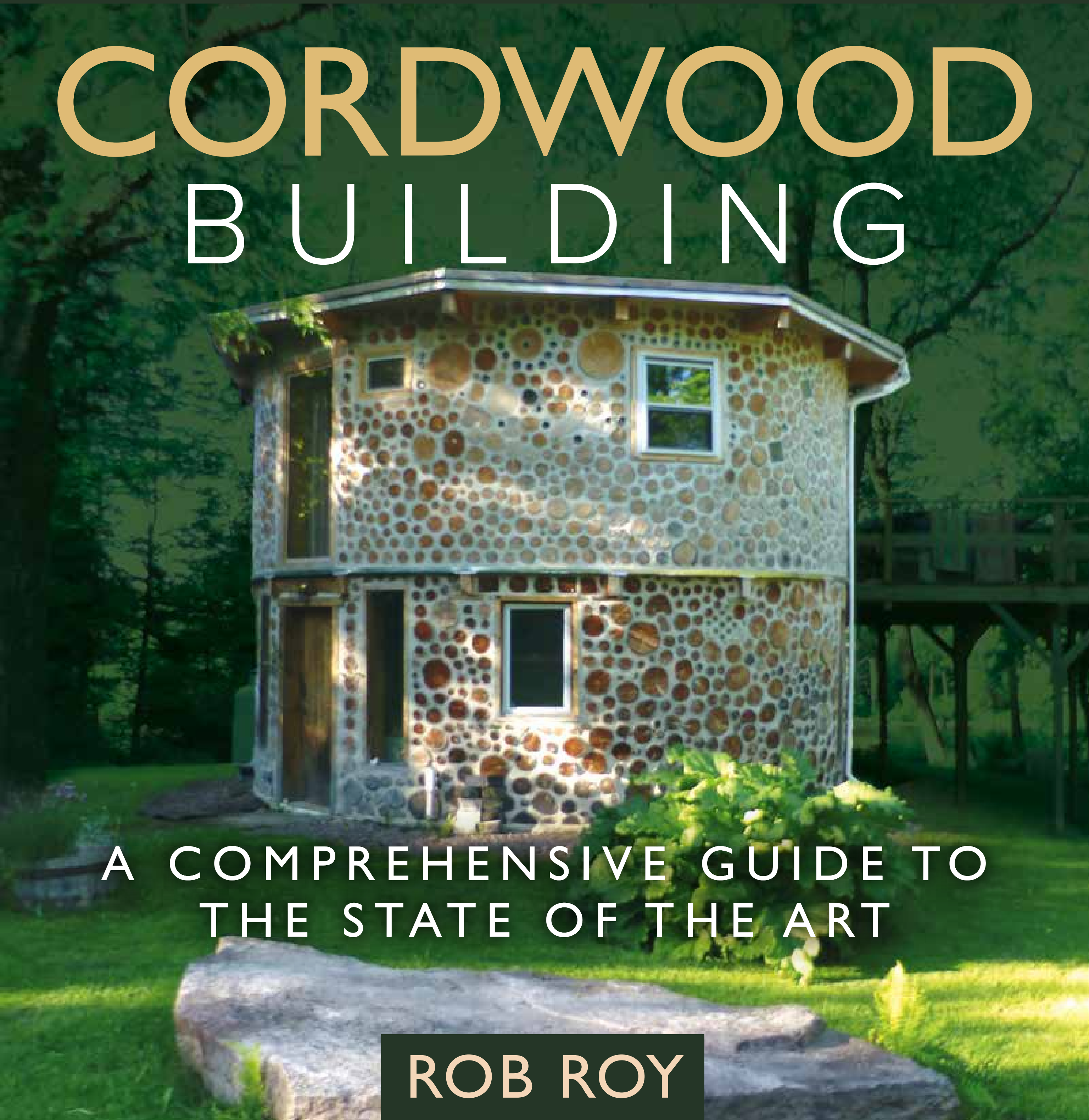
FULLY REVISED SECOND EDITION

CORDWOOD BUILDING



A COMPREHENSIVE GUIDE TO THE STATE OF THE ART

ROB ROY

Praise for *Cordwood Building*

By far the most comprehensive book ever written on cordwood construction. Fact-filled, richly illustrated, and full of experience-based advice, this is the only book you'll need if you are interested in this planet-friendly, simple, low cost, and artistic construction technique.

