A superior resource, covering so much ground that no other straw bale book does, with clarity and wit. An excellent, vital addition to the thinking person's literature of straw bale. —Mark Piepkorn, *The Last Straw*

Paul Lacinski and Michel Bergeron

SERIOUS STRAW BALE

A Home Construction Guide for All Climates

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PREFACE

THIS IS A BOOK ABOUT WALLS—about how to design and build beautiful (and hopefully durable) walls of bales and plaster. It is written with one intention, to provide you with the background necessary to *think* your way through a straw bale project even in an extremely cold and/or wet climat It is emphatically not a book that aims to prescribe one best way of doing things; part of what is exciting about bale and plaster walls is that they are not yet (and perhaps never will be) streamlined into a “one-size-fits-all” system.

This is also not a book about the general topic of building design. Materials are only a small portic of good design; they are subservient to the many interlocking issues—the needs of the occupant, aesthetics, energy use, site, structure, and budget among them—that weave a design program. This book does not attempt to lead the reader through all the stages of this intricate process. Many good books already do that. Instead, it looks at design issues from the specific perspective of the straw bal builder, and at each turn, offers strategies for how to integrate these types of walls into the larger process of design.

The central text of this book revolves around design issues. We hope these will be of use to anyone —architect, builder, owner-builder, Renaissance woman—who is thinking about how best to detail a bale-walled building. Some issues that are primarily the concern of owner-builders are covered in sidebars, as are some construction issues. Part 1 of the book, and most notably chapter 3 (“Plans, Permits, and Project Management”) is written with owner-builders particularly in mind.

Wherever possible, we have offered our opinion on the efficiency of a particular method or durability of a particular detail. You must understand that while we (and the many others who have contributed ideas to this book) have been at this work for some time, we don’t have all the answers to all the questions about straw bale construction. Much experimentation, systematization, and testing remains to be done. The goal of this book is to supply you with the best of the tools now available, so that you may begin to participate in this process. We hope the material that follows is useful to you, and that your bale adventure is as fun and rewarding as ours has been.

1/3

All building sites produce waste. On a straw bale construction site, the waste straw can be used as mulch!

Keep those Bales Dry!

The basic principles of bale construction, especially crucial in cold and/or wet climates, can be broken down as follows. Each of these is explored in substantial detail in later chapters, but just to start off with the big picture, we’ve herded them all together, here. The overriding design goal in straw bale construction is: Keep those bales dry! The way to accomplish that goal is to consider thes elements:

Siting

The site, which includes climate, local landforms, vegetation, and the character of the neighborhood, is the number one factor that determines whether bales are a good choice for a wall material, and how they should be finished.

Architectural Features

Precipitation is the greatest threat to bale walls; to a certain degree, site features can be ameliorated by roof overhangs, porches, connected sheds, and other features that help protect the walls from rain and snow.

Isolation from Ground Moisture

Bales should be held at least as far from finished grade as specified by the local code minimum for wood. They must also be protected from moisture that can make its way up through the foundation.

Flashing Details

Flashing and dripsills are crucial to prevent concentrated volumes of water from leaking into and sheeting down the wall.

Choice of Finish

There is no standard finish for straw bale walls. Choice of finish is an act of balance between the structural strength of more rigid materials and the higher drying potential and reduced cracking of more flexible materials.

Vapor-Permeable Construction

Whenever possible, those materials that are more vaporpermeable are a safer choice than those whic are less so. In cold climates, this is especially true on the exterior.

Airtight Construction and Mechanical Ventilation

Airtight construction and mechanical ventilation ensure good indoor air quality, reduce energy use, and control interior humidity levels, thereby greatly reducing interior moisture sources as a potential threat to bale walls.

Moisture Sensors

Without sensors, there is no way of knowing what is really going on inside the walls over the long term. All new bale houses should have at least a few, as insurance against moisture problems, and to allow residents to contribute to the body of knowledge about building with straw bales.

Straw bale techniques are becoming popular in the north even for large buildings.

Acknowledgments

In the ever-growing field of information and experience from which this book has emerged, a speci acknowledgment must go out to all those anonymous heroes of harsh climate construction who have, against the better judgment of their neighbors, built their own houses with this oddball materia known as straw. Squaring off to uncertainties about its appropriateness, these faithful souls continue to pour out a stream of new details and techniques, forever refining bale construction to meet the demands of their local conditions. Without their invaluable contributions, the authors and the several other bale enthusiasts whose names appear in this book would have needed many lifetimes of experimentation in order to access such a pool of creative ideas.

