150 forest service logs. My sister, Meredith, made the mistake of visiting for a week. She peeled and stained another 150 logs, and escaped by plane when her "vacation" was done.

The next step was squaring off the 600 log ends. Kirt and I worked together using a Rube Goldberg contraption I devised to ensure a straight cut. I built the floor in three months. It was supported by a pier-and-girder foundation, connected together by 2-by-12-inch floor joists on 16-inch centers. It would support a house full of hippos.

To tie it all together, this 2,000-squarefoot design incorporated mortise-and-tenon joints (see photos below). Yikes! Mortise and tenon joints! Could I really do this? There lay eight 300-pound 14-footers and four 400-pound 18-footers on the subfloor. And there I stood with a hammer and chisel. It was my moment of truth.

I laid each "bent" (two upright logs and a horizontal log) out as it would appear standing up, flattened the surfaces where the tenons would plug in and cut the mortises (slots) just so, using an electric chain saw, ship's auger and chisel. I cut a tenon on each end of the horizontal logs after taking great care to ensure a 90-degree junction. Everything had to be kept square with the imaginary centerline of each log. The four bents created three bays (space between bents), that were joined together by connecting girts (logs) and reinforced with knee braces.

All went well. Kirt helped me erect the framing members one at a time, fastening the vertical logs to the floor with 12-inch pole-barn spikes. Then we placed the 18-foot horizontal logs with a rented lift, slid the tenons into their respective mortises, and drove the woodfastening pegs home. Squealing with delight, we ran off for pizza and beer. It was Halloween, and our "skeleton" stood eerily in the moonlight.

For the next few days, Kirt manned the lift below while I hammered in rebar above (20 feet up on rented scaffolding). Nine-by-9-inch ridgepoles and rafter plates, perched atop their upright supports, swayed in the breeze.

Until each half-lap joint was secured with spikes we didn't feel safe; when we raised a beam, it raised our hair. Tension was high. Affectionate bickering now and then revealed a little cayenne pepper in our salad of love!







A mortise joint (above) fits together with a tenon joint (middle). They're held together with pegs (right), which will be cut off flush.

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The saddest day of my life: 6,000 hours of labor and $30,000 in materials go up in flames.

We stabilized the structure with 10 pairs of 4-by-10-inch rafters on 4-foot centers. They were joined together at a 6:12 roof pitch over the ridgepole and gusseted into place. At the overhang end, I predrilled holes and drove rebar into each rafter, down through the top plate and into a log. This method eliminated the need for a bird's mouth (a notch cut into a rafter so that it sits supported on the top plate).

Kirt was busy with his career, so now I was on my own, and I welcomed the challenge. For the next three months I worked on the roofs — all four of them. Because 2-by-6-inch tongue-and-groove pine sat on top of the rafters to create the vaulted ceilings, I had to build a grid on top of that roof to receive insulation, plywood, tar paper and metal. Every day was spent aardvarking around on my hands and knees, or limping back and forth with one foot higher than the other. Like a drunken sailor, even on solid ground I favored a gimp on my starboard side. Sometimes, to avoid the sun, I would work at night with a flashlight strapped to my forehead; I must have looked like a firefly. Mercilessly exposed to the elements, roofers are unsung heroes in the construction world.

I methodically put up the walls, one log at a time, and spiked them in place. To save my wrists for the cafe, I gripped the hammer with both hands and pounded away. I swapped the log ends alternately (big end up, big end down) to even out the taper and keep the walls plumb, and set each log 2 inches over the edge of the bottom plate, for a drip edge.

Next came the 36 windows and nine doors, to button up the place. I built the doors from tongue-and-groove pine and the window frames from cedar.

With only hand tools and a band saw, I had to call on friends Merle and Ivan (master craftsmen) to make the fancy cuts. Awning hardware opened rows of east and west windows for cross ventilation.

TOWARD THE FINISH LINE

To save money, I picked up my huge order of double-paned glass in my old Ford pickup (four trips!) and summoned Kirt to help unload and lift the heavy windows into place. While he pressed the fixed panes (some of them 5 by 3 feet) against my prepared stops, I secured them all around with 2-by-2s. No cracks, no shards, no gaping wounds; that was reason enough to go out for a Chinese dinner!



Kembo the dog enjoys the view from the large circular deck of house No. 2. The completed "fortress" sits on 10 beautiful acres in rural Oregon.

Inside the house, the inner walls remained rustic with visible logs, but the walls sheltering me from the outside had to be insulated. I furred them out with 2-by-4s to receive fiberglass batts and sheetrock. I chinked between the logs on the outside. I hired an electrician to do the extensive wiring but painstakingly did the plumbing myself — and passed inspection.

Let there be light! — but not just any light. I suspended chandeliers from ceiling fans. To help support the one 18-foot horizontal log that freely spanned the middle of the house, I fashioned two hanging knee braces out of black chains and turnbuckles (see photo, Page 25).

I rented scaffolding again, but this time to caulk every crack and apply a beautiful protective stain to the entire house. Night and day, up and down the rungs and ladders I climbed, buttering the logs with my linseed-oil concoction until they glowed like the sunset. I wiped the baseboards with a tiny cotton T-shirt and laid it out to dry.

On June 29th, 1995, the T-shirt spontaneously combusted and burned the house down in two hours. I put the fire out with tears. After six years of building, I was back to square one.

SECOND TIME'S THE CHARM

I had nominal insurance to cover tools and a new foundation, but rebuilding would have to be done the hard way: all over again. Fortunately, being a waitress in a coffee shop meant I knew a multitude of people. They rallied together, threw a music benefit on my behalf and raised enough money to buy foundation beams, floor joists and rafters. Then Kirt and I headed into the forest with our trusty chain saw.

After we stockpiled and peeled 300 new logs, Kirt took a leave of absence from his job to help me rebuild the basic structure. It took two years. I continued to waitress and do the finish work by making doors, cutting and fitting curved knee-braces, creating a "tree" as a king-post, and building the stairway, railings and decks, which took an additional three years.

House No. 2 cost about the same as house No. 1 — $15 a square foot, for a total of $30,000. Now that I have my home, I've come to the conclusion that it is better to have built and rebuilt than never to have built at all!

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CHOOSING A LOG HOME

By Greg Pahl



ROCKY MOUNTAIN LOG HOMES

If you have always dreamed of living in a log home, now is the time to turn that fantasy into reality.

Demand for log homes is up, partly because an increasing number of people view them as an attractive — and more sustainable — alternative to conventional housing. Others simply like the idea of living in a log home for its warm appearance and solid wood walls. Recent consumer surveys show that log homes are one of the fastest growing segments of the building industry, with more than 25,000 built every year, mostly as the homeowner's principal residence, according to the Log Homes Council of the National Association of Home Builders.

In the late 1960s, a renaissance in log home building began in the United States and Canada with small, simple, do-it-yourself kits mainly designed for back-to-the-landers. Today, modern log homes incorporate many different styles and can follow almost any floor plan. And many of those floor plans are custom designs; log homes now represent about 7 percent of custom homes in the United States. Although some may choose to build their own log homes, most homeowners hire a contractor to do the work.

Trying to select the right log home design can be a daunting task: More than 400 commercial manufacturers produce log homes, each with numerous styles and options.

"I'll be the first to admit it, we make it very difficult for consumers to compare apples to apples, so to speak, because every company has a different package," says Rich Horn, 2004 president of the Log Homes Council.

Typically, the manufacturer supplies the logs and other structural components, and may offer design assistance and construction services. When the design work is completed, the manufacturer delivers construction-ready materials to the building site. But this is only part of the larger picture, which also includes site work, utilities, a foundation or slab, heating and cooling systems, electrical and plumbing work, cabinetry and finishes and labor costs. Although prices can vary widely, the cost of a log home shell usually represents about a third of the finished home's total cost. Most reputable manufacturers can provide an estimate of the final cost to help you plan a budget, secure financing and decide how much of the work you want to do yourself.

Every potential buyer should understand the two main categories of log homes: manufactured and handcrafted. Both use the same

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general strategy of stacking logs on top of each other to create the home's walls, but they follow different methods of producing the logs.

MANUFACTURED VERSUS HANDCRAFTED LOG HOMES

The manufactured log home, as the name implies, is produced in a mill. The wall logs are sawed, planed or otherwise shaped to a specific size and uniform profile. The end result usually has a uniform appearance on both the exterior and interior. Because mill buildings and the machinery in them are expensive capital investments, manufactured log home companies generally are large organizations. And many of these companies also utilize the latest in computer-aided design (CAD) technology. The Log Homes Council has more than 50 manufacturer members that participate in a certified log-grading program and agree to follow a code of ethics.

A wide range of milled packages are on the market, according to Rob Pickett, who operates a log home consulting firm (www.robpickettandassoc.com) in Hartland, Vt. "Some milled logs are produced and shipped to the construction site, where the builder is on his or her own — not necessarily a problem for an experienced contractor," he says. "At the other end of the spectrum are highly evolved packages of pre-cut materials that arrive on the job site, all ready to be assembled with the help of detailed instructions."

Some manufacturers offer training sessions, and sometimes the representative who sold the package is involved in the construction or is available for technical assistance. Some packages include virtually everything needed to erect the house, some do not. As long as you do your homework in advance and work with a reputable manufacturer, a milled log home can be a solid, long-term investment that will appreciate in value with the passage of time.

Handcrafted log homes, on the other hand, are produced from whole logs by artisans. The logs are individually selected for placement in the structure and usually hand peeled. They may be green (freshly cut) or dried.

"Green wood is easier to work with and carve, but taking more time with harder, drier wood gives you the same results in the long run," says Robèrt Savignac, executive director of the International Log Builders' Association (ILBA) in Lumby, British Columbia.

The difference is when green wood is used, a greater allowance needs to be made for settling. Whether handcrafters use green or dried wood, they then carefully fit the logs to each other to ensure a structurally sound, weathertight wall system.

After the entire shell is completed, it is disassembled and shipped to the homeowner's site. Often, a member of the crew who originally built the shell oversees its reconstruction. Some



JAMES RAY SPAHN (2)

Top: Off-the-grid living in a spectacular setting: Perched at 9,000 feet, this Colorado log home, built by Timberline Builders of Durango, overlooks the Continental Divide and Roosevelt National Forest. Forty-eight solar panels (photo on Page 30) and a backup generator power the home and its appliances. Left: Handpicked from the site, granite rocks accent the fireplace in the great room.

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JAMES RAY SPAHN

Greener Options

Beyond using locally harvested trees for logs and insuring airtight sealings, there are numerous choices you can make to help create a more sustainable home:

- Energy Star double- or triple-pane windows with high-performance glass and insulated frames are environmentally responsible and will save you money in the long run on heating and cooling costs.
- Cellulose insulation is generally considered "greener" than fiberglass and is usually less expensive to install in attics. Regardless of the insulation type you use in your attic, the higher the R-value (resistance to heat flow), the more energy efficient your home will be. Also consider wool insulation — a superb natural insulator that can be used between logs. Good Shepherd Wool [(403) 845-6705; www.goodshepherd-wool.com] in Alberta is one of the few commercial sources.
- High-tech synthetic roofing shingles made from recycled materials are available that perform as well or better than the actual slate or cedar shakes they mimic. (See "Greener Roofing Options," Page 58.)
- Use low- or no-VOC (volatile organic compound) paints and finishes.
- Heating your log home with a renewable energy heating system — geothermal, solar, wood or biodiesel — will make it greener and save you money over the long term.

handcrafters bring the entire crew along. A four-year, 7,000-hour apprenticeship program sponsored by trade organizations and provincial authorities for log home construction now exists in British Columbia — this is intended to assure both the homeowner and the industry that handcrafters follow proper construction procedures in the province. The ILBA also publishes a comprehensive set of Log Building Standards for its members.





COURTESY BEAVER CREEK LOG HOMES (2)

Above: Log-building author Robbin Obomsawin uses a scribe to mark the notches that will later be cut to fit the logs tightly together.
Above left: Steve Christjohn uses the weight of his body and a cant hook to rotate a log into position.

The most obvious difference between a handcrafted log home and its milled counterpart is appearance. The handcrafted log home normally uses larger, whole logs that often retain their natural taper. The handcrafted home also is a more individualized project that often contains custom designs, such as unusual stairways, fireplace mantles or ornamental structural features (although these items also can be found in, or added to, a manufactured log home). Because of the significant amount of custom labor involved, handcrafted log homes tend to be more expensive than their mechanically milled alternatives.

"People are using logs because they have made a conscious decision to build with a healthy wood product that is renewable, and they understand there is probably a premium to pay for that building style," Savignac says. "Most people view the handcrafted home as an individual, more custom-oriented product as opposed to one that is cookie cut from a standard plan."

Traditionally, the handcrafted log home took longer to produce than a milled package, but that has begun to change in recent years with the development of new, more efficient handcrafting techniques. Nevertheless, the demand for good builders of handcrafted log homes exceeds the supply, and some companies have waiting lists measured in years rather than in months. But an increasing number of people who want a truly unique, customized log home think the wait is worth it.

ENERGY EFFICIENCY

A log home is not necessarily more energy efficient than other types of houses, but under the right circumstances it can be highly competitive. Many factors affect a home's energy efficiency, but eliminating air infiltration is one of the most important issues — a drafty wall is a problem, regardless of the type of house. Consequently, one of the most important characteristics of a well-built log wall is that it be airtight. Modern log walls incorporate a variety of different sealing strategies between logs to ensure an airtight fit, including a wide range of tongue-and-groove or spline designs normally used in conjunction with closed-cell foam gasket tape, acrylic chinking, butyl tape or other sealant products.

Another key component of a home's energy efficiency is the R-value for the walls and roof, a measurement of resistance to heat flow. Unfortunately, the R-value of an 8-inch log wall is lower than a typical 2-by-4 insulated frame wall. That same log wall, however, performs between 5 percent and 15 percent better than the frame wall for controlling heating and cooling loads over the whole year, according to Bion Howard, president of Building Environmental Science and Technology (www.energybuilder.com), a green building consulting firm based in Hilton Head Island, S.C.

This benefit, which has been documented in numerous tests, is due to wood's thermal mass value — its ability to absorb and later re-radiate heat. "Avoid walls of less than 6-inch thickness in most climates, and 8 inches in colder climates, for sufficient thermal protection levels," Howard says. "Thinner walls do not take advantage of the thermal mass of solid wood." Jeff Christian, director of the Buildings Technology Center at Oak Ridge National Laboratory in Tennessee, has been involved in numerous tests of thermal mass wall systems and

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agrees the solid wood components of a log home can help moderate swings in temperature and humidity in the home's living space. But he adds that there are diminishing returns as the solid wood wall thickness increases because "the heat buildup from inside the house just doesn't go very deep into the log before it radiates back out at night."

Thermal mass storage benefits aren't restricted to the structure of your home, Christian says. The type of floors, interior walls and even the size of your library and the type of furniture you own will affect the house's thermal mass and energy efficiency.

Other factors that influence the energy efficiency of a log home include roof insulation, the heating system (preferably a renewable one), appliances (preferably energy efficient) and the home's orientation to the sun, as well as the placement and type of windows to take maximum advantage of solar heat gain. But the combination of the thermal mass advantage and the cozy ambience of solid wood walls makes log homes an attractive choice for many people.

HOW GREEN IS YOUR LOG HOME?

Although it's not always the case, log homes can be easier on the environment than conventional types of housing, particularly regarding all the energy used in a home's manufacture, shipping and construction. "A log home can have lower embodied energy by a significant margin, particularly if locally sourced timber reduces the transportation energy cost," Howard says.

Manufacturing a log home kit takes less energy than to cut, plane, package, ship, locally transfer and distribute framing lumber, especially since most lumber is shipped from regions outside the 500-mile distance criterion of LEED standards (Leadership in Energy and Environmental Design) set by the U.S. Green Building Council, according to Howard.

If a manufactured log home can offer some advantage in embodied energy, then a locally sourced, handcrafted log home shines in this category.

"The handcrafted log home is the poster child for value-added wood products because of its low embodied energy; it wins hands down," Savignac says. "Someone with the proper training and experience who has a chain saw, a scriber, a measuring tape and a few other hand tools can turn a truckload or two of building logs into a beautiful home."

There are a few other things you can consider to make your log home as sustainable as possible. In addition to using local logs, you also can ask if the timber came from sustainably certified sources. This is a particularly useful strategy when buying a manufactured log home, where the source of the logs may be harder to track than with a handcrafter. Standing dead timber also can be a good source for log homes, but beware of insect-killed timber, which might still have an active infestation.

"I'm not saying that everyone should be living in a log home," Savignac says. "But you can replant trees, while it's pretty hard to replant concrete or steel. Logs are an answer to the green building concerns that many people have today, both for environmental responsibility and for healthy lifestyles."

BIGGER ISN'T BETTER

The size of the average log home in the United States has increased substantially in the past few decades. Fifteen to 20 years ago, the average was about 1,100 square feet. Today, the average is more than 2,000 square feet. "We definitely have seen an increase in the size of log homes that most people are purchasing today," Horn says.

But this trend is not necessarily mirrored on the handcrafted side of the industry, according to Savignac. "Although there are exceptions, in general I'm finding that people are building smaller and smarter," he says. "They're taking more time to design a house that is more functional, but not necessarily bigger."

So, if your budget is limited or if you simply want to minimize your impact on the planet, join this growing countertrend. Take a little extra time with the design, and you may end up with a better, smaller log home that truly meets your needs — whether it's handcrafted or milled.



COURTESY MAPLE ISLAND LOG HOMES

Log home designed by Maple Island Log Homes of Twin Lake, Mich.