—Lloyd Kahn, author of the Shelter Series of Building Books, including *Shelter, Home Work,* and *Tiny Homes*

Cordwood Building hits the proverbial nail on the head with its thorough investigation of this sustainable practice. Rich in hands-on practicality, replete with attractive case studies and loaded with eye-catching photos, the reader is invited inside the pages, to have a look-around. This tome should be on the must read list for anyone contemplating cordwood construction.

—Richard Flatau, author, *Cordwood Construction Best Practices* and Director at Cordwood Construction Resources

As keeper of the cordwood masonry flame, Rob Roy has devoted his 40-year career to the conscientious evolution of this unique building method. Champion of the owner-builder and defender of dollar-wise construction, his careful documentation of step-by-step procedure, user-friendly formulas, and ongoing development in the field combine to make this revised and updated edition an invaluable reference for the curious and serious alike.

—Richard Freudenberger, Resource Manager at Living Web Farms and former Publisher of *BackHome* Magazine.

I wholeheartedly recommend this new edition of Rob Roy's classic book on Cordwood Building, which I consider to be one of the foremost techniques for furthering the cause of sustainable architecture. Not only do the results look naturally gorgeous, but the walls provide good insulation and thermal mass, without the need for further treatment once they are assembled. Couple this with the fact that the building process is easily learned and utilizes marginal wood unsuitable for other construction, and you have an outstanding system that is fully explained in Rob Roy's comprehensive book.

—Kelly Hart, founder, www.greenhomebuilding.com

If anybody knows cordwood, it's Rob Roy, who's been at the center of this expanding movement for more than two decades, experimenting, innovating and living within his creations. His comprehensive, practical guide *Cordwood Building* explores the nitty gritty of cordwood "how to", lessons learned, and innovations like cob mortar, paper-enhanced mortar, and bottle ends.

A traditional building method for more than a millennium, modern cordwood homes pass building codes and introduce building science to the "hobbit way of building", and Rob Roy's in depth book addresses air infiltration, vapor barriers, discussions of mass and insulation, and even electrical wiring.

Practical and thrifty, *Cordwood Building* is on the cutting edge of "mortgage free" thinking, inspiring do-it-yourself tiny homes that utilize affordable materials, and offer a beautiful aesthetic.

—Catherine Wanek, author/photographer, *The Hybrid House*, co-editor, *The Art of Natural Building*, and co-founder of Builders Without Borders

CORDWOOD BUILDING

A COMPREHENSIVE GUIDE TO
THE STATE OF THE ART

ROB ROY

new society
PUBLISHERS

Cover design by Diane McIntosh.
All interior photos © Rob Roy unless otherwise noted.

Printed in Canada. First printing August 2016.

Any other inquiries can be directed by mail to:
New Society Publishers
P.O. Box 189, Gabriola Island, BC V0R 1X0, Canada
(250) 247-9737

LIBRARY AND ARCHIVES CANADA CATALOGUING IN PUBLICATION

Cordwood building : a comprehensive guide to the state of the art /
Rob Roy. — Fully revised second edition.

Includes bibliographical references and index.
Issued in print and electronic formats.
ISBN 978-0-86571-828-9 (paperback).—ISBN 978-1-55092-623-1 (ebook)

1. Log-end houses—Design and construction. 2. Log-end houses—History.
3. Building, Wooden. I. Roy, Robert L., author, editor

TH4818.W6C67 2016 694 C2016-904430-0
C2016-904431-9

Funded by the Government of Canada
Financé par le gouvernement du Canada
Canada

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new society PUBLISHERS www.newsociety.com

This book is dedicated, with love, to son Darin,
who took the ball and ran with it,
building his own cordwood/dome home
called Driftwood…about 100 yards from Earthwood.
The nut didn't fall far from the tree.

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Acknowledgments

I extend my heartfelt thanks to all of the dedicated authors, builders and innovators who shared their trials and discoveries so generously, including those whose names did not find their way into the body of the book. Your work was still valuable in fleshing out the whole story. In particular, there are several contributors who do have chapters—or parts of chapters—about their work, some written by themselves and some written by the author about their work. Thank you, Bruce Kilgore and Nancy Dow, Sandy Clidaras, Kelly Hart, Tom Huber, Alan Stankevitz, Michael Abel, Geoff Huggins, Rarilee and James Conway, Tony Wrench in Wales, Peter Robey and Blythe Tait in Tasmania, Lynda Wilson at the Australian *Owner-Builder* magazine, Ben and Mirtha Oliveros in Hawaii, Olle Hagman in Sweden, Dr. Kris Dick in Manitoba, and all our friends at Studio Gang Architects in Chicago, especially Claire Halpin, Todd Zima and Jeanne Gang.