If new cold-climate straw bale homes survive as long as their original Nebraska cousins have, thes people should be remembered as the pioneers of what is slowly becoming a vernacular architecture o our modern era.

Paul’s Personal Gratitudes

I must first thank the many warmhearted people across the northern U.S. and southern Canada who took time out from their own busy lives to share their work and their hospitality with me. Many of yo are mentioned in this book, and many are not; I wish to thank each of you (especially those with who I have not had the good manners to remain in touch!) for making my various research trips more fun and useful than I could ever have expected. Your generosity in sharing technical information has added tremendously to the vitality of this book. Your generosity in offering hospitality, stimulating conversation, and a glimpse into the ways in which you are trying to live decent lives has given me some real hope for the future of our species upon this fine planet.

I would also like to thank the many people who contributed photos, writing, or feedback to this project, and who were consistently willing to answer and re-answer my questions on topics about which they knew much more than I. Marc Rosenbaum and Rory Brennan deserve a special thanks for taking the time to read (and by your comments, improve) entire chapters of this book.

Then there is the matter of beginnings. I would like to thank John and Melissa Bissell for asking, eight years ago over excellent food and a friendly bottle of wine, “What would you do if you could d whatever you want?” And Matts Myhrmann and Judy Knox for taking me in and teaching me all I could handle, about subjects ranging far beyond straw bale construction.

Martha Twombly and Hannah Silverstein of Chelsea Green get an enormous thank-you for pulling this book together, and especially for the cheerfulness with which you both dealt with my somewhat erratic attention to submission details. I also thank Martha for getting me started on this book projec three long years ago.

Finally, three people deserve the deepest thanks: Michel, for the depth of experience you brought t the book, and for your openness and flexibility on issues small and large; Amy, for your continual encouragement and everlasting patience with the fact that I always worked later than I said I would; and Mom, for equipping me, early on, with the notion that I could do whatever I set my mind to.

Michel’s Personal Gratitudes

I want to address a very special *merci* to my co-author and new friend Paul for his extreme generosity while dealing for almost two years with the unavoidable English discrepancies of an autho whose native language is French.

Also to Jim Schley for his patience and friendship, and to Alan Berolz-heimer for his special editi
contribution.

And finally, to one very important person, my Master of Arts in life by his everlasting creative attitude, my eighty-seven-year-old father, Gérard, *merci beaucoup!*

PART 1

Straw Bale Buildings in Perspective

CHAPTER 1

WHY STRAW BALES?

WHAT IS A STRAW BALE HOUSE? Why are bales a good choice in a cold climate? Can bale walls be designed to withstand the vagaries of weather in the snow belt? These are questions we've bee asking of ourselves for a good many years, and they have now become the guiding questions behind this book. To begin at the beginning, however, we must ponder this question of why. The idea of building a wall of bales seems to entice people's imaginations. Why bales? We have come to believe that people are searching for alternatives to the plywood palace, to the modular mentality that has come to dominate the mainstream construction industry. Most new houses today are made of the sam materials: machined sticks and sheets of wood, plastic, metal, and gypsum. They are usually assembled according to the same set of principles, so that once you've built a few, they get pretty boring. Except for that small percentage in which a designer, owner, or builder puts some real though into creating a form and finish that suits the owner and the site, these houses somehow feel the same.

There are three main reasons that straw bale construction is different. First of all, bale walls look very different from sheetrock walls. They look like the product of a human, rather than the product o a machine. Though bales are a new material (which makes design work challenging and fun), the feel of the finished wall harkens back to the preindustrial era. It seems that as our lives become increasingly technological, more and more people want to surround themselves with spaces that feel handmade and timeless.

Process is the second reason. Conventional construction is mathematical and precise, while bales and plaster are sloppy and intuitive. These characteristics are inviting to amateur builders, not only because they make bale construction easy to learn, but because they stand in contrast to the obsessive efficiency that most of us have had to accept as a part of the industrial economy. People see bale construction as a chance to cut loose.

Third, bale construction feels like an alternative to ecological waste. It's akin to recycling. Recycling enjoys broad support across the political spectrum, because it's obvious, it's easy, and it gives people a sense that they can at least do *something* that is not harmful to the planet. While our agriculture is far from perfect, it does produce a lot of straw, so using some of it for construction makes intuitive sense.