For More Information

For additional information on the many different types of log homes and manufacturers that are available, these resources can be helpful:

Log Homes Council
(800) 368-5242, Ext. 8576
www.loghomes.org

International Log Builders' Association
(800) 532-2900
www.logassociation.org

Log Homes on the Internet
www.lhoti.com
Covers a wide range of log home topics, including a list of manufacturers and links to other resources.

But what is it really like to live in a log home? Tom and Denise Pavao have lived in their 1,800-square-foot handcrafted log home in Ashfield, Mass., since 1997. They spent several years carefully researching log homes before selecting a New York-based handcrafter. The home faces south to take advantage of passive solar gain in the winter. In addition, the Pavaos use a masonry heater as their primary heat source and generally burn between 2 and 3 cords of wood per season.

"The house has a wonderful warmth and solidity about it," Denise says. "When people come to visit us, they walk through the doors and immediately comment about how cozy it feels. We just love it."

Horn offers some final advice for prospective log home buyers. "The key to an enjoyable log home-building experience is to do your homework carefully," he says. "Then, work with a reputable log home manufacturer and be sure you understand the entire process and total costs. And don't be shy about asking questions."

Greg Pahl is the author of *Natural Home Heating: The Complete Guide to Renewable Energy Options* (Chelsea Green Publishing, 2003) and *Biodiesel: Growing a New Energy Economy* (Chelsea Green Publishing, 2005).

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THE CHARM OF CORDWOOD CONSTRUCTION

Story and photos by Rob Roy



Fashion a fabulous home from firewood.

Unabashedly, I admit to two great love affairs in my life: with Jaki, my wife of 30 years, and (this one is shared with Jaki) with cordwood masonry construction.

This ancient building style — many references date it back 1,000 years — has known a substantial rebirth since the first articles about it appeared in Mother Earth News a quarter of a century ago. In cordwood construction, walls are constructed of log-ends — short logs, 12 to 24 inches long — mortared up transversely in the wall, similar to the way firewood is stacked. In Canada, it's commonly known as stackwall building. Log-ends can be cut from wood that is unsuitable for other purposes, such as fire-killed standing wood, ends and pieces from a sawmill, logging slash, and curved branches and trunks. Portland cement, mixed with sand, sawdust and builder's lime, generally serves as the mortar between the "courses" of cordwood.

WHY BUILD WITH CORDWOOD?

In 1974, Jaki and I bought land in northern New York to pursue our vision of a self-reliant lifestyle. In those days, the "natural building" structure of choice was the log cabin. We had helped with constructing a log home, and we knew from experience that fitting and hefting the large logs was a lot of hard work. We also knew that in our area, 15 miles from the Canadian border, we would not find logs thick enough to provide adequate insulation against the harsh climate. And building another internal insulated frame inside the log walls seemed to defeat the purpose of minimizing the use of materials.

About this time, we stumbled upon the April 1974 issue of National Geographic, which contained a picture of a cordwood home in Skowhegan, Wash. Immediately, we knew that we had found a method of building that satisfied our criteria. Building with cordwood masonry would be cheaper and more efficient than building with conventional methods, as we could salvage "unsuitable wood" to use for construction and we could build the home ourselves. Cordwood's thick, stalwart walls also would buffer this region's temperature extremes. However, it was probably the unique beauty of these buildings that sealed the deal for us.

Over the past quarter century, Jaki and I have built four homes and innumerable outbuildings with cordwood masonry. In November 2002, we completed a beautiful new sunroom addition to Earthwood, our primary home and the home of Earthwood Building School, where we give workshops on cordwood construction. When people ask us why we're so enthusiastic about cordwood masonry, I am fond of listing what I call the "5-E Advantages."

1. Ease of construction. To lay up a cordwood wall, the builder need never handle anything heavier than a firewood log. Mortar is easily mixed in a wheelbarrow. We have found that the novice owner-builder readily learns the skills. For years, I have been saying that children, grandmothers and beavers can all build cordwood homes ... and they do!

2. Economy. Log-ends can be cut from less-than-perfect or salvaged wood — fire-killed standing wood, ends and pieces from the sawmill, logging slash, and curved branches and trunks unsuitable for lumber.

3. Energy advantage. Cordwood combines insulation with thermal mass better than any other aboveground building system I can call to mind. The secret is the unique insulated mortar matrix that is woven around all of the log-ends. The mortar does not conduct heat directly through the wall because of an insulated cavity built into the middle third of the wall's width. With a 16-inch-thick wall, for example, we use a 6-inch-wide insulated space between the inner and outer mortar joints. The insulation can be sawdust and lime (at a 12-to-1 ratio), which results in about R-3 of insulation value per inch of thickness. Other loose-fill insulation, such as perlite or vermiculite, also can be used. (Cellulose, which can trap moisture, is not recommended, and we no longer use fiberglass because of its high energy consumption during manufacture, as well as the danger of inhaling the glass fibers.)

Unlike lightweight, wood-frame walls, cordwood walls contain tremendous thermal

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Cordwood Confusion? Ask the Experts!

Practiced throughout the ages, cordwood masonry construction is experiencing a renaissance as hands-on home builders learn of its simplicity, energy efficiency and unique beauty. But with any unconventional building technique, cordwood construction comes with its own set of challenges. Here, we've addressed the most frequently asked questions.



Jaki and Rob Roy, pictured in their cordwood

A cordwood wall under construction at the Sage Mountain Center, a holistic living center near Whitehall, Montana.



Won't the log-ends rot? If basic care is taken, log-ends will not rot. Fungi, which need constant moisture to thrive, cause wood to rot. Cordwood breathes wonderfully along its end-grain, foiling fungi's propagation. To ensure long-lived log-ends: 1) Debark the wood; 2) Don't place wood against wood (this can trap moisture); 3) Don't use wood that already shows signs of deterioration; 4) Design your roof with at least a 12- to 16-inch overhang; and 5) Set your bottom course of cordwood at least 6 inches off the ground, on a good masonry foundation of stone, block or concrete.

What kind of wood should I use? Select light and airy woods like white cedar, white pine, cottonwood, poplar, spruce or larch (tamarack). These shrink (and expand) less than dense woods such as maple, oak, elm, beech, and some of the heavy Southern pines. Denser woods can be used only if special building-design strategies are used.

How long should I dry the wood? Light, airy woods should be dried at least a year, if you can wait that long. This will greatly minimize shrinkage. Dry dense wood just a few weeks, as there is the very real danger of wood expansion with dry hardwoods that get wet from driving rain. Wood expansion is a more serious problem than shrinkage; expansion can break up the wall, whereas wood shrinkage can be attended to in several ways. Research the chosen wood's shrinkage characteristics before deciding upon a drying time.

What mortar mix should be used? For more than 20 years, we have had good success with a mix of 9 sand, 3 sawdust, 3 lime and 2 Portland cement (equal parts by volume). Use sawdust from a light softwood rather than from a dense hardwood. First, pass the sawdust through a half-inch screen. Then, overnight, completely saturate it by placing it in a soaking vessel such as an old bathtub or an open-topped metal drum. The purpose of the sawdust is to slow mortar-curing time, which reduces mortar shrinkage. If softwood sawdust is not available, use a commercially available cement retarder. Also, use hydrated or Type-S lime, also called builder's lime, which makes the mix more plastic, and, as the lime calcifies, makes the mortar stronger over time. The Portland cement (either Type I or Type II) lends strength to the mix.

mass in the mortar. The log-ends themselves also possess both insulative and thermal mass characteristics. Because of this, cordwood homes do not suffer from wild temperature fluctuations; they are easy to keep warm and stay comfortably cool in the summer.

4. Environmental harmony. Cordwood masonry makes use of natural, indigenous materials — and even "waste" destined for the landfill. To further mitigate the environmental impacts of construction, some cordwood builders concerned with concrete mortar's high embodied energy use a cob mortar (clay, sand and straw) instead.

5. Esthetics. This acceptable spelling allows me to complete the "5-E" advantages of cordwood. To me, esthetics is just as important as any other consideration, because, ultimately, we must feel good about the house we call home. Cordwood offers an almost limitless outlet for creative expression. We like to incorporate special features into the walls, such as shelves and storage nooks. Colorful bottles embedded in the walls admit sunlight in all colors of the spectrum.

CORDWOOD STYLES

Cordwood accommodates three structural styles quite easily.

Our round Earthwood house is a good example of using cordwood masonry as a load-bearing structure. The lower courses at Earthwood support two full stories of cordwood masonry plus an extremely heavy earthen roof — sometimes covered with 3 feet or more of snow — a testament to the cordwood's impressive compressive strength.

Stackwall corners. For a rectilinear house without a heavy post-and-beam frame, stackwall corners can be built of special squared log-ends called quoins. This system enables builders to make walls 24 inches thick or more. The downside to using this method is that, like the load-bearing curved-wall construction, all the cordwood work must be done under the open sky, putting the builder at the mercy of the weather's whims.

Cordwood infill with a post-and-beam frame. Although I am partial to the circular design, building a strong post-and-beam frame from heavy, rough-cut timbers and putting the roof on prior to commencing the cordwood work offers compelling advantages. Not only does it afford protection from the elements, as you can work on the cordwood infill with a roof overhead, but it also may more easily gain the approval of your local building inspector, as he or she may not be convinced of cordwood masonry's suitability as a load-bearing medium. For building in seismic (earthquake-prone) areas, the post-and-beam style is the only method of cordwood building I would advise.

TO LEARN MORE

Along with my books and Web site, www.cordwoodmasonry.com/, another helpful site is www.daycreek.com, which lists other resources, tips and tricks helpful to a neophyte builder.

In addition to writing books and articles about cordwood masonry, Rob Roy also is the director of Earthwood Building School in West Chazy, New York [(518) 493-7744]. He and his wife, Jaki, have taught cordwood masonry construction across North America, and in Chile and New Zealand.

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DOWN TO EARTH HOMES

By Dan Chiras



DAN CHIRAS

Tuck your home into a hillside to cut your heating and cooling bills, create weather- and noise-proof shelter, and blend the house harmoniously with the surrounding landscape

Earth-sheltered homes fit a wide range of climates and a variety of building sites — even flat ones. Paired with passive-solar design, an earth-sheltered home can save you tens of thousands of dollars in fuel bills during your lifetime. Earth-sheltered homes are comfortable, affordable and energy efficient. And, if thoughtfully designed, earth-sheltered homes admit an abundance of natural light and are far less of an imposition on the landscape than conventional aboveground houses.

SUBTERRANEAN SECRETS

Earth-sheltered homes provide year-round comfort, but not because earth is a good insulator. It's not. Soil has an insulation value of about 0.25 per inch: 14 times less than wet-blown cellulose insulation and 20 times less than certain types of rigid foam insulation.

The secret of earth-sheltered homes actually lies in the constancy of the earth's temperature and its thermal mass. Below the frost line (usually 24 to 60 inches below the surface), the soil maintains a fairly constant 50 degrees, plus or minus a little, depending on the location. The baseline temperature in an unheated, earth-sheltered home in a cold climate (like mine in Colorado, for instance), hovers around 50 degrees. Besides taking advantage of the soil's temperature-moderating effects, earth-sheltered homes also are protected from heat-robbing winter winds and the scorching summer sun. Because conventional aboveground

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PAMM MCFADDEN

The soil bermed around this home in Tempe, Arizona, helps the house keep its cool.

homes expose most of their surface area to the elements, they are more vulnerable to temperature swings, conduction, convection and air infiltration. If outdoor temperatures plummet to 20 degrees below zero, for example, an aboveground home will need a boost of nearly 90 degrees to be comfortable. Raising an earth-sheltered home's internal temperature to the same temperature (around 70 degrees) requires only a modest, 20-degree boost, which is easily provided by passive-solar gain from sunlight. The sod's constant temperature, transferred to the home, also means that you never have to worry about water lines freezing.

In summer, earth-sheltered homes use the sod to keep their cool. It may be a blistering 95 degrees outside, but earth-sheltered homes stay in the low 70s — as cool as any air-conditioned home — without use of a noisy, energy-guzzling air conditioner and without astronomical utility bills.

Passive-solar, earth-sheltered homes boast 80 percent to 90 percent lower heating and cooling bills than conventional homes. "Even when passive solar is not incorporated," says Jay Scafe, President of Terra-Dome, an earth-sheltered home construction company, "fuel bills are frequently 50 percent lower than a conventional, aboveground home."

Typically built from concrete, rammed-earth tires or cement blocks, most earth-sheltered homes resist fire, termites, rodents, rot, earthquakes, wind, hail, hurricanes and tornados. Because of the weather-proofing, many insurance companies offer reduced rates.

Earth-sheltered homes could outlast conventional housing by decades, and they also require fewer resources over their lifetime. With few exposed surfaces, they require very little maintenance. There's no scraping and painting of siding or periodic re-roofing. You won't be cleaning gutters each spring either.

DESIGNING WITH DIRT

Although the costs of building an earth-sheltered home can be competitive with conventional home construction costs, constructing an earth-sheltered home is not without its challenges, says Scafe. Because they have to bear the constant weight of the earth pressing against the walls (and, in the case of earth-covered roofs, heavy roof loads), earth-sheltered homes have to be carefully designed. Several companies, such as Terra-Dome, Davis Caves and Formworks Building, Inc., sell plans that can be modified to meet your particular needs. Sutherlands, a lumber company that sells home kits, also sells a package for a three-bedroom earth-sheltered home, complete with insulation, doors, plumbing supplies and much more. The price tag does not include a backup heating or cooling system, or concrete.

If you are planning to build the house yourself, consult with qualified professionals. An experienced earth-sheltered-home architect or builder in your area can help you comply with building codes, meet fire safety requirements, and meet roof and insulation specifications. He or she may also help you secure financing.

Comparing Earth-sheltered Options

	Partially Underground	Bermed	Completely Underground
Visual disruption of landscape	Intermediate	Most	Least
Potential for passive-solar heating	Excellent	Excellent	Poor
Thermal stability	Intermediate	Good, but least of the three options	Excellent
Protection from wind	Intermediate	Good, but least of the three options	Excellent
Views	Excellent, but in one direction only	Excellent in all directions	Very little; principally open sky
Protection from noise	Intermediate	Good, but least of the three options	Excellent
Potential for natural lighting	Good to excellent, if done correctly	Excellent	Least of the three options
Cost	Intermediate	Least expensive	Most expensive

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Living Roofs

Most of us appreciate a roof over our heads, but don't give a second thought to the roof itself. It's no wonder: We're used to austere metal panels or lifeless asphalt shingles. The roofs of earth-sheltered homes, however, can be peppered with a profusion of Indian paintbrush, black-eyed susans, sky-blue asters or other floral delights. In the summertime, elk come to nibble on the luxuriant grasses that grow on my living roof.

A living roof consists of soil and plants on top of a wooden or steel-reinforced concrete roof. The three most important considerations when designing a living roof are providing adequate support, waterproofing and proper drainage.

Living roofs can be nearly flat, domed or sloping, up to 6 to 8 inches per running foot. To ensure that the substructure, the decking and the roof framing are kept dry, a waterproof membrane must be applied over the decking. Some builders use polyethylene because it is inexpensive and can be doubled over for additional protection. Most builders use more sturdy waterproofing material.

After the roof is waterproofed, soil is carefully placed over the roof in layers from 6 inches to 9 feet thick, depending on the strength of the underlying roof system. The soil can then be covered with sod that was removed with the excavation of your foundation or grading of your driveway, which greatly accelerates the establishment of a healthy living cover. You can plant the soil with native seeds, which are well-adapted to local soil and weather conditions, and more likely to survive. During the first year, the roof may need to be watered to ensure good seed germination and growth.

Although living roofs are beautiful and functional, you may want to leave a portion of your roof uncovered to house solar hot water or photovoltaic panels. The clerestory design of my house leaves space for both, and also allows me to harvest rainwater.

DIG THIS!

Earth-sheltered homes come in many shapes and sizes; choosing the right design depends on many factors, among them, personal taste, aesthetics, soil type, topography and proximity to groundwater (see " Comparing Earth-Sheltered Options " on Page 35).

Typically nestled into a hillside, partially underground homes are ideal for hilly or mountainous terrain. All but the southfacing walls are bermed, or banked, with earth, and dirt is placed onto the specially reinforced and carefully waterproofed roof and seeded with grasses, wildflowers or other native plants. Some folks even grow gardens on their living roofs. The partially buried earth-sheltered home is suitable for those who want to integrate their homes into the site and take advantage of passive-solar heating. Because water tends to drain down the hill toward the building and off the roof toward the back of the home, it is advisable to build in highly water-permeable soils and to install a water drainage system around the perimeter of the buried walls.

Bermed homes are built largely aboveground, and are suited to flat or very slightly sloped terrain. To earth-shelter a bermed home, dirt is pushed up against the waterproofed walls, usually to just below the windows, with doorways left unbermed. To provide additional earth-sheltering, some builders add a living roof (see " Living Roofs ," left). For those who are less concerned about merging their home with the site or for whom high water tables or water-impermeable soils pose a problem, the bermed structure may fit the bill.

Bermed and partially underground homes can take advantage of clerestory windows, a bank of vertical windows that runs along the uppermost portion of a wall, which helps bring additional natural light into the structure. Even though there are no windows on the north side of my house, you wouldn't have the slightest idea that you were nearly underground. The combination of the clerestory windows and south-facing glazing bring in so much sunlight that I rarely need to turn lights on during the day. When the sun shines, my house comes alive with light.