The Continental Cordwood Conference of 2015, held at our Earthwood Building School in July of 2015 added a lot of new technical information and news of case studies from around the world. Loving thanks to my wonderful wife, Jaki, for all her work on making CoCoCo/15 happen as smoothly as it did and for good and timely proof reading of the manuscript close to deadline. And to my friend, cordwood builder and writer Richard Flatau, for his help in editing some of the papers that came out of the conference, and for tracking down images for this book. Thanks to all who attended and contributed to the Collected Papers, some of which, rewritten, became the basis for chapters in this book.

Thanks, too, to Rob West at New Society for asking me to do this new book. Indeed, with CoCoCo/15 fresh, and the older book getting a bit dated, the time had come. Thanks to the usual gang of skilled bookmakers at New Society: my editor, Ingrid Witvoet; graphic designer par excellence Greg Green; friends Judith Plant and Sue Custance; and all the others at NSP who played a part in bringing this to print.

— Rob Roy, Director
www.cordwoodmasonry.com

Prologue: History of Cordwood Masonry

We can be fairly sure that cordwood's origins began in Europe, despite two tantalizing but unsubstantiated suggestions to the contrary. In an "Ask Our Experts" column in *Mother Earth News* of January/February 1983, the late "Cordwood Jack" Henstridge mentions 1,000-year-old "cordwood structure(s)" in northwestern Finland and in "the mountains of Greece." For an even more obscure origin, over 30 years ago a lady at one of our cordwood workshops told me about a 3,000-year-old clay tablet found on the island of Crete with instructions of how to build a cordwood wall.

In *Stackwall: How to Build It*, second edition (A and K Technical Services, 1995) co-author Dr. Kris Dick, P.E., speaking of the durability of cordwood masonry (stackwall), says: "Known ages of some (stackwall) structures are: Manitoba—50 to 100 years with poplar; Ottawa and St. Lawrence Valleys—100 to 200 (years) in various species. The oldest we have heard of is a monastery in northern Greece built about 800-900 AD and still in use."

There's the Greek reference again. It is intriguing, and I would dearly love to verify it.

But let's commence with more solid history, assisted by Professor William H. Tishler of Wisconsin (retired) and the two Olles of Sweden: cordwood builders Olle Lind and Olle Hagman.

Bill Tishler was professor of landscape architecture at the University of Wisconsin at Madison from 1964 to 2000, and, with his students, was instrumental in having the John Mecikalski General Store in Jennings, Wisconsin, listed on the Wisconsin State Historic Register and, later, the National Register of Historic Places. This excellent cordwood building was built in 1899 and was fully restored between 1985 and 1987, thanks to a grant from the Kohler Foundation. It is now a museum, which I have visited. The cordwood is still in excellent condition.

P.1. The Mecikalski General Store about 1983, before restoration.

Bill's article, below, is condensed from his Chapter 1 about cordwood's history in our original 2003 edition.

Olle Lind wrote Chapter 22 in Cordwood Building's first edition: "One Old and One New in Sweden." Olle Hagman has presented research papers on cordwood at both the 2011 and 2015 Continental Cordwood Conferences. In February of 2016, he sent me PDFs of pages from a book published in Polish—which neither of us could read—with several pictures of a variety of cordwood and stackwall-cornered buildings from 19th-century Czechoslovakia, including an 1858 date. There were heavy stackwall corners, timber frames with cordwood infilling, round log-ends and small split-ends. (*Budownictwo z Polan Opalowych*, by Jaroslaw Szewczyk, published by Politechnika Bialostocka in Bialystok, 2010.)

The Origin of Cordwood Construction

by William H. Tishler

One of the earliest references to this method of building was published in the *Wisconsin Magazine of History* in 1923. The article described an abandoned farmhouse in Walworth County in southern Wisconsin as having walls made of oak that had been felled from the surrounding woods and "sawed and split into sticks fourteen inches in length…used as nearly like so many bricks as possible."[1] Allegedly completed in 1849—later research suggests that 1857 was the actual date—its ingenious pioneer builder was a Yankee born in New London, Connecticut, who later lived in Palmyra, New York.

P.2. The Mecikalski General Store today.