Bruce Millard, a thoughtful architect from Sandpoint, Idaho, has developed this idea about buildin with bales a bit further. "Once people try this type of construction, they absorb it and agree with it, and begin to recognize it as a concept, as a psychological departure from the idea that industry is somehow more sophisticated than nature. It brings the left and the right together; it functions as a stepping block into an ecological way of building and living. People begin to ask, 'How can I put this to work in the rest of my life?'"

Bruce sees the bale itself as a short-lived material. "We will soon realize that straw is very valuabl —it will start going into particleboard and panelized materials, and it might be mixed with wood fibe for paper production." Bruce uses the bale as an introduction to a whole array of recycled-content panels and blocks.

Bales also tend to serve as an introduction to traditional natural building techniques from around the world, all of which have much longer track records than the bale itself. Loose straw has been used for millennia in combination with clay and sand, for everything from plasters to load-bearing walls. Five-hundred-year-old examples of straw and clay infill are still in use in Germany, and this material has actually been rewetted and put back into wall cavities during restoration. Thatch makes a beautiful, durable, insulative roof. These and other techniques must be explored and developed if we are to continue to create decent housing for future generations on this planet. (See chapter 15, "Beyond the Bale.")

Straw can provide thermal and sound insulation or even serve as a load-bearing wall, all in the form of a compact, portable, nontoxic, and recyclable bale.

Why Build a House of Straw Bales?

"Didn't you learn anything from the first little pig?"

A mouthful of oatmeal and an earful of propaganda against building with straw; many of us were spoon-fed this breakfast throughout our childhoods. How is it, then, that perfectly sane people can consider living in a house whose walls are bales of straw? Maybe urbanization, suburbanization, and the decrease in the North American wolf population has lulled them into a sense of complacency abo this domestic predator. Or maybe bales make such unusual walls that many of us are just willing to take the risk.

Beauty

The most compelling among many reasons to build with bales is the quiet beauty of bale walls. Unlik walls of panelized materials, which require layers of ornamentation to bring life to their unnaturally uniform surfaces, bale walls look and feel as if they were made by hand. Their deep windowsills and gentle undulations lend a comfortably safe, quiet feeling to the interior of a home, while the plaster finish softly gathers and reflects light, changing in subtle ways as the sun shifts through each day and season. The effect is a heightened connection between indoor and outdoor worlds, an especially important relationship in climates where people spend a good part of the year inside buildings.

"We fell in love with the deep windowsills and rounded corners."

"I like the massive feel, and the flexibility, of the bales; you can do anything with them, curvy or straight."

"The house has a solid, embracing feeling, like it has its arms wrapped around me."

Paul often describes bale walls as "plastered stone for the person of moderate means." This is not t imply that bale walls don't have a character of their own, which they certainly do; the point is that th massive, rounded feel of the bale wall is reminiscent of the old-world solidity of stone. (Bale walls also offer far more insulation value than stone walls, but we'll get to that later.) Part of the appeal of bale buildings is that they just feel safe. Storms can be howling outside, or cars roaring along a nearb highway at twice the reasonable rate, and after the (good-quality) door clicks shut on a straw bale house, you will find yourself in near total silence. This sort of quiet allows the home to act as a refug for the psyche; a place where the senses can escape the busy din of the postindustrial world.

Insulation Value

Straw bale houses may look and feel like plastered stone or earth houses, but they are in a different thermal category, entirely. Old stone houses are cold. New stone houses are typically built with foam insulation, either sandwiched between two independent stone walls, or blown onto the inside face of the stone. Both of these methods are quite expensive. Plastered bales, on the other hand, provide a highly insulative wall at a price that is competitive with quality conventional construction.

Paul's Very Subjective Discourse on Walls

Not all that long ago in Western societies, and in some societies still, most people spent most of their waking hours outside, in the unfiltered presence of fresh air, warm (and sometimes hot) sun, cooling (and sometimes downright cold) breezes, and the visual, aural, mental, and spiritual stimulation of the ever changing natural world. Now that most of our society seems to have moved indoors, exchanging fresh air and physical work for office partitions, stress, and air heated, cooled, and otherwise denatured by a central delivery system, it has become quite necessary for the home to serve not only as a refuge, but also as a vehicle of connection to the natural world, a world whose subtleties are easily overlooked when your senses have been trodden by the glaring images of the TV and computer screen.