The completely underground home — built around an atrium or courtyard — is perfect for those who want to blend unobtrusively with the landscape, and is well-matched for flatter sites that have permeable, well-drained soils and no threat of groundwater intrusion caused by a high water table. To ensure adequate lighting, rooms are built around a sunken courtyard. For more uniform lighting, special skylights, called lightwells, may be installed to deliver light to the backs of rooms. Visitors and occupants enter via a stairway that descends into the atrium. Most atria are paved or filled with decorative rock. Plants may be grown in the atrium, but because this space receives very little direct sunlight, they tend to fare poorly.



PALMI GUDMUNDSSON/NORDIC PHOTOS

UNDER CONSIDERATIONS

Earth-sheltered homes come with their own set of special considerations. One of them is radon, a colorless, odorless radioactive gas

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MICHAEL REEDER

This partially underground, earth-sheltered home near Overbrook, Kansas, was designed to thwart the brisk Midwestern winds while providing a sunny, sheltered courtyard that owners Larry and DeeAnn Woodson say remains enjoyable almost year-round.

produced by naturally occurring uranium in the Earth's crust.

Check radon levels in the soil before you build. Purchase a land radon test kit or use a regular indoor radon test kit, which is placed on a couple of bricks, then covered with a bucket and removed after an appropriate period, as stated in the instructions. Although radon can be remediated, it's good to know if the gas is there so you can install an effective radon removal system.

Earth-sheltered homes are generally more humid than aboveground homes. Scale's company installs ventilation systems controlled by humidistats that bring in drier, fresh air and mix it with moist, interior air. This helps prevent moisture from reaching uncomfortable levels inside the home. Other homeowners run a dehumidifier year-round to control excess moisture.

When you're ready to build, be sure to choose a site that will naturally drain water away from your house. Steer clear of areas that collect water during rainstorms or when snow melts. Avoid building in natural surface drainage areas or be sure to channel natural water surface flows around the building site.

A good site with natural drainage also requires permeable soils. The most permeable soils are granular and consist of a fair amount of sand or gravel. The worst draining soils have a high clay content, and expand and contract as moisture levels fluctuate. Perform percolation tests on the site's soil to determine its permeability.

Build above the water table, the upper limit of the groundwater. Building below the water table, while possible, increases the likelihood of leakage. In wetter climates, install drainage systems to move water away from the house. French drains, which consist of porous, 4-inch-diameter pipes covered with filter cloth and located in a bed of 3/4-inch crushed rock along the building's perimeter, work well.

Water has a curious way of finding any overlooked nook or cranny in a building, so waterproof the walls and the roof well. Even a tiny hole can let in water, wreaking havoc over time. Finding and repairing a leak can be difficult and costly, requiring removal of large quantities of dirt. Hedge your bets and waterproof, waterproof, waterproof. Earth Sheltered Technology of Mankato, Minn., uses a triple-layered waterproofing system that's backed by a lifetime warranty against leakage. A primary layer of dry bentonite clay is covered by heavy polyethylene sheeting, which is then capped with an oversized, heavy pool liner. Terra-Dome paints buytl rubber onto its concrete dome roofs, then applies a product called Paraseal (bentonite clay applied to a plastic sheet) over the most leak-likely areas. On my wooden roof, I used Bituthene sheeting covered by a half-inch layer of foam to protect it during backfilling.

Once you've waterproofed, insulate. Although an earth-sheltered home depends on the temperature-moderating qualities of the earth, good insulation (usually a rigid foam) between the building envelope and surrounding soil helps to ensure greater year-round comfort. In the winter, for instance, it reduces heat migration out of the home and into the soil. It also keeps walls warmer and prevents condensation, which can lead to mold and mildew and a host of related health problems.

Earth Sheltered Technology installs 3 inches of rigid polystyrene foam insulation over vertical walls and 6 inches over the roof, covered with 3 or more feet of earth. Terra-Dome places 2 inches of rigid polystyrene foam over the dome, which is typically 3 to 7 feet below grade; 1 inch of rigid foam over the back walls; and 2 to 3 inches over any exposed concrete, which is then typically stuccoed or covered with brick.

To further diminish heat loss and trap heat around the structure, I installed wing insulation — rigid foam insulation that is buried 18 inches below the surface and extends 2 to 4 feet horizontally from the walls. I placed insulation over a 6-inch layer of crushed granite to keep the area around my walls dry. As an added precaution, I also constructed plastic-lined and rock-filled drainage ditches on the surface to prevent water from percolating down from the surface. The drier the soil, the lower the heat loss.

For optimal winter comfort, orient your home to the south to take advantage of the low-angled winter sun and include the proper amounts of glass and thermal mass in your design. In many climates, passive-solar heat can serve most of your heating needs; only a small backup heating system (such as a woodstove) may be needed for heat when the clouds roll in.

Even if your site isn't ideally suited for passive-solar, an earth-sheltered home still will outperform a conventional home. The folks at Earth Sheltered Technology build homes that face in any direction, and say even north-facing homes enjoy "in excess of 50 percent energy savings in the winter and considerably more in hot summer months."

Whether you're in the market to build, buy or sell an earth-sheltered home, keep in mind that earth-sheltered homes still are considered by many to be "alternative." Selling one may require far greater diligence than selling a conventional home. If you're a buyer, you may encounter barriers when applying for a conventional mortgage, which could require you to seek out more progressive lending agencies. And finding an earth-sheltered home to buy can be even more problematic, Shafe says.

But, in a way, that speaks volumes for the merits of these structures. Of all the earth-sheltered homes he's built, only 10 have been put on the market in the past nine years. His clients like their homes so much that they stay for life.

Dan Chiras writes books and articles about ecological design and building from his earth-sheltered home in Evergreen, Colorado.

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LIFE IN AN EARTHSHIP

By Ellen Craig



ELLEN CRAIG

A Firsthand Report: Recycled tires become a super-efficient earth-sheltered solar home in Colorado.

I have always thought of myself as a fairly conventional, average sort of person, but I have to admit that my home, located near Breckenridge, Colo., is not at all average. About 10 years ago, I decided to move from my three-acre property to a larger, more remote piece of land. I was searching for ideas about energy-efficient, environmentally friendly houses when I stumbled on an article about Earthships.

An Earthship is a type of rammed-earth house, sort of a modern version of a Native American pueblo dwelling. It's a trademarked name and design, conceived by Michael Reynolds of Solar Survival Architecture, a company based in Taos, N.M.

The walls of this eco-friendly house are made of discarded tires, which are tightly packed with dirt using a sledgehammer, and then stacked like giant bricks. Mud is packed into the scalloped spaces between the tires and then usually finished with adobe, plaster or stucco.

Earthships are passive solar homes, which makes them extremely energy efficient. They are built with south-facing walls made almost entirely of glass — many people incorporate a greenhouse into this part of the house. During the winter, the sun is at a low angle in the sky, and sunlight streams in through the windows to heat the house's heavy walls, which act as thermal mass. When the room temperature drops below that of the walls, they slowly emit heat to warm the house. With windows and operable skylights for ventilation during the summer months, the building maintains a relatively stable temperature year-round. Many Earthship owners use woodstoves for backup heat, but otherwise, their houses are heated entirely by the sun.

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I was so intrigued by what I read that I journeyed to Taos for a two-day seminar. There I got to see a completed Earthship, and I thought that its wonderful greenhouse and exotic plants gave a warm, comfortable feeling to the house. I quickly decided that I could — and should — build this type of home.

BUILDING BEGINS

I purchased 35 acres in the mountains, selecting the site for its southern exposure, remoteness, spectacular view and large, interesting-looking boulders. Several of those factors ultimately made construction more difficult than I had planned, particularly the steep slope of the site! I purchased Earthship plans and put my existing house on the market. To my surprise, and somewhat to my dismay, it sold in three days, and I had six weeks to move. I quickly made plans to erect a fence for my dogs on the new property, and a friend was generous enough to lend me a pop-up camper, but life was still a bit rugged. I had no electricity and hauled all my water by hand.

Most of the heavy work on the house was completed within the next 16 months. Fortunately, I was able to take advantage of the warm summer weather for construction because that's when I had time off from my job teaching high school physics, math and electronics.

I worked on the house every step of the way, but decided early on to hire out some of the work to professionals, including excavating the site, building the roof and applying the exterior stucco. I also hired a crew of former students to help build the tire walls. I've done as much of the rest of the work as possible, including building the house's interior walls, and designing and installing the electrical system.







ELLEN CRAIG (3)

The walls of the house begin to take shape. The long south-facing wall of windows is one of the most recognizable features of an Earthship.

That first summer, I supervised the work as the site was leveled, and then the students and I began building the walls. Tire walls are best built by putting the larger tires at the bottom and decreasing the tire size as the walls get taller. I spent several days at the dump with a rented truck picking through heaps of wet, dirty and heavy tires, looking for the correct sizes.

The next step was to fill them with dirt: It took a crew of five about eight weeks to pack and level the tires for the first 1,100 square feet of the dwelling. I purchased a construction-grade transit to accurately measure the angles of the walls, and as a result, the completed walls vary no more than a quarter inch over a 100-foot span. The carpenters who built my roof were impressed. According to them, "stick frame" walls built by professionals are frequently much less flat.

With the roof completed, the garage doors in place and a temporary door on the side where there would eventually be more house, I moved inside. For the next 10 months, I lived without running water or electricity. The "kitchen" was a piece of plywood on two sawhorses with a 2-gallon water dispenser at one end and a two-burner Coleman stove at the other. I loved the dirt floor (no cleaning!) and the portable toilet (someone from the construction crew cleaned it and brought toilet paper).

INSIDE THE EARTHSHIP

The house is now 3,000 square feet, including a 720-square-foot garage. The rooms are huge: A living room, dining room and kitchen are combined as one large room; the other rooms include a bedroom, bathroom, control room (with batteries, water storage, etc.) and utility room. The house was designed so that it could easily be modified to include two more bedrooms and a bathroom.

During the excavation of the site, we came upon some large boulders that weren't going anywhere without heavy explosives. Fortunately, they were along the north side of the house where they could separate the kitchen and the living room. I opted to leave them, doing away with the wall that had been planned there, and instead installed a post and beam for structural support. Now, I'm quite glad we left the boulders intact. Everyone who visits admires them, and my cat loves them, too!

About a year and a half into the project, I finished the bathroom: a lovely free-form, curved wall built out of concrete and aluminum cans, in standard Earthship fashion. The shower and floor were tiled, the toilet and sink installed, so — at last — I had indoor plumbing. My first indoor shower was quite different from the outdoor showers I had been taking. There was no more view of the mountains, but it was breeze-free, with unlimited hot water, thanks to my on-demand water heater: a wonderful energy-efficient appliance that I would recommend to anyone.

The electrical system was my next major project. I had always wanted solar electricity, and I planned to hook up to the rural electric company as a backup. But because I had chosen such a remote location, it was cheaper to go completely off the grid than to bring in power lines.

I designed my own solar setup using ideas in the Solar Living Sourcebook I ordered from Real Goods and some help from its support staff. The water-pumping system is composed of two panels connected to a direct-current (DC) pump with no batteries, which means the pump only works in sunny weather. To compensate, I installed a 600-gallon cistern to store water. When the water level starts to get low, a float switch automatically activates the well pump. The electrical system consists of a dozen 75-watt solar panels, a Trace inverter, an Ananda APT Powercenter to monitor everything and 20 golf cart batteries. I followed the simple directions supplied by Real Goods and installed everything myself. I also bought a very efficient SunFrost refrigerator and a small freezer. All this cost less than having the power company run lines to my house. Since then, my solar system has operated for eight years at no additional cost. I think it was quite a deal.

With the solar power supply in place, it was time to wire the house for electricity. I bought a book called Wiring Simplified by H.P. Richter, drew my own plans and started stringing wire. Much to my delight, I passed both the electrical rough-in inspection and the final inspection on the first try. Not long after that, I got a certificate of occupancy and breathed a sigh of relief, knowing I had cleared the last legal hurdle.

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LINDA FITCH

Ellen Craig shows off an unusual feature of her home, the boulders that divide her living area into two rooms.



ELLEN CRAIG

Ellen Craig packs tires with dirt to create "bricks" that will form her house's walls.

FINAL DETAILS

Because I built predominately out of pocket, I am still finishing work on the interior of the house. My kitchen is still unpainted, but it's now completely functional, with a wonderful 1947 Wedgewood stove that I had retrofitted to burn on propane. I discovered that nearly all new gas stoves operate with electronic ignition, which would have drawn too much power from the batteries of my solar system.

My first real test of off-the-grid living came shortly after getting my certificate of occupancy when a fall snowstorm turned into a multiday blizzard. I called my mother who lived about 25 miles away and learned she was wrapped up in blankets sitting in the dark. Apparently, I had been blissfully ignorant that power was off to the whole county. I fetched Mom, and we weathered the blizzard at my house, toasty warm and with plenty of hot food, thanks to my glorious Wedgewood stove.

I am thrilled with how well the house turned out. Of course, if I were going to do it again, there are some things I would change. I would spend a year researching Earthship design and construction techniques before I decided on final plans. I would make ease of construction a major criterion in my choice of a building site. I also would pay for a professionally engineered and installed water drainage system; the simple drain I installed turned into a flooding nightmare that was only resolved after additional trenching and blasting to the tune of about $10,000. Most importantly, I would purchase an inexpensive trailer and connect it to electrical and water systems before moving onto the property so that I could live more comfortably while building. Never again do I plan to spend a winter camping above 9,000 feet!

Through this process, I've learned so many things I never knew about: strength and slump of concrete, tire sizes and carpentry terminology. I'm so proud of building this house that it's sometimes hard not to make faces when people tell me "we built our house," when what they really mean is they approved the plans and paid for all the labor. But I'm also encouraged to see how few resources it really takes to build and maintain a home with a very comfortable style of living. I love living off the grid, and I hope more people will have a chance to experience this kind of independence.

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EARTH-SHELTERED HOMES

By Rob Roy



ROB ROY

These energy-efficient houses are bright, airy, dry and quiet

Back in the '70s, earth-sheltered housing enjoyed great popularity, thanks in part to the energy crisis resulting from the 1973 oil embargo. Adventurous builders and researchers explored various forms of earth-sheltered building, from underground excavated spaces to surface-level buildings with earth piled in berms against their walls. People searching for alternatives to conventional building showed that sheltering a building with earth could reduce energy costs for both heating and cooling by half or more — at little or no increased expense.

Once again, America's overconsumption of energy has made energy efficiency an important consideration in all facets of our lives, including home design. In addition, there is a new awareness among "green" and "natural" builders that we are "paving and roofing this country to death," in the words of architect and underground-building guru Malcolm "Mac" Wells. An earth-bermed house can reap about 95 percent of the energy advantages of a fully underground home, and adding an earth roof, or living roof, further promotes planetary health by "greening" the house's footprint. Most buildings have a negative impact on the planet. Combining earth-sheltered walls with a living roof has the potential for the least negative impact.

Wells also advocates the reclamation of "marginal" land; he says we should not build on the best, most beautiful property available, but instead take land that has been diminished by human activity and return it to greenscape. At Earthwood, our home in West Chazy, N.Y., my wife, Jaki, and I built our earth-sheltered, earth-roofed home in an abandoned gravel pit, converting almost two acres of near-lifeless moonscape to a living, green, oxygenating earthscape

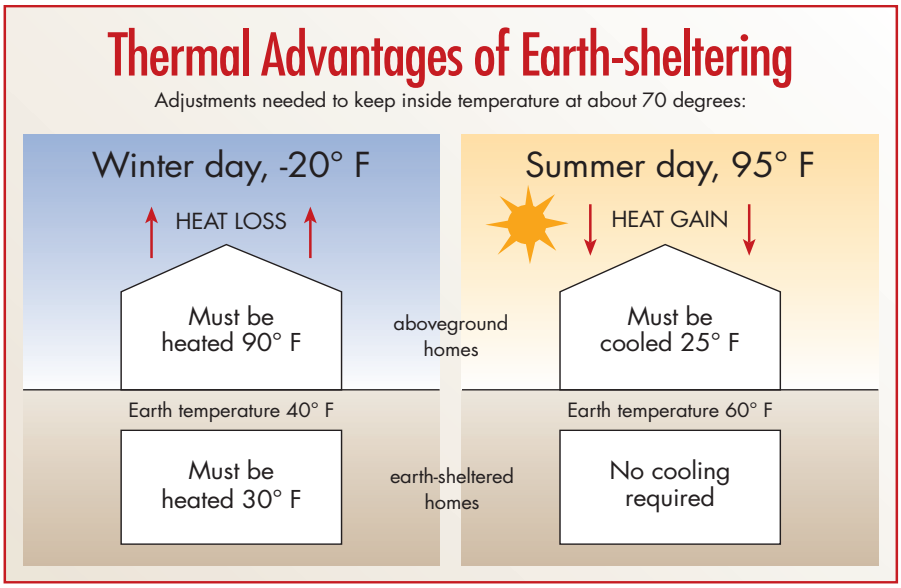
HOW EARTH-SHELTERING WORKS

A common misconception is that earth is a great insulator. In fact, earth is a poor insulator, even more so if it's wet. However, earth is a good capacitor that can absorb and store heat; it's excellent thermal mass. It stores what we call warmth, but it can also store what I call

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"coolth," which is, after all, simply heat at a lower temperature.

Two independent thermal masses interact in an earth-sheltered home. The first is the mass of the earth itself, over which we have very little control. The second is the mass of the building, over which we have great control through the placement of insulation. Building a house 6 to 8 feet below grade in far northern New York, where I live, is like moving it 1,000 miles to the south, into a mild winter climate much like that of Charleston, S.C. Heating is the most important energy consideration where I live, but earth-sheltering helps with cooling as well. At the depths at which we typically build — 6 to 8 feet for a single-story home, a few feet deeper for two stories — the earth temperature in our area varies from about 40 degrees in early March to about 60 degrees in late August. We can use this narrow 20-degree temperature range to our advantage for both winter heating and summer cooling. (See "Thermal Advantages of Earth-sheltering," above.)