Could the technique have originated in Canada? Authoritative research on early cordwood building was undertaken some time ago by Wisconsin's eminent architectural historian Richard W.E. Perrin. In his book, *The Architecture of Wisconsin*, and in an article on the subject, Perrin discusses examples of Wisconsin's cordwood buildings, suggesting that their origin "is definitely not European, but very likely Canadian."[2] He bases his conclusion on the cordwood buildings in Quebec and in the Ottawa area of Ontario that have been documented by the Canadian Inventory of Historic Buildings. The method was apparently used in lumber camps, according to Sibyl Moholy-Nagy in her 1957 book, *Native Genius in Anonymous Architecture*.[3] However, Canadian architectural literature seldom mentions stovewood structures, and the method is variously referred to as "log butt," "cordwood," "wood block," and "stackwall" construction. Curiously, the *Encyclopedie de la maison québécoise* even indicates that the technique is "of American influence."[4]

In his book, *An Age of Barns*, Eric Sloane portrays two examples of stovewood structures and suggests a Germanic influence, stating that "the design is best known as that of the German settlers of Wisconsin."[5] This statement is not documented, however, and studies of Wisconsin's German architecture and its Old World antecedents provide no indication of this relationship.

The Swedish Institute of Building Documentation, as well as the Swedish Museum of Architecture, provided useful information that included newspaper clippings referring to two examples of cordwood construction in older Stockholm suburbs. One account referred to a two-story "cubicle in Hagalund…built in 1887 by a blacksmith." Another clipping referred to a second cordwood house built in the suburb of Hagalund by a man who "felled trees, sawed them into pieces of firewood, and began to pile. When he had finished piling and had secured it with mortar, his woodpile consisted of four one-room flats…the building is of great interest architecturally."

Both Swedish agencies suggested that the stovewood technique could have been imported from America by returning immigrants. In correspondence with the author, a curator at the Museum of Architecture further stated that cordwood construction using "quality timber…is not known in Sweden, where good logs would be used in the usual more advanced way. Poor people, however, who could not afford to buy timber have sometimes used firewood in the way you describe. The walls were then hidden behind plaster.… Furthermore, it is reported that workers at sawmills, who could get wasted wood from the employer free of charge, sometimes built their houses in this technique."

Evidence of cordwood construction in Norway and Sweden is set forth in an article by Lars Rambøl in the Norwegian journal *Museumsyntt*, entitled "Stovewood Barns: How Did They Originate?" Mr. Rambøl describes the restoration of a stovewood barn at Langsrud in Eidskog and appeals for more information about the method, which is "little known, even among ethnologists." He describes such buildings as "constructed of wood chunks as they appear before they are split for stove-wood. The chunks were placed in layers in wet clay without the addition of any sort of binder (such as hair from a horse's tail or mane, straw, or horse manure, etc.) The height of each stratum…are approximately 40 centimeters [16 inches], and between each layer there are placed boards as strengthening members. The walls are 35 centimeters [14 inches] thick."

The Rambøl article mentions scattered examples of stovewood barns in Surnadal in NordMøre, and a few places in southern Trøndelag. In his district, Eidskog, "the building technique is well known among older people and had its widest distribution…in the period from 1890–1920," and that "experts on the other side of the border in Sweden tell us that the stovewood technique had been used already in the 1850s," when it became widely spread throughout the Varmland area.

The validity of a Scandinavian origin was given further support in a 1979 interview with an 80-year-old mason in northern Wisconsin. The builder of several cordwood structures, he confirmed learning this construction method from his father who acquired the technique in his native Sweden before emigrating to America.

Many questions remain unanswered. Is cordwood a folk building tradition that originated in the United States? Can it be given a logical pattern of diffusion into

North America? Why did the technique not receive wider acceptance and use? Perhaps growing interest in the economy, ease of construction and the energy-conservation value of this unusual construction technique will generate more interest in its origins and early use.

An Old Cordwood House Near Stockholm *by Olle Lind*

In Botkyrka, near Sweden's capital of Stockholm, there is a small cordwood house, deserted since 1950. The house measures 25 feet by 16 feet 5 inches and has a wall thickness of about 12 inches. It has been documented that the building was constructed about 1860. I am somewhat surprised that it is still standing, since the foundation was badly constructed from the very beginning and consists only of stones placed directly on the soil. On top of the stones are beams (or sill plates), the same thickness as the cordwood walls. Above the sill plates, the walls are constructed of split spruce log-ends, with the masonry courses stabilized by horizontal wooden planks. As Swedish spruces have low resistance to rot, I found it remarkable that most of the log-ends are unbarked and are still sound. The mortar between the logs is clay reinforced with about 40 percent sawdust. There appears to be very little mortar shrinkage.

P.3. This old house in Botkyrka, Sweden, dates back to about 1860. Despite a foundation of stones on the ground, unbarked spruce log-ends, a clay and sawdust mortar, and more than 60 years of neglect, the walls are mostly intact. Olle Hagman visited the same house in 2015 and reported that one side of the roof was ruined and so one wall was starting to rot. Credit: Olle Lind.