A person building with bales can bring the outside in by playing subtly with light, texture, and form. This requires a certain sensitivity on the part of the bale layer and the plasterer. On the one hand, it is possible to allow the short sight of the trowel too much control over the plastering process the result is a flat, rather dead surface that speaks only of the mechanical ability of the hand that applied the plaster. It is also possible to get so carried away with lumpy textures and wild paints that the subtlety of the space disappears into a gawky argument between elements. A quietly beautiful wall lies between these two extremes.

What do I mean by this? The relationship between windows and views serves as a parallel exampl Let’s say you come to a site. It’s a nice spot for a house, and it has this incredible view of a range of mountains. You sit there, maybe eat a picnic lunch and drink a glass of wine, and you look at the view. The sun is warm, and maybe you’re just a touch sleepy, but you’re also excited and so you’re talking with your partner about this great spot that you’ve found, about how beautiful it is, and about the future. You do this a few times, maybe a whole bunch of times, and you’re designing a house in your mind, and of course this view must be the central feature of the living room, because it’s been the central feature of your experience of this place. So you build the house, and you spend quite a su of money on a big picture window, or maybe on a whole gable end of the house filled with glass, so that you can bring those mountains in.

For a while, maybe during the construction process and for a few months after you move in, you spend a few minutes after supper looking out at the mountains, and you feel good. One day, a year later, you’re stopped in front of the window; maybe you’re cleaning the glass, and you pause for a minute, realizing that you haven’t actually looked at those mountains for some time. You’ve glanced at them in passing (how could you not, they’re right there, staring you in the face), but you haven’t really stopped to look in detail at the change in color with the change of seasons, or at the movement of the snowline, or at individual trees and boulders. For all of your effort and expense, you haven’t succeeded in bringing the mountains in, at all. The wall of glass has come, as walls inevitably do, to simply define the perimeter of your living space. (Meanwhile you’re cold whenever you sit near that wall in winter, and your heating bills are quite a bit higher than they ought to be.)

Why has this happened? There are two reasons. First, an unmoving scene is not really all that interesting when viewed through a pane of glass. Birds at feeders, trees blowing in the wind, fire trucks racing by, these things work because motion attracts the eye, causes you to look through and beyond the window. If you attempt to fix your attention upon an unmoving object, however, a pane becomes a lens, a psychological obstruction between you and the thing you are trying to see.

Second, anything becomes commonplace when it is constantly staring you in the face, precisely because you soon stop taking the time to look at it closely. Instant gratification is incompatible with visual richness—nothing in this world is truly interesting to look at more than once or twice, until you learn to pause, even for only a few seconds at a time, and look closely.

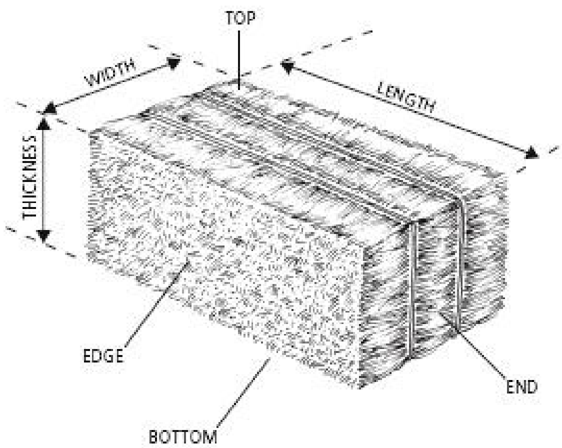
The most beautiful bale walls I have seen have a quiet feeling; they invite a person to slow down, look longer, look closer. They make utmost use of the light that strikes them, which is to say that the look different at different times of the day, and through the seasons. They also change as you look closer, or back away. My favorite bale walls tend to be light in color, with a flat, typically unpainted finish, so that light can reflect from them without creating an unpleasant glare. Their surfaces are les lumpy than what Matts Myhrman describes as “softly irregular.” Flecks of mica or finely chopped straw, or subtle variations in color, keep the wall interesting right up to the point where you fairly well have your nose pressed against it. I prefer curved window wells to those that are flat or beveled, because they react with far greater variety to changes in angle and intensity of light.