It is important to insulate between the home's structural mass and the earth's mass. Without insulation, the earth will wick heat out of the home and bring it to a matching temperature. In winter here, that would be 40 degrees — not comfortable, but a far better starting place for wintertime heating than sub-zero surface temperatures. But if we place insulation between the mass of the home and the earth's mass, we can keep the home's internal temperature at comfortable levels. Your climate determines how much insulation to use and how deep to place it. The entire earth-sheltered portion of Earthwood is wrapped with extruded polystyrene insulation, including under the concrete floor and around the concrete foundation footings.



JIM MILSTEIN

ADVANTAGES OF A LIVING ROOF

You don't have to place an earth roof on an earth-sheltered home, but it has some compelling advantages in addition to the ecological benefit already mentioned:

Longevity. The properly designed earth roof is the longest-lasting roof you can build, because the earth and insulation protect the waterproofing membrane from the three conditions that eventually break down every other common roof surface: ultraviolet radiation, erosion and freeze-thaw cycling, which all damage exposed roofing over time.

Insulation. Solid earth is not good insulation, but 3 or 4 inches of light soil with vegetation growing in it has some insulation value. In winter, the earth roof holds snow better than other roofs, and fluffy snow is a good insulator.

Cooling. The plants growing on a living roof shade it, and the evaporation of moisture off the roof actively cools it.

Protection. Even a few inches of soil protects against fire, radiation and sound. Fully bermed sidewalls that meet the earth roof also add protection against earthquakes, tornadoes and hurricanes.

Aesthetics. The earth roof is hands-down the most beautiful roof you can build, particularly one planted with wildflowers or several different sedum varieties.

EFFECTIVE BUILDING TECHNIQUES

Within the larger field of earth-sheltered housing, I have specialized in building techniques that are appropriate for an owner-builder and involve moderate costs for materials. There is not space in a magazine article to cover the actual construction and technical details of all the various materials, but the following techniques have worked well for us on several buildings.

Surface-bonded block walls. You can build below-grade walls using poured concrete, stone masonry or conventionally mortared blocks. But my favorite is concrete blocks, stacked dry (no mortar between blocks) and coated with an eighth-inch layer of fiber-reinforced surface-bonding cement. Even inexperienced builders can construct such walls — applying the surface-bonding cement is not unlike frosting a cake. A surface-bonded wall does not have the tremendous moisture content of a poured concrete wall, which I would not advise inexperienced builders to tackle anyway. And the millions of embedded reinforcing fibers make it much stronger than a conventionally mortared wall against the lateral pressure of the earth berm.

Heavy timber roof framework. I advocate construction using heavy timbers you might get at a local sawmill at a reasonable cost. For example, Earthwood is stoutly built, with a post-and-beam frame consisting of 8-by-8-inch posts and girders varying from 8 by 8 inches up to a 14-foot oak girder with a 10-by-12-inch cross-section. Our roof rafters are 5 by 10 inches, or 6 by 10 inches where spans are a little greater. Over the rafters, we use 2-by-6-inch tongue-and-groove planking.

Have your plans designed or checked by a qualified structural engineer. It is imperative that the framework be engineered to support the required load. This includes the load of the structure itself, typically 10 to 15 pounds per square foot (PSF) for this type of structure; the weight of the saturated earth (about 10 PSF for every inch); and your snow load (ask local officials; mine is 70 PSF). Earthwood is designed to carry a combined load of 185 PSF.

Waterproofing and drainage. In an earth-sheltered home, the earth is your friend, but the

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ROB ROY (3)

Left: Author Rob Roy (right) and an assistant snap a chalk line to guide trim cuts as they install roof decking over radial rafters.
Center: A bituminous waterproof membrane goes over the decking. Right: Jaki Roy weeds the roof before the wildflowers come into bloom.

water in it is not. We place at least 4 inches of tamped sand below the floor for drainage, but the roof and any walls in contact with earth must be thoroughly waterproofed. Several good waterproofing membranes are available on the market, including large thick sheets of rubber, Neoprene or EPDM (two kinds of artificial rubber) and various bentonite clay products.

I prefer the membranes composed of laminated top layers of black polyethylene backed with a sticky bituminous material. Backing paper protects the membrane from sticking prematurely to unintended objects. The rolls are typically 3 feet wide and 50 to 75 feet long. I like these membranes because they provide high-quality waterproofing and they're moderately priced (50 cents to $1 per square foot) and easy for inexperienced builders to apply. You simply pull the backing paper off the underside of the membrane as you roll it onto the surface to be sealed. Each sheet typically laps over the previous one by 2½ to 4 inches. Installers press the sticky bituminous mastic down with the heels of their hands. Some of these products work better after the application of a "surface conditioner" (like a primer), which improves the adhesion of the sticky surface to the wood. Factory-finished edges are pre-caulked, but cut edges must be sealed with a compatible caulking. A membrane of this type goes on very quickly. A couple of people could cover a simple, shallow-pitched roof of, say, 1,200 square feet in a few hours.

Over and over again, I tell students in my earth-sheltered building classes that "drainage is the better part of waterproofing." If you provide an easier place for rainwater to go than into your house, it will go there. I used to make my own drainage layer out of crushed stone covered with loose hay or straw as a filtration mat to keep the fine particles of earth out of the drainage layer. It worked well, but was a lot of hard work to install and added another 20 PSF to the design load.

Now, I use one of the composite drainage materials made for this purpose by several different companies. They essentially create a quarter-inch channel of air over the roof, and the water travels swiftly along it down the pitched roof and drips off the edge. They consist of a tough nylon mesh covered on one or both sides with a filtration mat.



POVY KENDAL ATCHISON

BUILDING THE LIVING ROOF

I recommend a pitch for an earth roof between 1 in 12 (1 foot of rise in 12 feet of horizontal run) and 2 in 12; 1.5 in 12 is my favorite. Water drains readily in this pitch range, yet the earth does not slump off the roof.

I install the waterproofing membrane directly over the roof planking. Over the membrane, we place sheets of extruded polystyrene insulation, the thickness depending on location, local codes and the purpose of the building.

Atop the insulation, I install a layer of 6 mil black polyethylene. This inexpensive layer is not intended as a waterproofing membrane — you've already installed that. Rather, it acts as the base of the all-important drainage layer. Water rides this plastic quickly to the drip edge.

The composite drainage matting goes on top of the polyethylene. The earth goes over the drainage matting. There is no gain in placing more earth on the roof than needed to maintain the chosen green cover. Remember, saturated earth is heavy — don't surpass your total engineered load.

Finally, plant the roof, choosing native plants. Sedum is a succulent plant that stores moisture in its leaves, perfect for seeing a living roof through a drought situation without the need for watering. Sedum can grow in 3 inches of soil, and many varieties are quite colorful. Grasses and wildflowers need 7 to 8 inches of soil. In arid climes, go with desert plants.

Rob Roy is director of Earthwood Building School in West Chazy, N.Y., which he has operated with his wife, Jaki, since 1981. Earthwood offers instruction in cordwood masonry, earth-sheltered housing and post-and-beam framing techniques "for the rest of us." For more information, visit www.cordwood-masonry.com.

This article was adapted from Roy's new book, *Earth-Sheltered Houses: How to Build an Affordable Underground Home,* a Mother Earth News "Book for Wiser Living" from New Society Publishers.

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BUILDING WITH EARTH

By Dan Chiras



NIGEL VALDEZ

Homes made from earthen materials are affordable, comfortable, sustainable and enduring. Here are the pros and cons of adobe, cob, rammed-earth and soil-filled tire techniques.

In the rain-drenched landscape of Cottage Grove, Ore., Ianto Evans and Linda Smiley live in a delightful little cottage fashioned from a most unlikely material, a mix of mud and straw, known as cob. Their home is warm, cozy and comfortable — not at all what you might think of a dwelling made out of ... well, dirt.

Ianto and Linda are two of a growing legion of people worldwide who are embracing earth building, a centuries-old tradition of architecture and construction. This unlikely band of Earth heroes is helping to forge more sustainable homebuilding techniques.

Building homes from earthen materials has a long, illustrious past. For virtually all of history, our ancestors lived in shelter fashioned from locally available materials, especially earth. Today, approximately half the world's people still inhabit dwellings made with soils harvested from the Earth's crust.

WHY BUILD WITH EARTH?

For one, earthen homes are clean, comfortable and beautiful — even breathtaking. The thick, solid walls create a sense of comfort and security. Walls made of earth are not only strong, they are capable of resisting insects, earthquakes, hurricanes, tornadoes and fire. They have the very real potential to last hundreds of years.

Earthen homes are appropriate for a variety of climates and are ideally suited for passive solar heating and cooling. If designed well, they stay warm in the winter and cool in the summer with little, if any, need for auxiliary energy. Built largely from soil excavated on site, earthen homes require substantially less fossil fuel derived energy to build than the conventional wood-frame homes popping up by the millions.

Reduced energy consumption provides a wide range of environmental benefits, including reductions in greenhouse gas emissions. Earth homes require much less wood to build, helping ease pressure on the world's over-harvested forests. Materials are collected locally: No huge mines or clear-cut forests are required to supply

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building materials, and the blemish produced when extracting earth can generally be repaired quickly and easily with little environmental impact. A hole dug to extract clay-rich dirt for an adobe home, for instance, can be filled in, regraded and replanted, or it can be left to fill with water, creating a pond for wildlife to drink from on hot summer days.

Construction of earth homes is user-friendly. Most earthen building techniques require very little skill and are ideally suited to owner-builder projects. You can learn what you need to know in a weeklong workshop and by reading some of many books on the subject.

Earth homes can be quite economical, further adding to their appeal. Here are the pros and cons of the major earth home options: adobe, cob, rammed earth, tire homes and earthbags.



COURTESY LAURA SANCHEZ

Top: This adobe home sits in the foothills of the Sandia Mountains near Albuquerque. Bottom: Habitat for Humanity workers build an adobe home in Santa Fe, New Mexico.

ADOBE

Adobe brick home-building is an ancient technique that originated in the Middle East and later spread to Europe. As the Spanish sought riches in the New World, they brought this method with them. Today it is still practiced in Mexico and to a lesser degree in other parts of North America.

Traditional builders use adobe blocks made from a mix of clay-rich soil, sand, straw and water. The mixture is poured into block forms and baked in the sun. A couple of weeks later, the bricks are ready for use.

Like conventional bricks, adobes are laid in a running bond — an overlapping pattern — then mortared in place with adobe mud. For added protection, adobe walls should be finished with an earthen or mud plaster.

Although traditional adobe block-making still reigns in poorer countries, many contemporary adobe builders in North America are substituting machine-made blocks — called pressed earth blocks — for sun-dried adobes.

Pressed earth blocks are stabilized with a little cement and cranked out in a fraction of the time of a traditional adobe brick. This process generates more uniform blocks and makes adobe home construction feasible in wetter climates. Despite these advantages, pressed earth blocks represent industrial production shunned by some in the natural building movement.

There are still many good reasons to continue this centuries-old adobe tradition, besides the general benefits of earthen building mentioned earlier.

ADVANTAGES OF ADOBE

- Adobe mud is a widely available, local resource.
- Construction is approved by most building departments.
- For owner-builders traditional adobe is inexpensive and a fairly low-skill job.

DISADVANTAGES OF ADOBE

- Building is time-consuming and labor intensive.
- If labor costs are high, adobe home construction can be quite expensive.
- Traditional adobe block construction requires adequate drying periods, and thus might not be suitable for wetter, colder climates.



COURTESY SANTA FE HABITAT FOR HUMANITY

ENGLISH COB

When I first heard a natural builder mention cob homes, I began to wonder: How in the world do people make homes out of corn cobs?

They don't. Cob is an Old English word meaning a lump or rounded mass. Cob homes are mud-walled buildings, made from rounded masses of clay-rich dirt stacked on foundations by hand, then kneaded and shaped to produce smooth surfaced walls.

Cob builder Becky Bee, author of The Cob Builder's Handbook, likens cob construction to "hand-sculpting a giant pot to live in." Unlike clay pots, though, the walls of cob rooms are thick — 4 to 24 inches — strong and durable. When the cob mix dries, it takes on the hardness of sandstones.

Like adobe, cob consists of mud and straw. Mixed in pits, usually tromped by feet, the cob is then formed into small-loaves, which are deposited on the foundation, then massaged and shaped by hand.

Slowly but surely, a wall emerges with smooth, curved surfaces. Finished cob walls

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DAN CHIRAS

Used tires packed with earth can be laid like giant bricks to form walls, which are then plastered.

may be left unplastered or may be painted with a traditional lime wash to provide protection and beauty. In many instances cob is coated with an attractive, protective layer of earthen or lime plaster.

ADVANTAGES OF COB

• Wall building is fun, easy to learn and relatively inexpensive.
• Encourages artistic expression and lends itself to curved walls and other usually exciting features, such as niches
• Durable, fireproof and nontoxic.

DISADVANTAGES OF COB

• In most of North America cob is a "new" building concept: obtaining approval may be difficult.
• Can be time-consuming.

RAMMED EARTH

Rammed earth is one of the oldest of all natural building methods. Rooted in North Africa and the Middle East, it dates back to the time of the pharaohs. Today commercial builders in California, New Mexico, Arizona and Colorado are using this time-tested technique to construct modern homes.

To build a rammed-earth home, wooden or steel forms are mounted on a 1- to 2 foot-thick foundation. Six to 8 inches of slightly moistened dirt is shoveled into the forms, then tamped with a pneumatic tamping device. More dirt is added, then tamped. Once the form is filled, it's removed. The moistened soil dries, creating a thick, strong, sandstone-like wall. "Raw" earth walls, especially those containing native subsoil and clay, are remarkably durable and handsome.

Traditional rammed-earth construction relies on a mix of 70 percent sand and aggregate (small stone) and 30 percent clay. The clay acts as a binding agent.

In areas where moisture and earthquakes are a problem, rammed-earth builders often use a mix of sand and Portland cement, although the results lack the visual appeal of raw earth walls. Rammed-earth walls may be left as is, or plastered or stuccoed to provide an additional measure of protection.

ADVANTAGES OF RAMMED EARTH

• Produces an extremely attractive and enduring structure.
• Suitable for many different architectural styles.
• Often cheaper to build than brick, stone and adobe structures.

DISADVANTAGES OF RAMMED EARTH

• Requires special skills and construction of forms; generally not suited for owner-builders.
• Costly, if labor costs are high.
• May be difficult to gain building department approval.

TIRE HOMES

While some builders ram or pour earth into forms, others are building walls using earth that's packed into old automobile tires. Called rammed-earth tire homes, or simply tire homes, this distinct architecture makes use of an abundant waste product (Americans discard nearly 250 million car tires each year.)

These structures are the brainchild of New Mexico architect and builder Michael Reynolds, who calls his tire homes Earthships. In building an Earthship, tires are laid out, typically in a U-shape, on compacted subsoil or on a foundation.

The tires are then filled with dirt from the site, and the dirt is compacted using a sledge hammer or a pneumatic tamping device. A fully compacted tire bulges with 300 to 350 pounds of dirt.

After the first row is finished, a second row is laid down, filled with dirt and tamped. Tires are placed on top of the first course in a running bond, with six to eight rows of tires making up a wall.

The tire walls are typically finished with a mud plaster or cement stucco, erasing all evidence of their composition and eliminating fire hazards and potential odors.

With the walls complete, the rest of the building is framed in. Depending upon your building design and skills, the result can be the funky look of an Earthship or a more normal-looking house for those with more conventional taste.

ADVANTAGES OF TIRE HOMES

• Uses an abundant waste product and local resources. Most are earth-sheltered and thus protected from temperature extremes.
• Often easier to get approval, thanks to extensive data and assistance available from Reynolds.
• Resistant to earthquakes, tornadoes and hurricanes.

DISADVANTAGES OF TIRE HOMES

• It's hard work.
• Tire homes tend to have an open design and can be noisy and less than private.
• Walls tend to gobble up living space.

EARTHBAG HOMES

Although humans have been using sandbags to build bunkers and to hold back rising flood waters for a very long time, building homes from bags of dirt is a relatively new concept in the field of natural building.

Earthbag walls are made from reject burlap or polypropylene bags (the kind bulk rice comes in). The bags are filled with slightly moistened clay-dirt or cement-stabilized dirt, then pinned shut, laid down on a foundation and tamped. When the soil dries, it hardens like rammed earth. Earthbags are set in a running bond, then covered with plaster. Earthbags are ideal for creating vaults or for building round structures with domed roofs.

ADVANTAGES OF EARTHBAG CONSTRUCTION

• Easy to learn.
• Used to build domes, vaults, foundations and patio walls.

DISADVANTAGES OF EARTHBAG CONSTRUCTION

• Labor-intensive.
• New, and thus difficult to obtain approval from building authorities.

CLIMATE SUITABILITY

Earth homes are suitable in a wide range of climates, even some rather wet ones. Cob, for example, does extremely well in Oregon's soggy, rainy forests and Old England's wind-battered, rain-drenched coasts.

In all earth building systems, the key to success in wet climates is to prevent the mud from being eroded by protecting walls from rain. A well-designed roof with a suitable overhang provides adequate protection. A coat of lime plaster is often applied for added durability.