> All of this surface irregularity and general curvaceousness creates a wall whose outstanding features are the small pools of light and shadow that move across its surface as the sun makes its wa up and down the sky. Not surprisingly, this effect is most pronounced in rooms with access to early-morning and late-afternoon light.

Buildings consume roughly one-third of the energy used annually in the United States. Superinsulated buildings (bales provide a super-insulated wall) keep their occupants more comfortable than their conventional counterparts, while pumping far less carbon dioxide and pollutants into the atmosphere. In other words, they cost less to heat and cool, to you and to the plane

In 1998 tests at Oak Ridge National Laboratory in Tennessee found that the Rvalue of a bale wall laid flat measured at 1.45 per inch, while tests by the California Energy Commission found a bale wa laid on edge to measure at 2.06 per inch. (This translates to R-26 for a two-string bale laid flat; R-29 for a two-string bale on edge; R-33.5 for a three-string bale laid flat; and R-33 for a three-string bale on edge.)

The insulation in a bale wall is continuous; it is not interrupted by less insulative wooden member as is the case with conventional construction. A 2-by-6 and fiberglass wall, rated at R-19, will really only achieve this value in the insulation cavities. In designs that do not specify advanced framing techniques to reduce wood use in corners, around windows, and in other detailing, the decrease in overall wall Rvalue due to thermal bridging through the studs can be substantial. Imperfections in th installation of insulation materials can also reduce the performance of conventional walls, to the poi where their effective Rvalue is not much more than half that of a bale wall.



Basic bale nomenclature.

The actual performance of a bale wall system is also influenced by the thermal mass of both the bales and the plaster. This factor has a significant effect on the wall’s ability to store heat, and thus t maintain a constant temperature. It also appears to affect the rate at which heat flows through the wa In the Oak Ridge tests, one side of the wall was heated to 70°F (21°C) and the other chilled to 0°F (–18°C). It took most of two weeks at this temperature difference before the wall began to lose heat at steady rate. This means that as heat moved through the wall, some portion of it was being stored within the mass of the wall. Presumably, it was only after the wall temperature had stabilized that he began to flow through at a consistent rate. David Eisenberg points out that in real world conditions i most cold climates, two straight weeks at a 70°F temperature difference would be quite an unusual event. Temperatures typically swing up in the daytime and down at night. The combination of mass and uninterrupted insulation in a plastered bale wall flattens these swings, providing even greater comfort and energy savings than the wall system’s rated Rvalue would imply.

Veteran solar architect Ken Haggard, of San Luis Obispo, California, points out a further benefit o the bale and plaster combination: “The thermal mass is integral to the wall finish.” Good passive sol design, of course, relies on a combination of southerly glazing, superinsulation, and internal mass. In conventional buildings (1/2-inch drywall, wood floors) the amount of glazing that can be added for solar gain is limited by the heat storage capacity of the building’s interior. Since adding mass to the interior is often viewed as an extra expense, many houses with good solar orientation end up with a disappointingly small proportion of their heat provided by the sun. Or (and this might be more common), lots of windows are shoved into the south wall, with little thought given to where the heat will be stored. The result is excessive heat buildup on sunny afternoons, coupled with excessive heat loss at night.

Guest room. Wisbaum home, Charlotte, Vermont.

In a bale building, there is no practical way around the application of one inch or so of plaster on the interior of the walls. This adds up to quite a lot of thermal mass, which translates into opportunity (and room for error) in the passive solar components of the design. It also means that a well-designed solar bale house cannot be spoiled in the construction phase by a foolish decision to eliminate the mass, in order to save a few dollars.

Nontoxic

Bales are a natural material. Unlike many manufactured building products, they contain no toxic ingredients, and are chemically stable. They will release no unhealthy chemicals into your home, and will not emit poisonous fumes in case of a fire. A relatively small amount of fossil fuel energy is consumed in the production of straw bales, and no toxins are released during the production or installation processes. Straw can eventually be composted back into the soil.

Use of Resources

A great deal of straw is grown around the world every year, enough for millions of houses. Some percentage of this straw (depending on soil type and the fertility program of any given farm) should b going back into the soil, ideally mixed with animal manure, which provides the nitrogen necessary fo its decomposition. (This scenario bears no relationship to current agricultural practices in the industrialized world, but it is a worthy ideal, nonetheless.) Much of this straw is now burned in the field. By incorporating straw into buildings, we reduce particulate pollution and lock up carbon in a solid state, rather than releasing it as carbon dioxide, the most important greenhouse gas. We might also reduce the pressure on forests (the most important carbon sinks and oxygen producers on the planet) and the demand for relatively energy- and pollution-intensive industrial insulation materials.

Pliny Fisk III, of the Center for Maximum Potential Building Systems in Austin, Texas, points out that a better idea than using the straw from annual grains is baling the stems of native perennial grasses (as the original bale builders did) and invasive exotic species. GreenSpace (Paul's company) has begun to experiment with the mixed stems of old field succession plants: goldenrod, milkweed, mixed native grasses, various woody perennials, small saplings. These are the plants that move in when pastures or hay fields in our region are allowed to fall out of agricultural use. New England hill farmers are often happy to part with these bales for half the price of good straw or hay, as the inputs are less, and part of their payment comes in preventing their land from growing up to brush.

A further development, suggested by biologist and landscape architect Ruth Parnall, of Conway, Massachusetts, would be a baler that could wade into marshes, to harvest phragmites *(Phragmites communis)*. This European reed (used for thatch) has overrun much of the wetlands of the Mid-Atlantic and Northeast regions of the United States Consistent, aggressive bal-ing of phragmites coul become a useful tool in containing its spread.

> Whether the labor is volunteer or professional, almost every project is a custom project, with details and techniques invented during the design and construction phases.

Economical

"Plastered stone for the person of reasonable means." Have you priced out a stone building lately? Or calculated the time to build one yourself? Most traditional earth and stone building systems have become quite expensive nowadays, because human labor has become expensive, compared with efficient assembly of machine-produced building components. The reason bales have risen to such prominence in Santa Fe is that the building code there requires that everything (including strip malls look as if it is made of adobe. Bale houses are substantially less expensive than real adobes, and look and perform a whole lot better than stick frames mas-querading as earth.

In the industrialized world, bale construction is getting to be cost-competitive with good-quality stick-framed construction, assuming a tight design that doesn't drive labor costs through the roof. Mechanical or volunteer application of plasters and hands-on experience with a few bale projects hel substan-tially, here. Availability of bales is also impor-tant. It is not really fair, however, to compare ~~bale walls with 2-by-6 walls. They look more like stone or earth, and they perform more like double-~~ stud, 10-inch-deep walls, blown full of cellulose.

Because bale construction is still maturing, it is also reasonable to assume that the cost of walls wi continue to drop. Whether the labor is volunteer or professional, almost every project is still a custon project, with details and techniques invented during the design and construction phases. We are all constantly refining our methods, hunting down those details that make for an efficient construction process. This is part of the fun, of course.

A small pile of recyclable materials is often all that is left over after construction of a straw bale house.

In areas of the world where machined materials are expensive or unavailable, and straw and labor are cheap, bales will compare favorably with any other type of construction. Bale houses tend to be more durable and comfortable than either government houses (typified by the random and horribly expensive application of industrial techniques), or scabbed-together houses (usually built of whateve cast-off materials happen to be lying around). Bales offer a route back toward the sensible, owner-built, locally adapted housing that could be found everywhere on this planet, before the Industrial anc Green Revolutions swelled our population and our egos.

Owner-Builder Friendly

At the time of this writing, most of the bale buildings in the world have been owner-built. This ratio i sure to change over time, as bale buildings develop a longer track record, as more mainstream home buyers and financers begin to recognize the strengths of walls built with bales, and as more contractors develop expertise in and enthusiasm for this type of construction.

Bales will remain a choice material of owner-builders, however, because they are so well suited to "gang of friends" method of construction. (See below, under "Fun.") Novices are also attracted to the apparent simplicity of the wall system. Even people who have no experience with construction can wrap their minds around the idea of stacking bales. On many occasions, this initial sense that "I can d this!" leads an otherwise intimidated nonbuilder out of his or her shell, toward a willingness to take o framing, plaster, finish work, and so forth.

With a good design, careful organization, and the guidance of a few skilled people, it is possible to keep dozens of volunteers engaged in various stages of bale and plaster work.

Fun

Many aspects of construction can be great fun. Framing is enjoyable unless you are stuck doing it every day, because it goes so quickly that structures seem to appear out of thin air. Some people love the attention to detail required by finish work. Hard as it is to believe, many drywall contractors seem not to mind hanging and taping wallboard.