Most earth homes are concentrated in hot, dry climates and are suited for passive solar heating and cooling in such areas. Thick wall mass protects interiors from temperature extremes.

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If earth homes have a limitation, it is cold climates. Earth is a poor insulator. However, this inadequacy can be countered by building thicker walls that retard heat flow, creating an insulation-filled cavity in the interior of the wall or applying external insulation.

DOWN TO EARTH

Although earth building is a great option, the movement is hindered by the lack of experienced and willing architects, engineers and builders.

Fortunately, the majority of earthen building techniques lend themselves to owner-builder projects. If you choose to build your own home, you'll need instruction — a weeklong workshop, perhaps. Experiment with a small shed or a cottage before you tackle a house.

Over the years I've found there's a widespread romanticism among many natural builders, which sometimes hides the limitations or problems you may encounter. One result of this rosy outlook can be an oversimplification of home building and an underestimation of construction costs. Although earthen wall building may be relatively simple, there's a lot more to a house than exterior walls. Roofs, plumbing, electrical wiring, interior walls and finish details require considerable skill. If you're not a competent and somewhat experienced builder, you'll need to hire professionals.

Where cost is concerned, remember that building exterior walls with earthen materials, especially if you do a lot of the work, may cost less than using conventional materials. However, exterior walls constitute only 10 percent to 15 percent of the total cost of building a house. Among other things, the full expense of a house depends on the complexity of the design, the amount of labor you supply versus construction supplied by subcontractors and the expectations you have for the finished product.

That said, it is possible to build from natural earthen materials a house that will perform well in almost any climate, providing a classy comfort and aesthetic quality unrivaled in most conventionally constructed homes. Selecting the appropriate method for your purposes and life can bring that dream home.

Writer Dan Chiras, Ph.D., lives in a nearly independent passive solar/solar electric, rammed-earth tire and straw bale home in Evergreen, Colorado. This article is adapted from his book, *The Natural House: A Complete Guide to Healthy, Energy-Efficient Environmental Homes*.





DAN CHIRAS (2)

Earthbag construction is easy to learn and lends itself well to curves and arched features.

Earth-Building Resources

Adobe Homes for Today by Laura and Alex Sanchez

The Hand-sculpted House: Building a Cob Cottage by Evans, Smith, Smiley

Building with Cob by Weisman & Bryce

The Natural Plaster Book by Guelberth & Chiras

Designing Your Natural Home: A Practical Guide by David Pearson

The Rammed Earth Renaissance - Video by David Easton

Earthbag Building by Kaki Hunter & Donald Kiffmeyer

Building with Earth by Paulina Wojciechowska

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EARTHBAG CONSTRUCTION

By Kaki Hunter and Donald Kiffmeyer



OK OK OK PRODUCTIONS (5)

Make durable buildings from the dirt in your yard.

You can build a magnificent shelter with a couple of rolls of barbed wire, a bale of bags, a shovel and nothing more than the earth beneath your feet. This is the premise that inspired the imagination of visionary architect Nader Khalili when he conceived the idea of "sandbag architecture." In his quest to seek solutions to social dilemmas such as affordable housing and environmental degradation, Khalili drew on his skills as a contemporary architect while exercising the ingenuity of his native cultural heritage; earthen architecture is common in his homeland, Iran, and throughout the Middle East, Africa, Asia, Europe and the Mediterranean.

According to many building professionals and environmental groups, earthen buildings currently house more than one-third of the world's population. Thousands of years ago, people discovered and utilized the principles of arch and dome construction. By applying this ancient structural technology, combined with a few modern-day materials, Khalili has cultivated a dynamic, contemporary form of earthen architecture that we simply call "earthbag building." He teaches this technique at the California Institute of Earth Art and Architecture in Hesperia.

SIMPLICITY AND BEAUTY

Earthbag construction uses earth as the primary structural element, and it helps create curvaceous, sensual architecture while providing structural integrity. Earthbag structures can be monolithic, meaning that an entire structure is built from foundation to walls to roof using the same materials and methods throughout. Corbelled earthbag domes (bags laid horizontally and stair-stepped up to form the dome) foster simplicity and beauty. Earthbag domes designed with arch openings can eliminate 95 percent of the lumber used to build the average stick-frame house.

Earthbag building utilizes the ancient technique of rammed earth in conjunction with modern woven polypropylene bags as a flexible form. The basic procedure is simple:

•Fill the bags using suitable pre-moistened earth.

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This cement-block frame, earthbag-infill house was the first of its kind in Utah to receive a building permit.

•Close, fold and pin the bags to make neat square-cornered rectangles similar to grocery-store brown bags.

•Lay the finished bags in a masonry-style running bond.

•Thoroughly compact with hand tampers after a row has been laid.

•Lay two strands of four-point barbed wire, pushed down with bricks, between every row. This acts as a "Velcro mortar," cinching the bags in place and providing exceptional tensile strength (resistance to lengthwise stress) while allowing the rows to be stepped, creating domes and other unusual shapes.

•Apply exterior and interior plasters.

Earthbag walls can be linear, free-form or a perfect circle formed by the use of an architectural compass. Arched windows and doorways are built around temporary arch forms until the keystone bags are tamped into place. The finished walls then cure to durable, cement-like hardness.

Earthbag construction helps avoid wood consumption for the walls, and it also can eliminate wood for the roof frame where corbelled domes are utilized. Conventional wood roof systems consume a lot of trees. This may be sustainable for those who dwell in forested areas, but for people living in relatively treeless areas, designing corbelled earthbag domes offers an opportunity to create shelter using the Earth's most abundant natural resource — earth itself. Why cut and haul lumber when the most common, versatile, energy-efficient, cost-effective and termite-, rot- and fire-proof construction material is available?

EARTHBAG STRENGTHS

Another advantage of earthbags is the tensile strength inherent in the woven-poly bags when combined with the use of four-point barbed wire. It's a double-whammy of tensile vigor not found in most other forms of earth construction. Rammed earth and even concrete need reinforcing rods to keep them from pulling apart when placed under opposing stresses. The combination of a textile casing and barbed wire builds this tensile strength into every row of an earthbag structure.

In order to use some forms of earth construction in humid environments, a percentage of cement, lime or asphalt emulsion must be added to chemically alter the composition of the earth, making it resistant to water absorption. Earthbags, on the other hand, can effectively utilize raw earth for the majority of the walls, even below ground, because the bags provide mechanical rather than chemical stabilization. The textile bag supports the raw earth even when fully saturated. This means builders can use a wider range of soil options, extending earth construction into nontraditional earth-building regions such as the Bahamas, the South Pacific and a good portion of North America.

Khalili has demonstrated the structural integrity of his raw earth (nonchemically stabilized) earthbag domes. Under static testing conditions simulating seismic, wind and snow loads, the tests surpassed 1991 Uniform Building Code requirements by 200 percent. These tests were done at the California Institute of Earth Art and Architecture (www.calearth.org) under the supervision of the International Conference of Building Officials. The earthbag system has been proven to withstand the ravages of fire, flooding, hurricanes, termites and two earthquakes with magnitudes of more than 6 and 7.

Earthen walls function as an absorbent mass able to store warmth and re-radiate it back into the living space as the mass cools. This temperature fluctuation is known as the "thermal flywheel effect." The effect of the flywheel is a 12-hour delay in energy transfer from exterior to interior. This means that at the hottest time of the day, the inside of an earthbag structure is at its coolest, while at the coolest time of the day, the interior is at its warmest. This delay is possible only in walls greater than 12 inches thick and can be modified by climate, house orientation, wall color and the placement of windows and doors.

EARTHBAG COSTS AND LIFE CYCLE

In most cases, materials for earthbag construction are inexpensive, abundant and accessible. Grain bags and barbed wire are readily available throughout most of the world for a fraction of the cost of cement, steel and lumber. Dirt can be harvested on site or trucked in for the cost of transportation. Developed countries have the advantage of gravel yards that produce vast quantities of "reject fines" as a byproduct of road building.

Earthbag construction, like straw bale and other earth-building methods, is labor-intensive, and that is where the majority of the "cost" is incurred.

The simplicity of the earthbag technique lends itself to owner/builder and "sweat-equity" housing endeavors and disaster relief efforts. Properly designed corbelled earthbag domes excel in structural resilience in the face of the most challenging natural disasters. Does it really make sense to replace a tornado-ravaged tract house with another tract house? An earthbag dome provides more security than most homeowner insurance policies could offer by building a house that is resistant to fire, rot, termites, earthquakes, hurricanes and flood conditions.

Earthen architecture endures. If we can build one ecologically friendly house in our lifetime that is habitable for 500 years, we will have contributed to a sustainable society.

Adapted from *Earthbag Building*, a Mother Earth News "Book for Wiser Living," by New Society Publishers. Authors Kaki Hunter and Donald Kiffmeyer have been involved in the natural building movement for 14 years and specialize in environmentally friendly and affordable building methods. To order, go to www.MotherEarthShopping.com.

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Advantages of Earthbag Building

We love earthen construction in all its forms. The sheer joy of mixing and plopping cob into a sculptural masterpiece is unequaled. But for the first-time owner/builder, there are some distinct advantages to earthbag construction. Here are the advantages we think it gives to the do-it-yourselfer as compared to other types of earth building.

Adobe is one of the oldest-known forms of earthen building. It is probably one of the best examples of the durability and longevity of earthen construction.

Adobe is made using a clay-rich mixture with enough sand to provide compressive strength and reduce cracking. The mix is liquid enough to be poured into forms and then left until it's firm enough to be removed from the forms to dry in the sun. Adobe bricks cannot be used for wall building until they have completely cured. While this is probably the least expensive form of earthen building, it takes more time and effort. Earthbag building, on the other hand, does not require as much time and attention as adobe. Because the bags act as a form, the dirt mix is put directly into the bags and immediately placed on the walls. They also don't need as much moisture as adobe — earthbags cure in place on the wall, eliminating the time spent waiting for the individual adobe bricks to dry.

Rammed earth is another form of earth building that has been around for centuries and is used worldwide. Many miles of the Great Wall of China were made using rammed earth.

Rammed earth involves the construction of temporary forms into which earth is compacted. These forms must be built strong enough to resist the pressure exerted on them from ramming (compacting) the earth into them. The soil also must be a specific ratio of clay to sand with about 10-percent moisture by weight added to the mix.

In most modern rammed-earth construction, a percentage of cement or asphalt emulsion is added to the earthen mix to help stabilize it, increasing cohesion and compressive strength and decreasing the chance of erosion once the rammed-earth wall is exposed.

Earthbags act as the form for the earth, and because they stay within the walls, earthbag construction eliminates the need for heavy-duty wood and steel forms that are not user-friendly for the first-time owner/builder.

Cob is the traditional English term for a style of earth building. It is particularly useful in wet climates where the drying of adobe is difficult. England and Wales have cob structures that have been in use for nearly five centuries.

Cob uses a combination of clay, sand, straw and water to create stiff bread-loaf-shaped "cobs" that are plopped in place on the wall and "knitted" into each other to create a consolidated mass. Like earthbags, cob can be formed into curvilinear shapes. Unlike earthbags, cob requires the use of straw. The straw works for cob in the same way that steel reinforcement does for concrete.

While the tensile strength of earthbags creates a sturdy "brick," cob requires a certain amount of time to set up before it can be built upon. As a cob wall grows in height, the weight of the overlying cobs can deform the lower courses of cob if they are still wet. The amount of cob that can be built up in one session without deforming is known as a "lift." Each lift must be allowed time to dry a little before the next lift is added to avoid this bulging deformation.

Pressed block is a relatively recent type of earthen construction. It is the marriage of adobe and rammed earth. Using an optimum rammed-earth mix of clay and sand, the moistened soil is compressed into a brick shape by a machine that can be either manual or automated.

The main advantage of earthbag building over pressed-block construction is the same as that over all other earth-building forms — earthbags do not require a specific soil mixture to work properly. Adobe, rammed earth, cob and pressed block rely on a prescribed ratio of clay and sand; or clay, sand and straw.

— Kaki Hunter and Donald Kiffmeyer





Left: Co-author Kaki Hunter (center) fills a continuous earthbag tube right on the wall to minimize carrying and lifting. Above: This undulating wall shows the results of the earthbag technique used to create a utilitarian yet artful structure.

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GET MUDDY! MAKE EARTH ART

By Kiko Denzer



CATHERINE WANEK

Mud is a perfect material for art and architecture; it's durable, beautiful and easy to work with. Earth is used by many cultures for building — in fact, it's the most common construction material on the planet. For comfort, beauty, ease of use, ecology and economy, it beats most other materials hands down. While earthen accents are easy to incorporate into new cob or straw bale walls, you don't need to build a brand new house to enjoy them. Whether you have sheetrock, masonry or even wood walls, mud can add texture, color and warmth to any interior. All the examples shown here were made with basic clay plaster mixtures, and reflect the artistry and lives of their makers. And don't worry if you're not an artist; if you can make mud pies, you can make art out of earth!

LIVING WALLS

Earthen plasters add life to a building. There's a reason a so-called "perfect finish" is often referred to as "dead" straight, or "dead" flat — dead surfaces don't move. When every inch of a wall is the same, there's no variation of light, shadow, texture or color. But as you walk past a hand-plastered wall, you notice shifting light and shadow — it lives! Rather than just connecting corners, sculptured walls literally shape space. Living, handmade plaster walls embrace you.

Earth is easy to sculpt, and sculpture need not be complicated. Mud makes it easy for anyone to make beautiful textures, patterns and lines. Just rounding a corner or building up edges at doors or windows helps define a room. Extending the play of light from a flat wall into the third dimension removes the division between sculpture and architecture.

Designs shown on these pages were made of clay subsoil, sand, fiber and additional binders as needed. Sand and fiber help control drying and cracking, while binders add workability, strength and resistance.

Small decorative earthen accents are relatively easy to make. Consider making a draw-

You're never too old to play in the mud — have fun, get dirty and make creative earthen accents that will add life to your home.

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Earthen plaster gives you unlimited design possibilities. Here are some low relief pieces by the author done on sheetrock for a gallery show. The show entrance (below) was made of mud over cardboard that was temporarily attached to movable gallery panels. The show was completed in about four days by a crew of five.

KIKO DENZER (8)

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An Earth Plaster Recipe

- *One part "clayey" subsoil*
- *Three to four parts sand*
- *Just enough water (too much causes slumping and cracking)*
- *One half part fine fiber, quarter inch or less is best for detail work and thin plasters, but anything works, from cow or horse manure; to chopped grass or straw; to horse or human hair.*

Mix all of the above in a wheelbarrow, bucket or the like, using your hands, a shovel or power tools. Remember, it's easier to add water than to take it away! I make my plaster a bit wetter than peanut butter, and adjust as I go. The finer your materials, the finer your plaster. Remove coarse materials by sifting through a window screen or quarter-inch hardware cloth.

Then smear the mud on by hand, with masonry trowels or any other tool you can think of. You can go up to about a half inch thick before you'll start having trouble with cracks and slumping. For more thickness, apply multiple coats, add longer fiber and give it some textured surface to "grab" onto. Try texturizing with small sticks or reed mats, mason's lath, coarse burlap glued and pegged on, twine wrapped and tied around nails, etc.

Use circular strokes to smooth the surface. Try different tools for different effects—from deep finger and hand prints, to subtly undulating strokes of your palm. Wood gives a softer finish, metal a harder polish. A tool held perpendicular to the mud will make a ragged line, but at a low angle, it will make a clean line. Scratch or carve in a design using forks, knives or spoons — experiment! Adjust the recipe "to taste." See "Get Muddier!" more details.

ing on graph paper first, but if drawing makes you nervous, just start playing with mud on a piece of sheetrock. For a large mural, try enlarging the design on a grid, it's easy and it teaches proportion. Divide the design in half or into quarters, then copy it section by section until you've recreated a larger version.

THE MANY FACES OF MUD

Just like people, mud varies. Still, a few basic principles and some practice can make you an expert artist of your own soils, techniques and recipes.

The term "plaster" is generic, and applies to everything from real, under-your-feet mud, to gypsum plaster (also called "plaster of Paris" or "casting plaster"), to traditional African mixes of manure and clay, to stucco (the old fashioned kind made of lime and sand, or the post-World War II type made with cement). Earthen plaster is merely "clayey" subsoil mixed with sand and fiber. Clay is the primary binder, while sand and fiber limit cracking. Any mud can be "plaster."

A well-finished plaster won't rub off easily and can be cleaned. If you have pure fine clay soil and "sharp" quartz sand, your mud will be quite tough and hard. If you have silty soil and soft, "round" sand, your plaster will be more vulnerable.

Earthen art can be further cemented and stabilized with binders. One approach is to mix sticky stuff like lime putty or wheat paste directly into the plaster. The other approach is to paint a penetrating wash, such as casein, whitewash or sodium silicate, over dry plaster.

Most plaster sticks well to most surfaces, though texture is often helpful, and sometimes necessary, depending on the thickness of the mud. Texture on a wall helps thick plaster stick — the thicker and heavier the layer, the more surface texture you'll need for it to stick well. A thin plaster sticks beautifully to plain or painted sheetrock, with little or no prep. It's also easily applied to most masonry, such as brick, stone or block. I even have applied it successfully to masonite and glass. Very fine mud works best on a smooth surface. Mud sticks to wood too, but because wood swells and shrinks, it must be covered with a layer of tar paper or other waterproof barrier, followed by a textured material for the mud to grab onto. Otherwise it cracks and falls off when the wood moves.

Maintenance needs vary, but the beauty of mud is that "worn" surfaces made of natural materials often look more interesting than fresh ones. Look at our love affair with ancient buildings. Traditionally, old buildings were maintained with a fresh coat of lime wash or other natural paint which, over the years, produces a "patina of age" that can't be faked.