Bale construction is fun for two reasons. The first is because its two main components— stacking bales and smearing plaster— lend themselves to work parties. With a good design, careful organization, and the guidance of a few skilled people, it is possible to keep dozens of volunteers engaged in various stages of bale and plaster work. Because the process can be broken down into man distinct tasks, people are free to try different jobs and learn various skills. There are niches to be fille by persons of all levels of physical ability and experience. The synergy of this group effort (not to mention the sheer volume of work possible in a day) is one of the greatest thrills of straw bale construction.

The second reason is that laying bales and applying plaster are essentially right-brain activities. Stacking bales is much more like playing with blocks than it is like any mainstream construction practice. This is especially true when the structure is framed in advance, because in this case plumb and level have already been determined by the framing crew. Clay plaster work is reminiscent of making mud pies. You can smear the stuff on the wall with the heel of your hand. You can throw it at the person working next to you. If you are so inclined, you can get yourself completely coated in eart

Durable

The oldest bale structures in Nebraska date back nearly one hundred years, to the invention of the baler. The oldest bale house in New England has kept its occupants warm and dry through twenty-fiv wet, coastal winters, and is still in excellent condition. (See the profile of the Hay House, following this chapter.) Bale walls appear to last indefinitely, if kept dry.

Combinations of straw and clay have been used for millennia all around the world, and five hundred-year-old houses with straw-clay walls are still inhabited in Germany. (See chapter 15, Beyond the Bale.)

Fire Resistance

Plastered bale-wall systems have outperformed wood-framed walls in fire tests. In a trial performe by SHB Agra Engineering and Environmental Services Laboratory in Albuquerque, New Mexico, in 1993, walls built of two-string, wheat-straw bales were examined both bare and with plaster skins.

In the first case, on an uncoated wall, the fire took 34 minutes to work its way through, at a seam between two bales. The maximum applied temperature was 1,691°F (921°C).

The second test, on a wall finished with gypsum plaster on the heated side and cement stucco on th unheated side, was even more impressive. The heated side of the wall reached 1,942°F (1,060°C), while the highest rise in temperature on the unheated side, after two hours of exposure, was only 21°I Behind cracks in the gypsum plaster on the heated side of the wall, charring in the straw was only 2 inches deep.

Unfortunately, the final report on this test has never been produced, because of a lack of funding. The U.S. and Canadian national code bodies, therefore, have yet to issue a fire rating for plastered ba construction. Nonetheless, the results of this test have been very influential in convincing local and state code officials that plastered bale walls pose no unusual threats to their occupants, in the case of fire. At the Sivananda Lodge (see profile following chapter 8) bales were easily accepted for a one-hour fire rating. The case has also been made that plastered bale walls, because of their density, are more fire resistant than the ubiquitous studs and drywall.

Rodents and Insects

When detailed correctly, bale walls are highly resistant to damage from insects or rodents. Tiny bugs (springtails, most often) have sometimes been present on the interior surface of plaster while it is drying, or in houses that have experienced high moisture levels within the bales. Under normal circumstances, they seem to depart once the plaster has cured fully. The best defense against insects seems to be to keep your walls dry.

Happy crew at work during a straw bale workshop.

The same set of details that protect your bales from damage by moisture should also be sufficient t keep out rodents, for at least as long a period as in conventional construction. We will not claim that mice will never get in: Rare is the building that has stood for fifty years without these little monsters finding a way into the walls. Typical plaster finishes (or appropriate screening, in the case of a sided building) should provide reasonable protection against their entry.

Even if mice do eventually sneak in, it is distinctly possible that they will matter less than in a conventional cavity wall. Rodents rarely bore into bales; they favor the slightly less dense horizontal runs between courses. Their movement throughout the wall is, therefore, limited. Also, without a larg cavity to scratch around in, the occasional mouse should not be very much of a nuisance to the occupants of a bale building.

The first of Paul's two favorite stories about rodents and straw comes from the Hay House, in Connecticut, the oldest bale house in New England. Over the past twenty-five years, squirrels have, a times, taken up residence in the rafter cavities. David Brown, who owns the Hay House, explains that at one point the squirrels could even get into the living space; they apparently enjoyed standing on to of a bookshelf and watching him dress in the morning. Never, in all of this time, has there been any evidence of squirrels moving into the bale walls, even though the top of the north wall has never been plastered.

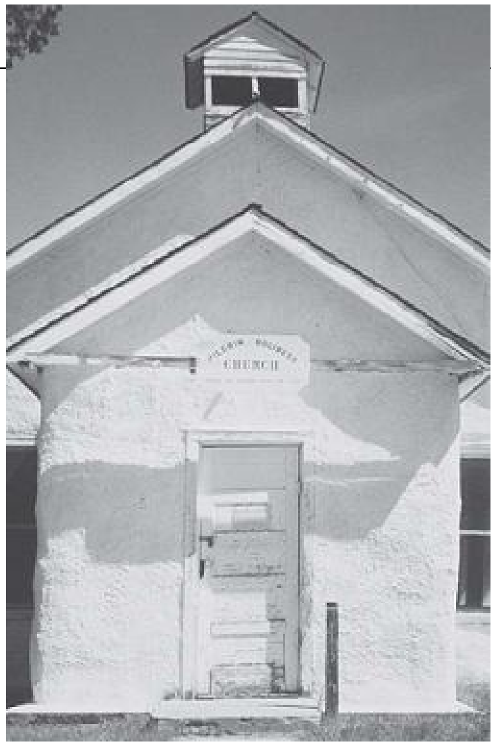
> The best defense against insects is to keep your walls dry.

Marc Rosenbaum, P.E., of Energysmiths, in Plainfield, New Hampshire, relates another story: At one point he had some bales stacked under a porch roof, near his front door. They were to be incorporated into the walls of an entryway addition. In preparation for the work, he had an electrician disconnect an electrical box that was cut into the foam-core, stressed-skin panel wall of his house. Within weeks, he found evidence of mice chewing into the newly exposed foam, and tacked a board over the hole. Come spring, and upon removing the board, he found an entire family of dehydrated mice within the foam panel; when he then moved the straw bales, mouse signs were nowhere in evidence.

Such anecdotes do not necessarily add up to the assumption that rodents are not an issue in bale houses. The fact is, however, that we have yet to come across a well-detailed building that has had an problems with these unwelcome guests.

Earthquakes

The solid, unshakable feeling of bale walls turns out to be based in physics. In 1998 tests by David Riley and his students at the University of Wash-ington found that bale walls finished with gypsum plaster on one face and cement stucco on the other (both reinforced by wire) showed an unusual abili to absorb the sort of push-pull shear forces (no, that's not the official engineering term) that are typical of seismic events. "Only under substantial displacement (e.g., an earthquake) would bales in a wall be subjected to the movement applied in this test; however, the test results show that the bale walls were capable of absorbing a significant amount of energy on repeated cycles. For this reason, a bale structure should behave favorably under seismic loads."[1]



The Pilgrim Holiness Church in Arthur, Nebraska, built by the congregation with donated rye-straw bales.

Another revealing test was performed in Berkeley, California, in the spring of 1998, on a straw bal arch. The arch and test were designed by Skillful Means and structural engineer David Mar, with inpu from other experienced members of the California straw bale community. The arch was built of three string bales, finished with meshreinforced cement stucco, inside and out. The inner and outer curtain of mesh were fastened together by wire ties run through the bale core of the structure. A specially calibrated hydraulic jack simulated earthquake forces by simultaneously pushing in and pulling out o the arch.

The arch performed extremely well. Its elastic limit (the point at which the stucco began to crack) was not reached until the out-of-plane load totaled 55 percent of its weight—nearly double the seism code requirement of 30 percent. The test rig was incapable of causing the arch to fail. The maximum load was 115 percent of the weight of the structure; this is the equivalent of turning it on its edge and applying a further 15 percent of its weight.

David Mar thinks that bales will turn out to be an unusually appropriate material for earthquake-prone regions. He believes that bale walls designed according to the seismic principles that govern masonry walls offer the advantages of lighter weight, greater ductility, and, most important of all, th ability to absorb significant quantities of energy without failing catastrophically.

Historical Background to Modern Bale Building

Straw bale construction began with the invention of the baler, at the tail end of the 19th century, in th Sand Hills region of Nebraska. The Sand Hills are a vast tract of grass-covered dunes, formerly the margin of a sea that filled up the Mississippi Basin. As water receded, the shoreline sands drifted int the Sand Hills formation.