LOCAL COLOR

Colors can be mixed into the plaster itself or applied to finished surfaces. Try colored earths if you have any around your area — they're especially common in the Western states. I collect natural earthen color pigments when I see them in road cuts or construction sites. Various shades of yellow, orange, red, brown and black all are common around my home in central Oregon. However, if you don't have easy-to-get color underfoot, concrete pigments work well (Davis Colors, for example), and often are composed of various iron oxides that are quite potent in small amounts, and relatively cheap at builders' supply stores. (Be aware that some blues, yellows and greens, especially those used in potters' glazes, can be highly toxic; some contain heavy metals and pose hazards even just with skin contact.)

THE PRICE OF CREATIVITY

What does it cost to add earthen accents to your home? Well, how long is a piece of string? If you hire a contractor and buy commercial products, the costs could mount to the point at which a deluxe paint job starts to look cheap. If you do it yourself with local mud and sand, you may spend nothing. Your best bet is to take the time to experiment and play. Prove the truth of my favorite quote, "An artist is not a special kind of person, every person is a special kind of artist."

Kiko Denzer has been an earth artist since 1994, when he attended a cob building workshop. He made ovens first, and sculpture followed naturally. Then he got various mud jobs: at a restaurant making ovens, designing garden walls, doing interior plastering, as well as various school projects, gallery shows and community installations.

GET MUDDIER!

BOOKS & PRINTED MATERIALS

Dig Your Hands in the Dirt: A Manual for Making Art Out of Earth
by Kiko Denzer (Hand Print Press, 2005)
Details on Denzer's earthen mural projects.
www.handprintpress.com

Build Your Own Earth Oven
by Kiko Denzer
Combine the utility of a wood-fired oven with the ease of earthen construction.
www.handprintpress.com

The Hand-Sculpted House
by Ianto Evans, Michael G. Smith & Linda Smiley
Everything you need to know to build an earthen building, including plasters.
www.MotherEarthShopping.com

The Last Straw Journal
Detailed information on various techniques and materials can be found in the following back issues: Issue #43: "The Case for Clay," Issue #33: "Earth-Cement Plaster" and Issue #29: "Selecting Lime Products."
www.thelaststraw.org

The Natural Plaster Book
by Cedar Rose Guelberth & Dan Chiras
Guelberth also operates the Building for Health Materials Center (www.buildingforhealth.com), which supplies plastering tools and materials.
www.MotherEarthShopping.com

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OUR HANDMADE HOME

Story and photos by Les Oke



We cut our own lumber and built our off-the-grid home for only $5,000.

During the days of skyrocketing interest rates in the late 1980s, my wife, Jane, and I realized that our dream of owning a home was slipping away. For the first eight years of our marriage, we lived in a rented house in Norwich, Ontario, and we just couldn't save fast enough to buy our own place.

Then, a friend gave us a box of 80 back issues of MOTHER EARTH NEWS. That box opened up a whole new world for us. Reading those magazines, we realized other people looked at the world the same way we did.

In 1992, we purchased 20 acres of bush in Northbrook, a hamlet in eastern Ontario about 150 miles from Norwich. The property had a plowed back road with school bus service, but it didn't have electric power. We were determined to live without the "monthly mortgage," as my wife calls it, to the electric company.

The same friend introduced me to *Living the Good Life,* the classic homesteading book by Helen and Scott Nearing, and I discovered self-sufficiency. I began corresponding with Helen (Scott had died five years earlier) about our move and our worries. In her motherly way, she patiently guided us through our fears. I still have those letters.

On May 5, 1994, we moved to our property, determined to build our house before the first snow. We had saved $5,000 for this purpose.

We lived in a tent trailer that I had bartered for when working with a local carpenter. By June, we had the land cleared and the concrete footings and block walls done. A local contractor put in the septic system and well, and cleared the land for $700.

Early June saw us agonizing over the high price of lumber. The next week I was at our chain saw dealer to pick up oil and a new chain when I casually mentioned the price of lumber. He asked, "Have you seen these mill attachments that fit on your chain saw? You make your own lumber if you've got trees." Excited, I told him, "I've got 20 acres of trees. Keep talking!"

He explained how it worked and I ordered one (see photo left). When it arrived the next week, I set it up and went to work. The mill attachment cost C$250, but it literally paid for itself the first day.

Throughout June and July I cut lumber. I'm proud to say that not one piece of store-bought lumber makes up our house frame. We cut studs, 6-by-6-foot floor joists, 10-by-10-foot

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Top: Les Oke cut all the lumber for his family's house using this Gransberg Alaskan Mark III chain saw mill attachment. Above: Jane Oke cans vegetables from the family garden.

beams, 19-foot-long roof trusses and 12-inch-wide roof boards, all with the chain saw mill. Granted it was smelly, hot and dirty work. But the chain saw mill proved indispensable to this "cheap Scotsman," as my wife calls me.

We only cut mature trees, and we used dead and damaged trees whenever possible. Because we cut the lumber right where the trees fell, all the waste was left to break down and fertilize the forest. In a healthy forest, there is no need to replant; simply let natural regeneration take place.

Building the house turned out to be a slow process. Soon October was closing in on us and we only had the second floor done. A roof was two months' work away. What should we do?

After working for nearly five months without a day off, we took a trip to my parents' home in southern Ontario. While we were there, my dad mentioned a large greenhouse grower who suffered hail damage to half his plastic greenhouses. His insurance was replacing all his greenhouses and he had lots of 200-by-400-foot rolls of used plastic to give away.

I loaded two rather unwieldy rolls of plastic into our full-sized van. The children sat on the plastic for the five-hour trip home. The next day we installed two layers of plastic over the second floor to make a makeshift roof, crossed our fingers and moved in. It was Sept 25, 1994. Finally, we were warm and happy and we lived in the house like that for three years. During those years we started a market garden business and began selling organic produce just like we had before we moved. That provided most of our income, along with part-time jobs. We built a 60-foot greenhouse with cedar (cut with the chain saw mill) and the left-over plastic.

We spent the off-season cutting roof trusses and boards. March 1997 was unseasonably warm and sunny, so we decided to put the roof on. We worked 22 days straight, and at 10:30 Sunday morning of the next day we pounded down the last shingle nail. Then it started to rain.

Jane and I stood on the hill overlooking the house, holding hands and rejoicing as water dripped off the eaves. We were done. Our completed house is 1,400 square feet with eight rooms. It cost only $5,000 but took four years to build.

The children sometimes complain about the kerosene lamps, or no electricity and video games like their friends, but we know they're happy. We recently hooked up solar panels to run a computer and lights. Nearly nine years without a utility bill. Hallelujah!

During slow times, we work on other projects. In 1998, we built a root cellar from field stone, a wonderful building material. It's free for the taking and looks tremendous when the project is done. It's also a great challenge to master a new art. Believe me, it is an art putting irregular stones together and imagining what they will look like when you're finished. After the root cellar, we tackled our fireplace. It looks beautiful and is the focal point of our first floor. Everyone remarks on how well the fireplace fits in with our timber design.

When we're asked why we live the way we do, one event always springs to mind: the ice storm of 1998. Two full days of freezing rain put most of eastern Ontario, southern Quebec and the northeast United States in the dark from downed power lines. It virtually paralyzed the area for weeks. In contrast, our children were ready at the school bus stop the day after the storm ended, but the school was closed for two weeks. We were relatively unaffected.

The hubbub that followed the storm included a gigantic cleanup effort in the affected areas. Our 90-year-old neighbor flatly refused to be removed from her home and placed in an emergency shelter, unequivocally telling her would-be rescuers, "I've lived more years than I care to remember with just my woodstove, my hand pump and a bucket. It's you people who have the problem." She promptly went back into her house, closed the door and proceeded to fire the woodstove to make her supper.

Our neighbor really makes us laugh — our lifestyle is similar to how she grew up more than 80 years ago. She smiles when she talks to us because we can relate to each other. Most people today just don't get it.

I know that anyone with a modest amount of energy and perseverance could do what we've done. I owe a great deal to the people who have gone before me and shed light on our own journey to self-sufficiency. Special thanks go to Helen and Scott Nearing. I hope they're smiling at our accomplishments, wherever they may be. And thanks to Mother Earth News most of all. There was a time when I read readers' reports to learn. Now I hope that I can help someone else in return.

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CHOOSING THE RIGHT SAWMILL

By Brook Elliot



BROOK ELLIOTT

Portable sawmills fall into three general categories: chainsaw mills, circular sawmills and band sawmills. They are available in a diversity of styles and operating systems, and are priced to fit any budget. "Which to pick," says Will Johnson, president of TimberKing, a portable sawmill manufacturing company, "depends on what you are going to do with it."

The variables, he says, are how much lumber you plan to saw and how quickly you need to cut it. A third variable is how finely finished you need the boards to be. Here are the pros and cons of each type of mill.

CHAINSAW MILLS

From a cost standpoint, chainsaw mills are inexpensive, and thus very appealing for homestead and farm use. Prices start under $100. But these mills are relatively slow, which means you can use them for major projects only if you have lots of time. Even with the special chains used for lumbering, they still make rough cuts; further milling is required for finished surfaces.

And they waste a lot of wood. "Generally," say's Erin Domagalski of Hud-Son Forest Equipment, "a chainsaw mill has 20 percent more kerf (width of the blade cut) than a band sawmill."

Most chainsaw mills require heavy-duty power heads. Your current chainsaw may not he powerful enough to run it, and a new chainsaw — which can double the cost — may be needed. Special-purpose chains and bars are required as well.

Most chainsaw mills are used with a framework you construct around the log you are cutting, which can be a slow, awkward process. Lining up the first cut is particularly important with these mills, because that surface acts as a guide for the rest of your cuts. The Alaskan Mark III from Granberg International is a good example of this type of chainsaw mill. Exceptions (like those available through Tilton Equipment Co.), consist of a rail-and-stand system in which the log is held by base stands and the saw rides upside down on the rails.

If you want to cut your own lumber, explore these options to make the best choice.

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For $1,695, this do-it-yourself solar kiln kit from Wood-Mizer includes the building plan, solar panel film, hardware and fans.



BROOK ELLIOTT(2)

Michael Best of the Sustainable Mountain Agricultural Center uses a moisture gauge to check the wood in his solar powered wood kiln.

CIRCULAR SAWMILLS

At one time, all sawmills used circular blades. Most larger commercial operations still do. Their primary benefit is speed. Circular saws cut much faster than band saws, but the downsides are that they are expensive and they usually have a larger kerf, so they waste more wood. The quality of the cut tends to be on the rough side.

Circular sawmills tend to be transportable, but not portable. They can take as much as a full day to erect once moved to the work site. And most times a crew of three to five people is needed to operate one efficiently and safely.

Older circular sawmills work with a vertical blade mounted in the bottom of the bed, similar to a workshop table saw. Modern ones position the blade overhead, with safety guards, like a radial arm saw. A good representative is the Mighty Mite "D" series sawmills.

A novel approach is the Lucas Mill, an Australian design imported by Bailey's, which uses a special five-tooth, thin kerf blade mounted horizontally to cut logs that sit on the ground instead of laying on a bed.

BAND SAWMILLS

Today's portable sawmill industry is dominated by bandmills. Technology has made them available in such an array of configurations and operating systems that they've almost displaced circular sawmills.

Although slower than circular sawmills, bandmills are truly portable either with an integral trailer system or inside a pickup truck. They are simple and safe to operate; produce less waste because of a smaller kerf; create smoother surfaces, requiring less milling; and are flexible enough to cut specialty lumber, such as shakes, shingles and clapboards. And they are much more affordable.

Depending on your needs, they come configured as small, manually operated mills; as midsized units with power heads and basic hydraulics; and as industrial strength mills, with power heads, built-in de-barkers, hydraulic log-handling systems and computerized networks.

When choosing a bandmill, the one thing you don't have to worry about is its cutting quality. Virtually all modern bandmills produce the same high-quality surfaces, requiring little final finish work. Configuration and cutting speed are the two important variables within each class.

However, don't pay much attention to manufacturers' claimed production speeds, says TimberKing's Will Johnson. "Productivity numbers are almost meaningless," he says. "There are just too many variables — including log size, lumber thickness and how fast the operator can work — to provide realistic production figures."

Decide whether or not you really need the particular bells and whistles on any given model. While full hydraulics are helpful, for instance, they can push the price up to $30,000 very quickly.

Manual bandmills come with either ground-level or elevated beds. Ground-level beds usually are found on mills that are transported by truck. Log handling is a lot easier with them, but there may be more operator fatigue from constant bending. Elevated-bed mills usually are transported by trailer and are easier to operate. But log handling is more of a bother, requiring ramps, lifts or additional equipment.

Manual bandmills can be used for commercial cutting, but are considered best for personal use on farms and small acreages.

A step up from manual mills are those with automatic carriage-feed systems and, in some cases, automatic setworks. Most do not include log-handling hydraulics. These mills are a lot less labor intensive and are good for custom sawing. They also are a good option for those with physical limitations, or for jobs requiring a lot of cutting in a short time period.

Bandmills in the middle price range include hydraulic log loading, turning, clamping and, in some cases, hydraulic toe boards. They are considered ideal for custom-cutting and production.

At the top of the line are the high production bandmills. These come with complete hydraulic and electronic operations for greater production, custom sawing and commercial lumber manufacturing.

When you're considering purchasing a sawmill, part of your decision should include what necessary accessories, such as log-handling equipment, you might need. If you can do the job with cant hoops and peavey poles, then a manual mill might meet all your requirements. But if you want to cut bigger logs that require a separate log lifter, then a hydraulic mill might make better sense.

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GREENER ROOFING OPTIONS

By Claire Anderson and Scott Hollis



JOSEPH JENKINS

There are roofing products that are gentle to the environment, and many of them are more attractive than standard roofing materials.

Builders have always said "a good hat and good shoes" are essential to protect a house from any type of weather. Even so, home builders opt to install the cheapest, shortest-lived shingles on four out of five new homes built in the United States today.

"'First cost' is the overriding issue in most home building," says Alex Wilson, executive editor of BuildingGreen, publishers of *Environmental Building News* and *Green Building Products*. "Builders are trying to get the most house for the least money. And most homeowners have bought into the idea that they should build or buy the largest house they can afford. Doing so means they cut corners on the material's durability and performance."

Incorporating green building materials into your home makes much more sense when you take a long-term view of home building and its life cycle costs. Only then is it apparent that building with better roofing materials is in your best interest. And now, eco-friendlier roofs are more attractive, affordable, durable and readily available than ever.

CRITERIA TO CONSIDER

Not all roofing material is created equal. Each has attributes that best suit certain structures and environments. Choosing the right product for your home involves a careful analysis of such factors as durability, solar reflectivity, cost and ecological impact. If you have considered reroofing your home or are planning to build a new house, weigh these criteria before selecting a roof material.

First, consider the roof's durability: How long will it last? Some asphalt shingles are in-

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ECOSTAR

Above: Made of synthetic rubber, this recycled roof has the look and feel of slate, but weighs significantly less.

expensive to buy, but they have half (or less) the life expectancy of many other roofing materials. But higher-quality asphalt shingles can be a viable option if properly chosen, says Clarke Snell in his book, *The Good House Book: A Common-Sense Guide to Alternative Homebuilding*. "Poor quality asphalt shingles ... are the Styrofoam cup of the building industry, [but] high-quality asphalt shingles are much cheaper than metal, easy for one person to install, accommodate roof punctures such as chimneys and skylights with relative ease, and can last 30 to 40 years or more." The moral here is that even the same product type can have a wide range of quality, so be sure you know what you're getting before you buy.

Another consideration when choosing a new roof is the material's solar reflectivity, known as the albedo. If you are planning to retrofit an older home with a greener roof, its albedo may be a greater concern than a newer house with efficient insulation. Use of lighter colored, low solar-absorbent roofing surfaces is one of the key measures advocated in the "Cooling Our Communities" program of the U.S. Environmental Protection Agency (EPA).

Studies conducted by the Florida Solar Energy Center compared the performance of roofing materials. Asphalt shingles had a solar reflectance ranging from 3 percent (onyx black shingles) to 31 percent ("white" shingles). Brown wood shingles were found to have a solar reflectance of about 22 percent, and a brownish-orange terra-cotta cement tile had about a 24-percent solar reflectance. In contrast, white and light-colored metal roofing had reflectances ranging from 50 percent to 66 percent.

Improving the albedo of your roofing surface can cut cooling costs by up to 50 percent, depending on how much insulation is in your ceiling or roof. And, while you save on cooling costs, you'll also prolong the life of your shingles. According to www.energystar.gov, roofs with high solar reflectivity maintain a more even core temperature, which protects against the shingles' deterioration.

"Cooling-load avoidance can be important in some situations," Wilson says. "But if a house is properly insulated to at least R-24 [the higher the R-value, the lower the heat flow] in the ceiling or roof, the heat gain or heat loss through solar energy absorption on the roof surface is really pretty minor. With the insulation levels recommended in a green home, albedo is not a significant consideration."

ASPHALT OPTIONS

According to the Asphalt Roofing Manufacturers Association, more than 12.5 billion square feet of asphalt shingle products are made each year — enough to cover more than 5 million homes annually.

The attraction to asphalt shingles is they are affordable and lightweight — no additional engineering is needed to put them on your rooftop. Of all the roofing products available, they usually are the least expensive upfront, but proportionately less durable over time.

"It's a hard sell to push homeowners to longer-lasting alternatives because those alternatives are usually a lot more expensive, and the homeowner probably doesn't expect to stay in a house for more than 20 years," Wilson says.

"Asphalt is a bad roofing option from an environmental standpoint," Wilson adds. "In addition to all the resources going into making such a short-lived product, there is a tremendous amount of solid waste generated from the removal of old shingles."

Every year about 11 million tons of asphalt shingles are shucked into landfills, according to www.shinglerecycling.org. In fact, old asphalt shingles constitute about 3 percent of all municipal solid waste. Asphalt shingles can be recycled, but so far the technology to do so is in its infancy, and widespread asphalt shingle recycling is not available.

Asphalt shingles come in two different kinds: organic-based or fiberglass-based. The organic kind are made from materials such as recycled waste paper, wood fibers and felt, then saturated with a specially formulated asphalt



GLADDING MCBEAN



2004 ROOFSCAPES, INC.

Left: Clay-tile roofs are often considered green for their ability to be removed, reused and installed on other buildings. Additionally, clay has a high resistance to wind and fire, and is low maintenance. Right: "Living roofs" offer a way to reduce heating and cooling costs, improve local air quality, mediate urban heat-island effects and reduce storm-water runoff.

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Green Roofing Materials Comparison

Product	Avg. cost per sq. ft. material	Avg. cost per sq. ft. installed	Estimated life in years	Recyclability	Maintenance after installation	Solar reflectivity (albedo)
Asphalt shingles	Low	Low	12 to 40	Low	Low	Depends on color
Thatch	Moderate	Very high	50 plus	High (compostable)	Moderate	Depends on color
Wooden shingles	Moderate	Moderate	10 to 30	Low to high	Moderate	Usually poor for brown woods
Clay tile	High	High	100 plus	High	Low	Depends on color, but poor for darker colors
Slate	High	High	100 plus	High	Low	Depends on color
Living roofs	High	High	Up to 40	Moderate	Moderate to high	Cools through evaporation
Polymer and rubber shingles	Moderate	Moderate	Up to 50	Low	Low	Depends on color
Metal	Moderate	Moderate	20 to 50	High	Low	Depends on color, but usually good

coating and surfaced with weather-resistant mineral granules. Organic-based asphalt shingles contain about 40 percent more asphalt per square (100 square feet) than fiberglass, which gives them more weight, durability and blow-off resistance. Fiberglass shingles start with a glass-fiber reinforcing mat that is coated with asphalt and mineral fillers for adhesion, then embedded with ceramic granules. Asphalt shingles come in many different shapes, sizes, thicknesses and grades. If you do choose to use asphalt, make sure to pick the most durable shingle that suits your structure's needs, usually an organic variety.

CLAY-TILE ROOFS

Made from abundant raw materials, ceramic-tile roofs are one of the longest-lasting roofing materials available. "Fifty years is nothing for a tile roof," says roofing restoration expert Joseph Jenkins of Barkeyville, Pa. "Fifty years is a young tile roof." In fact, tile roofs can easily last for more than 100 years, often outlasting the buildings they protect. Because of this, they often are considered "recyclable roofs" for their ability to be removed and installed on other buildings. Clay tile also is coveted for its high resistance to wind and fire, low maintenance and ease of repair.

Disadvantages include its heavy weight and its high initial cost. Tile roofs can easily cost two to three times more than an asphalt shingle roof, but the initial expense will pay off in many years of hassle-free roofing.

OUT OF THE WOODS

Generally split from Western red cedar, Alaskan yellow cedar and Eastern white cedar logs, wooden shingles are available in a variety of shapes and sizes. They have an estimated life of 25 to 30 years in dry climates, and 10 to 15 years in moist climates. Wooden shingles allow the roof to "breathe" and release water vapor, provided they are laid over a subsurface that allows for air circulation behind the shingle.

While the rustic beauty of wooden shingles is obvious, they do have their drawbacks. "I am not a fan of wooden shingles," Wilson says. "The raw materials are typically not sustainably produced, and the durability is fairly short, particularly in wet climates."

Moist climates will promote mold, rot, mildew and fungus growth, and arid climates will result in warping and cracking over time. The initial cost also can be high — twice as much or more as asphalt shingles. Wooden shingles may not be suitable for use in fire-prone areas. Check with your local building code official first.

According to the Center for Resourceful Building Technology, the wooden shingles predominantly found on the market are from old-growth forests. For homesteaders with the ability and the resources, hewing your own wooden shingles from already fallen local timber is a viable alternative.

STEP UP TO SLATE

Slate stone roofs are perhaps the most durable of all roofing materials. They also are strong, available in a color spectrum from sea green to earthy red, and are quite beautiful. Tiles can be made in almost any shape, and they can be installed on roofs in a variety of thicknesses, widths and lengths.

Slate can weigh 6 to 7 pounds per square foot, which may require additional structural support for your home or building. The minimum slope for a slate roof is a ratio of 4:12, Jenkins says, but the best use for slate roofing is for steep slopes. Like clay tile, slate also can last long past the life of the building — making it extremely recyclable — and it is initially more expensive than many other roofing materials, but less expensive when comparing the long-term cost over a roof's life.

Slate can last almost indefinitely, depending on the type, thickness, fasteners, roof slope and installation, with only minor maintenance. With the right tools and a little know-how, installing or repairing a slate roof is fairly straightforward. Reclaimed slate also is available.

"By recycling a slate roof yourself, you can own a lifetime stone roof for less money than the cheapest of asphalt roofs," Jenkins says. "If you're not that industrious, you can buy new or used slates and install them yourself with the proper guidebook and tools." Professional slate-shingle installation also is widely available.

UNDER THE EARTH

Living roofs, covered with a dense mat of growing plants, are sprouting up on the tops of commercial and residential buildings in the United States as a way to reduce heating and cooling costs, and to improve local air quality. Urban heat-island effects (the tendency for large asphalt and concrete areas — such as in cities — to build up more heat than the surrounding countryside) also are reduced, as is storm-water runoff. Living roofs can detain more than 50 percent of rainwater from a typical storm, which reduces the loads placed on storm sewers in urban areas, according to Green Building Products.

Also referred to as a "green roof," a living rooftop usually consists of a waterproof membrane, such as a modified asphalt or synthetic rubber (EPDM), over the roof sheathing. Next, a root barrier and drainage media are placed. On top of the drainage media, 2 to 6 inches of a planting mixture (lightweight aggregate, sand, organics, clay and silt) are laid. This soil structure supports drought-tolerant plants such as succulents, herbs, forbes, grasses and some low groundcovers.

Due to their weight and need for solid structural engineering, living roofs are better suited to new construction, rather than retrofits, although a structural engineer can help you determine the feasibility of your existing building structure for supporting a living roof. Water will add another 10 to 25 pounds per square foot when the living roof is saturated, so this roofing method shouldn't be taken lightly. Weight requirements (including snow, where applicable) need careful consideration when a suitable roofing structure is designed for holding up all that earth.

Living roofs are now available from a handful of suppliers for either commercial or residential application. The Green Products Directory lists U.S.-based companies that specialize in this area.

One of the problems with living roofs is what to do if they ever spring a leak. Tracing the leak back to its origin can be a time-consuming exercise in frustration, and solving the problem may require some professional consultation and careful excavation.

GRASS ROOTS ROOFS

Thatch roofs, made with the dry, coarse stems of reeds or grain crops, have been common wherever these materials exist for thousands of years.

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COURTESY OVONIC SOLAR

These thin-film photovoltaic panels are bonded directly onto the metal roof.

A common misconception is that thatch absorbs large amounts of water. In fact, in a thatch roofing system water is transferred down the roof from stem to stem until it drops. The steep pitch usually (at a ratio of 12:12) associated with thatch roofs allows for water to be shed at a very fast rate, according to the Building Conservation Directory (www.buildingconservation.com), a Web site dedicated to the conservation of historic buildings.

Besides being water-resistant, thatch roofs are wind-resistant. And, because of the thousands of air pockets between and within the plant material, thatch also is a good insulator, providing an R-value of about 40.

Fire can be a concern, however, and thatcher Colin McGhee of Staunton, Va., says that to comply with fire codes on public buildings, his company treats its thatch with an odorless, nontoxic fire retardant. "But thatch, as it's used in roofing applications, is inherently very fire resistant," McGhee says.

Thatch reed roofs are long-lasting, with life spans estimated between 50 and 100 years, if constructed and maintained properly, McGhee says. "Every 12 years or so, thatch roofs need a brushing and dressing off, and the ornamental ridge replaced. I've worked on [thatch] roofs in England that are more than 100 years old and still going strong."

But at a considerable price per installed square foot, most of us don't have deep enough pockets to roof our houses with thatch. If you're entranced with thatch, consider tackling a smaller project such as a garden shed or gazebo. For do-it-yourselfers, McGhee sells inexpensive, "shaggy" thatch mats at less than $5 per square foot.

Keep Your Cool with Solar Attic Fans

Many homeowners install vents that rely on convection currents to help keep air circulating through the attic, and others rely on active fans (powered by electricity) or windy days to keep air in motion. The best designs have continuous soffit and ridge vents to remove any moisture that might get into the ceiling or attic insulation. But if these vents are not feasible, solar-powered attic fans can be a reasonable alternative.

During summer months, attics in many homes trap heat, putting an extra burden on your cooling system. In the wintertime, poorly ventilated attics can sequester warm, moist air that rises from a home's heated interior. As moisture condenses and collects on various surfaces, wood rot, stained ceilings and peeling paint can result. If moisture infiltrates attic insulation, it can reduce the insulative abilities of the cellulose or fiberglass.

A solar-powered fan (or vent) works solely on its own power, year-round, to help keep attic air moving when you need it most — during daylight hours. No wiring is needed to install the fan, and most are in place in less than 30 minutes. Some models can even be installed at the site of an existing attic vent, eliminating extra roof penetrations. Because most are low-profile, they integrate almost seamlessly onto your rooftop. Solatube's Solar Star attic fan circulates air at 800 cubic feet per minute, providing coverage up to 1,200 square feet. Prices for solar-powered fans start at $295.

Natural Light Solar Attic Fan: Natural Light Energy Systems
(800) 363-9865; www.solaratticfan.com

Solar Star: Solatube
(800) 966-7652; www.solatube.com

Elite Solar-Powered Attic Fan: EcoVantage Energy
(877) 591-0661; www.ecovantageenergy.com

RECYCLED ROOFS

The rise in popularity of green building has produced a large variety of recycled roofing materials, ranging from rubber shingles to imitation slate tile made from recycled plastic and waste-wood composite. Known as polymer-composite or synthetic roofing, these products have the advantage of being lighter than clay tile or slate. Their inherent flexibility makes them resistant to hail damage, high winds and even occasional foot traffic. Made primarily of synthetic materials, they also resist organisms that promote decay. Most polymer roofing materials carry 40- or 50-year warranties, but also carry a high initial cost, often about $3 per square foot.

Panelshake roofing panels, molded from a mixture of old milk jugs and waste-wood fibers, mimic the look of natural slate and tile roofs. Another composite roofing product, Enviroshake, combines reclaimed materials such as recycled plastic, agricultural flax- and hemp-fiber waste and a little bit of post-consumer recycled tire rubber. Touted as an alternative to traditional cedar shakes, Enviroshakes incorporate UV protection with excellent mold-, mildew- and insect-resistant properties. Once installed, they are almost maintenance-free. By using 60-percent to 70-percent recycled tire rubber, Euroslate moves rubber from the road to your roof. And as an interlocking roofing system, Euroslates offer a similar look to slate.

Although polymer-composite roofing offers some environmental benefits up front, no infrastructure exists currently to support the reclamation and recycling of these materials at the end of their useful lives. Robert Falk, Ph.D., one of the original designers of the product, says he eventually would like to see a buyback system put in place to promote the return of used composite building materials to companies for remanufacture.

Fiber-cement shingles, made by blending Portland cement with finely ground sawdust (from recycled sources), sand and clay, are another composite product. Known for their durability in warmer climates, they typically carry a 50-year warranty. Unfortunately, fiber-cement shingles absorb water, which may weaken the shingle due

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ROOFING RESOURCES

For a comprehensive listing of all green roofing materials and company information, we highly recommend *Green Building Products,* published by BuildingGreen (www.buildinggreen.com).

WOOD SHINGLES

Search for Forest Stewardship Council- and SmartWood-certified products at www.smartwood.org and www.fsc.org

CLAY TILE AND SLATE

Gladding McBean has more than 125 years of experience making clay roof tile and terra cotta. (800) 776-1133; www.gladdingmcbean.com

To find a clay-tile or slate roofing contractor or sources of new and used clay tile or slate in your area, visit the Directory of Slate Roof Contractors at www.jenkinsslate.com.

The Slate Roof Bible, by Joseph Jenkins, gives an in-depth look at slate roofing through the ages, and provides complete instructions for slate-roof installation and repair.

RECYCLED ROOFING PRODUCTS

Polymer-composites: EcoStar, (800) 211-7170; www.ecostarinc.com

Euroslate: GEM, (403) 215-3333; www.euroslate.ca

Eco-Shake: Re-New Wood, (800) 420-7576; www.ecoshake.com

Panelshake: Teel Global Resource Technologies, (800)-322-8335; www.teel-grt.com

Used tile and slate: Jenkins Slate, (866) 641-7141; www.jenkinsslate.com/usedslate.htm and www.jenkinsslate.com/new-usedtile.htm

THATCH

McGhee & Co. Roof Thatchers, (845) 721-0443; www.thatching.com

Offers consultation and installation services across the United States. Also sells ready-made, thatched-roof playhouses, doghouses and, for do-it-yourself projects, "shaggy" thatch by the square foot.

LIVING ROOFS

Roofscapes, (215) 247-8784; www.roofscapes.com

Weston Solutions sells the GreenGrid system, which is a modular living roof design that allows for rapid installation. (312) 424-3319; www.greengridroofs.com

Visit www.greenroofs.com for the "international green roof industry's resource and online information portal." Go to www.greenroofs.org or www.ecoroofseverywhere.org for general information.

PHOTOVOLTAIC ROOFING

Sunslate: Atlantis Energy Systems, (916) 438-2930; www.atlantisenergy.org

Uni-Solar: United Solar Ovonic, www.uni-solar.com

to freeze-thaw cycling in cold weather. Some products, however, have coatings or polymer constituents to minimize water absorption.

METAL ROOFS

Metal roofing can be made with up to 25-percent recycled steel from scrapped automobiles. This form of roofing is the lightest medium available, weighing a fraction of slate or clay tiles. Additionally, metal will not rot or crack, is noncombustible and designed to resist hurricane-force winds. Metal roofing also reflects more radiant sunlight than it absorbs, which saves you money on heating and cooling, and it comes in a wide spectrum of materials: steel, stainless steel, aluminum, copper and zinc alloys. Each has different properties that affect durability, price and appearance. Prices range from about $1.80 to $6 a square foot, which may seem expensive, but its long life, minimal maintenance and reduced installation labor makes it proportionately affordable over the long run. It's lightweight and durable, with a life expectancy of 20 to 50 years, and you can sheet right over an existing roof with it.

Metal roofing does have a few drawbacks. Some types of metal roofing such as aluminum make more noise during rain or a hailstorm and can dent. Long-term issues include paint finishes that can peel, chip, fade or scratch.

PHOTOVOLTAIC ROOFS

The last word in eco-friendlier roofs may be the introduction of photovoltaic (PV) roofing shingles and thin-film laminates that both serve as a protective roof cover and energy powerhouse. When the sun strikes the solar cells embedded in their matrix, electricity is produced. These types of shingles may even produce power on partly cloudy days. According to the National Renewable Energy Laboratory, solar shingles provide the same durability, flexibility and protection as asphalt shingles. Most are warranted to produce power for at least 20 years.

United Solar Ovonic's Uni-Solar shingles incorporate directly onto the roofing surface and usually integrate well with conventional asphalt shingles. The company estimates that replacing a 450-square-foot section of conventional shingles with solar shingles can meet a third of a typical household's annual electricity needs. Atlantis Energy System's SunSlate PV tiles can be incorporated with tile, shake, metal or asphalt-composite roofs.

Joe Schwartz, CEO of *Home Power* magazine, says one drawback to solar shingles can be the myriad connections and roof penetrations that the shingles necessitate. And the dark color and high absorbance of solar shingles can actually add to a home's thermal load. (This can be remedied by insulating the home from the shingles, such as with a radiant barrier.)

United Solar offers a simpler and less costly option with its PV laminates that are bonded directly onto metal roofing. The photovoltaic sections are larger with fewer connections and roof-penetrating drill holes. These panels range in size from 4½ (31 watts) to 18 (136 watts) feet, with wiring either in the ridge cap or the eave soffit. On average, about 180 square feet of roof area with good solar access generates 1 kilowatt of electricity. Go to www.uni-solar.com for more information.

The biggest hurdle for installing PV-shingle or tile systems is their high initial cost. Uni-Solar Model SHR-17 solar roofing shingles, for instance, cost about $135 for every 7-by-1-foot section, not including installation, power inverter, batteries, mounting, fuses and wiring. You're not only buying a roof, however, you're also buying energy-producing solar panels.

Additionally, a growing number of states now offer tax and rebate incentives of up to 50 percent of a system's total cost to help ease the cost of investing in this renewable energy technology. (To find out if you are eligible for any incentive or rebate programs in your area, search the Database of State Energy Incentives at www.dsireusa.org.) Factor this in with the reduced or even nonexistent electricity bills you'll encounter each year, plus the satisfaction of producing pollution-free electricity, and solar roofing becomes a far more viable roofing option.

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SAVE MONEY WITH USED BUILDING MATERIALS

By Tabitha Alterman



HABITAT FOR HUMANITY

Before purchasing new building materials, consider other options.

The construction of an average-sized home (2,000 square feet) usually results in 8,000 pounds of construction waste. Add that to the waste generated by demolition, and the figures are astounding: Every year in the United States, 136 million tons of construction and demolition waste are tossed into landfills. This debris amounts to more than half of all landfill waste — but if handled properly, much of it can be diverted and reused. Here are several ways you can locate reclaimed and recycled construction materials:

"Freecycling" (www.freecycle.org) is an easy-to-use Internet service for people who want to trade things locally. Membership is free, and after a quick registration, each local group allows its participants to post messages for objects they want to unload or request items they need. Although it is not limited to construction materials, there are plenty of building treasures being swapped by more than 1.3 million members in about 2,700 communities. Also try www.buildrecycle.net and www.sustainableabc.com for lists of similar organizations across the country. Internet auctions such as those on eBay (www.ebay.com) frequently include construction materials. The trick with eBay is to make sure you actually are purchasing a recycled product, rather than a new one.

Another good place to find used building materials is your own neighborhood. Your neighbors who are remodeling probably will be thrilled that you want to take that old bathtub, shower door or fireplace mantel off their hands. Houses set for demolition also are gold mines for materials, especially wood, hardware and fixtures such as sinks and cabinets.

Habitat for Humanity operates retail outlets called ReStores that sell used and surplus building materials at a fraction of their regular prices. The proceeds from ReStores help fund construction of Habitat for Humanity housing. Local construction companies and salvage yards often are willing to unload their "waste" onto eager takers. Look up "used," "recycled," "salvaged," "antique" or "junk" in the Yellow Pages.

The technology to reconstitute many construction waste items into new products is rapidly progressing. Many states recycle drywall, and a few recycle carpet. Several kinds of glass can be made into new windows. Cardboard, paper and agricultural fibers can be turned into lightweight home insulation or particleboard. Rastra building blocks are made from recycled plastic foam and concrete.

Some professional builders are making it easier than ever to reduce, reuse and recycle when building or remodeling a home. Many contractors and companies will use reclaimed or recycled materials whenever possible. Visit the Green Building Professionals Directory (directory.greenbuilder.com/search.gbpro) for a list of resources near you.

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PERFECT PLASTER

Story and photos by Dan Chiras



A homeowner's guide to plastering, including a plaster prime, earthen plasters, moisture management, lime plaster and cement stucco.

Commonly used as a protective finish over exterior walls, plasters also offer durability and beauty for interiors. But choosing the right plaster is not just a matter of aesthetics: The very lifespan of your home can depend on your choices. Today's homeowner has many varieties from which to choose: natural plasters of earth, lime or gypsum, and stuccos of cement or synthetic materials.

A PLASTER PRIMER

Knowing the characteristics of the wide array of plasters in use today, and the pros and cons of each, will help you make the correct choice for your home.

Plasters and stuccos usually consist of three basics: a structural component, a binding agent and some sort of fiber. Sand provides most of the volume of a plaster and serves as the structural component of all plasters and stuccos except gypsum plaster. Depending on the mixture, sand also can lend texture to the plaster.

When water is added to a plaster or stucco mix, binding agents — such as lime, gypsum or cement — cause the sand particles to adhere to each another, creating a pliable, cohesive material that spreads smoothly and bonds onto walls. As the water evaporates, plasters and stuccos

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Earthen plaster require the handiwork of folks who don't mind getting dirty.

set, or cure, and the binding agents create a hard, protective finish.

Fibers frequently are added to increase the plaster's strength, provide reinforcement and reduce or eliminate cracking. Straw, cattails and wool are used in earth plasters; fiberglass is added to cement stucco. In days gone by, horse hair was added to a gypsum plaster base coat.

Plasters and stuccos are spread by hand or trowel, or sprayed on with a mechanical sprayer or pump. Instead of one thick layer, several thin coats are applied to reduce slumping, which may cause plaster to detach from a wall. Thin-layer application also reduces cracking as plasters and stuccos dry. When cured, plasters and stuccos produce a fairly fireproof layer, covering combustible materials in the walls' interiors.

Plaster can provide a smooth or textured finish depending on the plaster and application method. With its small imperfections and ability to be molded around corners and niches, earthen plaster can lend a warm, rustic feel to a home or "create smooth walls with even curves and a polish so fine it feels like glass tossed up from an ocean beach," says Keely Meagan, author of *Earth Plasters for Straw Bale Homes*. Gypsum plasters and stuccos can take on a multitude of textures as well. Compared to earthen plasters, achieving a uniform finish for gypsum and stuccos generally requires less work.

EARTHEN PLASTERS

Earthen plasters are the most ancient of all plasters and continue to be used in many parts of the world today. Here in the United States they find a receptive audience among many natural builders, who are making homes out of straw bales and earthen materials, such as adobe, rammed earth and cob.

Earthen plasters require some experimentation. Unlike other wall finishes, such as gypsum plaster, earthen plasters are not sold in ready-mix powders, except in Germany, where they are available in bags from building supply outlets. Earthen plasters must be made from scratch: dirt, often with a little sand, straw and cooked flour paste (hardener) or manure added to create a more durable finish that won't shed sand or fine clay particles. In most locales, earthen plasters are made from subsoil containing a mixture of clay, sand and silt. The subsoil in some regions is perfectly suited for earthen plaster. In other areas, the subsoil may need to be amended with additional sand or clay to create a workable mix. Most mudders experiment with various mixtures to see which ones are easiest to apply and adhere well, and determine which mixtures offer the best long-term performance. Even so, it doesn't take a mad chemist to get a good mix.

With the right clay-sand-silt ratio, little more is required to make an earthen plaster other than screening, stomping and smearing. First, dirt is screened to remove pebbles, rocks and organic debris, such as roots. Then it's mixed with water and straw, and stomped or stirred. (Kids and adults love to join in: It's far more marvelous than mudpie making and is a satisfying stress reliever.) Once the mixture is thoroughly combined, the mud plaster is applied to walls by hand or with a trowel.

Builders of straw bale, adobe, cob and other types of natural homes use earthen plasters for interior and exterior walls, usually applying the plaster in two or three layers. The first coat or two levels out the wall surface. The last coat, or finish coat, provides a smooth, suede-like finish and color. When the finish plaster has dried, many builders apply an alis (pronounced al-lee), a paint made from powdered clay mixed with earthen pigments, to give walls a wash of dramatic color.

"Earth plasters make the most beautiful walls I have ever seen," Meagan says. "The colors are gorgeous and incredibly varied."

Materials for an earthen plaster often can be gathered from the building site itself — for example, from the foundation excavation — making this plaster an inexpensive material with low embodied energy. (Embodied energy is the total energy required to extract, manufacture and transport a material.) Even if they're not available on site, clay-rich dirt and sand often can he imported from a nearby field or gravel yard, ensuring the lowest embodied energy within the entire family of plasters and stuccos. The small scar that results from extracting dirt for an earthen plaster can be filled easily and replanted, or converted to a small pond, erasing all sign of human activity. Ease of reclamation, combined with its low embodied energy makes earthen plaster by far the most environmentally benign of all wall finishes. And earthen plasters are perfect for people who want to avoid using petrochemicals and other synthetic chemical paints.

Earthen plasters are easy to repair and maintain. If cracks develop in a finished wall, you simply wet the wall and smear on more finish coat, smoothing out the surface and feathering the edges. Alis can be applied to cover up the repair work. Using alis instead of manufactured paints for wall color also spares individuals from exposure to harmful chemicals.

If a home is built with adequate roof overhangs to protect walls from heavy rains, earthen plasters can be used in a wide variety of climates, even some rather harsh ones. Ideally suited to natural home building, earthen plasters allow walls to breathe and permit water vapor that enters a wall (for example, through cracks around window or door openings) to evaporate. This characteristic helps protect earth and straw in a wall's interior from moisture. Water accumulation can cause straw bale walls to mildew and eventually decompose, and earthen walls to deteriorate and collapse.

Although earthen plasters are nontoxic, environmentally friendly and easy to make, they're not always permitted in local construction codes. Local building-code officials may be reluctant to give their approval, especially for exterior applications. However, providing code officials in your jurisdiction with published information on the durability of earthen plasters and designing a home to protect the walls from weather may convince them of the merits of this readily available, eco-friendly material.

LIME PLASTER

Lime plaster is a mixture of lime and sand with fiber occasionally added. The primary

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Earthen-plastered buildings, like St. Francis de Assisi church in Ranchos de Taos, N.M., have weathered the centuries. Bottom: A new earthen-plaster straw bale home in Colorado.

component of lime plasters is lime putty, a hydrated-lime product (calcium hydroxide) with the consistency of sour cream. It can only be purchased from a few sources like the Building for Health Materials Center in Carbondale, Colorado (www.buildingforhealth.com). Lime putty also can be made from Type N or Type S hydrated lime (not agricultural lime). Available in many building-supply outlets, these dry powders are fairly inexpensive.

To make lime putty from hydrated lime, the powder is first mixed with water. Protective clothing and eyewear are essential, as the reaction between lime and water produces an intense heat that can boil and splatter this caustic material. Before you attempt mixing lime putty on your own, read more about it. Consider working with a skilled lime plasterer to gain hands-on experience.

After the water and hydrated lime are mixed, the material is left to sit, usually a day or two, although veteran lime plasterers like their lime to hydrate, or slake, for months or years to achieve full hydration. When fully slaked, the lime putty is separated from the water layer on top, mixed with sand and applied to the wall, either by gloved hand or trowel. Some lime plasterers like to harle — throw — lime plaster onto walls from a distance of about 3 feet. Generally, two or more harled-on coats provide a durable exterior finish, although harling is an art most often reserved for experts.

As lime plaster cures, the calcium hydroxide in the mix slowly reacts with carbon dioxide in the air. In the process, calcium hydroxide is slowly converted back to the parent material — calcium carbonate or limestone — producing an extremely durable and highly protective wall surface. After application in drier climates, walls need to be misted one to three times a day for one to two weeks to prevent the lime plaster from drying out too quickly, which weakens the material considerably and can cause it to crumble off the wall.

Lime plaster is the strongest and most durable of all plasters and stuccos on the market today. It provides superior protection over stone, cement, cement-block and brick walls, and is ideal for exterior applications, especially in rainy climates where driving rains are common. Lime plaster is quite suitable for interior walls and for application in straw bale, straw-clay, cob and adobe homes. Like earthen plasters, lime plasters permit the escape of water vapor within walls.

Because of lime plaster's long set time, working with this plaster requires more experience than earthen plaster. Its caustic nature makes it potentially dangerous to all who work with it. Intense energy is required to manufacture lime from crushed limestone, so lime plaster also has a high embodied energy. For these reasons, lime plaster may best be used as a thin top coat over an earthen plaster base coat. Approval from building-code officials should pose few, if any, problems.

GYPSUM PLASTER

Gypsum plaster is primarily composed of calcium sulfate, a mined mineral. Until the advent of drywall (gypsum wallboard), gypsum plaster was widely used as an interior wall finish in the United States and Canada. It was usually applied over wood lath — wood slats nailed horizontally onto wall-framing members. But as the popularity of drywall skyrocketed, gypsum plaster fell out of favor. It is now rarely used in conventional home construction, except as a decorative coat over drywall to produce texture and interesting patterns. In the interiors of many natural homes, however, gypsum plaster is experiencing a revival.

Gypsum plaster is widely available, relatively inexpensive and easy to work with. You can purchase it in dry-powder form from many building-supply outlets. Powdered mixes require only the addition of water and a little stirring before application.

Gypsum plaster goes on quickly and adheres well to a variety of surfaces. It is usually applied in two coats: a base coat and a finish coat. Because it sets up quickly, application of the final coat proceeds soon after the first coat is laid down.

Another benefit of gypsum plaster is it expands slightly as it dries and sets up, which reduces or eliminates cracking. Most other plasters shrink a bit when curing and are more prone to cracking. Although hairline cracks may form in gypsum, daubing cracks with a wet cloth or sponge seals them.

Gypsum plaster sets quite hard, producing a durable interior-wall and ceiling finish. Like lime plasters, gypsum plasters require little maintenance. Most finish gypsum plasters can be wiped clean if soiled and are not subject to dusting or crumbling.

But gypsum has its disadvantages. Although it provides a durable interior surface, gypsum plaster is too water soluble to use on exterior walls. Because it sets up so quickly, it is difficult for beginners to work with. In addition, gypsum contains a number of chemical additives to improve set time and hardness. These volatile organic chemicals outgas from the



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material both during application and after the plaster dries, and may be of concern for chemically sensitive individuals.

CEMENT STUCCO

A mixture of portland cement, sand, fiber and small quantities of lime, to permit it to expand and contract without cracking, cement stucco provides a durable finish for exterior walls. Cement stucco has a long history of successful application in a wide variety of climates, from the arid deserts of Arizona to the frigid forests of Wisconsin. This tough exterior finish can be pigmented or painted to achieve a wide variety of beautiful colors. Cement stucco may last a building's lifetime if applied correctly.

Usually applied in three coats over masonry materials such as concrete or concrete block, cement stucco forms a protective wall finish that resists assault from an assortment of forces, from woodpeckers to weed-eaters. It may also be applied onto exterior sheathing products such as plywood or oriented strand board (OSB). For best results, a water vapor-permeable, water-resistant building paper (like tar paper) is first attached to the sheathing. Tar paper and similar products protect the wooden sheathing from water that may seep in through the stucco, while permitting moisture inside the wall to escape. The plaster is applied over metal lath or chicken wire fastened over the tar paper and into the sheathing. Lath provides reinforcement and a rough surface onto which the cement stucco attaches.

Cement stucco sheds water well and offers some vapor permeability, unless sealed with a waterproof paint, but it's not breathable like earthen, lime or gypsum plasters.

Components of cement stucco — cement, sand, lime and fiberglass strands — are easy to obtain and relatively uncomplicated to mix. These stuccos can be worked into a variety of textures by altering the size of the sand particles, controlling the consistency of the mix and by using special application techniques. Because cement stuccos are widely used in North America, finding an experienced plasterer is easier than for most other plaster wall finishes.

Despite their ease of application and availability, cement stuccos have the highest embodied energy of all plasters and stuccos, so they're not your most eco-friendly choice. Cement production requires extensive mining and cement itself generates significant pollution in its manufacture.

Cement stuccos also tend to crack, especially around doors and windows. Cracks are difficult to repair and, if not sealed quickly, allow moisture to penetrate walls, damaging wood and insulation. Adding lime and fiberglass fibers to the mix helps prevent this predicament. Cement stucco can create serious problems when applied to straw bale, cob or adobe homes. Not only do unsealed cracks permit moisture to enter, cement may wick moisture into walls through capillary action, causing water accumulation inside earthen and straw walls, and the eventual deterioration of the walls.

SYNTHETIC STUCCO

Synthetic stuccos consist of sand suspended in a mixture of acrylic polymer, latex and pigments. Applied to hundreds of thousands of homes in North America, synthetic stuccos are purchased premixed in 5-gallon buckets. Application is as easy as stir, scoop and stucco: Simply pop open the top, stir a little, then scoop out the material and trowel it on the wall.

Like cement stuccos, synthetic stuccos are applied over a variety of substrates. The most common application calls for two coats applied over an insulating foam board nailed to exterior-wall sheathing. Synthetic stuccos are typically called exterior insulation and finish systems (EIFS).

Synthetic stuccos are convenient, go on quickly, dry rapidly and provide a nice finish. They are typically used for exterior applications, where they form a protective, waterproof, nonbreathable barrier. More flexible than other materials, synthetic stuccos expand and contract without cracking in response to changes in temperature.

When manufacturers first introduced them in the 1980s, synthetic stuccos promised excellent, low-maintenance protection against the elements. Unfortunately, in the early 1990s many homeowners and home inspectors began to notice serious problems — most notably, rotting walls — caused when the synthetic stuccos were improperly installed or when cracks were not sealed. Inspectors soon found that water, which had entered wood-frame walls from various sources (cracks around windows, for instance), couldn't escape. The waterproof membrane trapped even small amounts of moisture, causing framing members and wood sheathing to rot, often resulting in severe structural problems.

Homeowners and insurance companies have spent millions of dollars repairing homes coated with synthetic stuccos, says David Dobb, a contributor to This Old House Online (www.thisoldhouse.com). So serious are the problems that several class-action lawsuits have been brought against the manufacturers. Some municipalities have banned synthetic stuccos completely.

In the wake of this disaster, manufacturers have devised a new technique for applying synthetic stuccos. In this system, a waterproof, but breathable, house wrap is first applied to the sheathing. Then a thin mesh is attached to create a route for water drainage. Rigid foam is nailed in place next, and stucco is applied over the foam.

Although these steps add to the cost of application, this new, improved system is believed to prevent water accumulation in walls. Use this material with caution and inspect your walls for cracks and water intrusion regularly; every six months is recommended. If you find damage, repair it immediately.

PERFECT PLASTER

Matching the right material to the job is the key to perfect plaster. While plastering is a rather labor-intensive process that requires considerable patience and skill, with a little training and experience, almost anyone can master it.

If you're not tempted to try your hand at plastering, hire a professional. Although it will cost quite a bit more, the results will be well worth it. Choose wisely and design your home to protect the plaster from water, its No. 1 nemesis. Protect your plaster or stucco and it will protect your home for many years to come.

Contributing Editor Dan Chiras is an authority on environmental issues and sustainable building. His book, *The Natural Plaster Book,* is available at www.MotherEarthShopping.com .

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