Historical Variations

by Olle Hagman

Wood masonry has been around for almost two hundred years, but has mostly been practiced by DIY builders, with local, situational, and even individually adapted solutions. One result is a wide variation in practices.

Materials

The most commonly used mortars were based on clay; in some cases, only clay. Clay with a high silt content was usually mixed with sand to decrease surface cracking. Straw or other fibers were often added to reduce cracking, creating cob. Sometimes cow or horse manure was added to increase water resistance, and sometimes a small amount of lime. In the late 19th and early 20th centuries, some builders used a mix of clay and sawdust. Mixing was heavy work and often done through treading, sometimes by horses. Lime mortar was used in a few cases. Only more recently have a few structures been built with cement-based mortars.

P.4. Wall detail of the Botkyrka house. Note the use of horizontal boards as stabilizers between courses. The mortar is a mixture of clay and sawdust. Credit: Olle Lind.

P.5. Cob masonry with waste wood from sawmills. Credit: Olle Hagman.

The most commonly used species of wood were pine and spruce, but sometimes, due to local conditions, aspen or birch were used as well. In most of the old houses, the wood pieces were often remarkably fine-split, but they could sometimes be round or cut into halves. Usually the wood was de-barked, but not always. It was also common that the wood came from old log houses that had for some reason been taken apart and the logs cut into pieces. In some parts of Sweden, there are also concentrations of plank-end houses, where off-cuts from sawmills were used, with the fibers parallel to the length of the wall. In southern Norway, close to the Swedish border, there are some other interesting examples of mortaring with waste-wood from sawmills.

Design

Most of the old wood masonry houses in Sweden were built with load-bearing timber structures. The thickness of the posts varied, from the most common seven or eight inches, down to four inches in some walls built in the early 20th century. Load-bearing wood masonry walls were rather unusual. They appear mostly in outbuildings, and are usually at least ten inches thick.

A significant specialty in Fenno-Scandinavian (Sweden, Norway and Finland) wood masonry is the frequent use of stabilizing horizontal laths or headers of dimensional lumber. These were sometimes put between each layer, especially when round pieces or wood from log houses were used, but the spacing can be larger. Usually they are one to three inches thick, but there are examples where seven-inch-thick logs were used as headers. These headers were used both with post-and-beam structures and load-bearing walls.

Wood masonry was used for many different purposes in Scandinavia. In homes, it was almost always done with a post-and-beam structure. It was used for meeting halls, in particular prayer houses. At least in one case, wood masonry was used in a factory, a liquor factory from the 1910s. It was also used for many kinds of outbuildings, from barns to sheds and even dry privies. It could also be used as extra insulation and protection, as in sheds used for slaughter. Then the walls were usually plastered with cob.

Most of the older log-end or plank-end houses in Sweden were fashioned to imitate other materials. Normally they were plastered with cob or lime plaster to look like stone or brick houses, or covered with boarding to look like wooden houses. Outbuildings were exceptions to this. In barns, at least one side of the wall was usually uncovered. In some cases the outbuilding walls imitated the look of stone masonry or wood piles.

Newer wood masonry houses are almost never built as imitations of traditional techniques. Instead, the technology is used today to break with traditional house design. This can be done in at least two ways. Some adapt to what we might call an American "cordwood style," with exposed round or roughly split cordwood. Some adapt to what we might label a "hobbit style," often in rounded shapes and covered with thick and sculptured layers of cob plaster.

Chronology of Cordwood Building in Sweden

Stove-wood building could have been invented earlier, but to become an attractive alternative it had to wait until around 1840, when the first thin-blade handsaws made from roller steel were marketed. Without effective log-saws, people must have found it more convenient to build log houses using axes. The whole 19th century was a time of experimentation in construction technologies, and a new tool such as an effective handsaw invited new experiments. The first to adopt stove-wood building were rather well-off people in the countryside. As with most other new technologies, the "early adopters" were people who could afford to experiment. At the time, house building was still not professionalized, but mostly done by laymen, and the early wood masons applied construction routines and solutions from related technologies, such as stone and brick masonry.

A breakthrough in wood masonry came in the 1870s. One reason was the introduction of the lightweight and rather inexpensive bucksaw and of motorized chop saws. The professionalization of building had started, but, particularly in the countryside, people still built their own houses. Also, it was still a time of experimentation, and many variations of wood masonry were tried, including plank-end masonry. This was particularly common in two parts of Sweden. One was the north part of the west coast, close to Norway. The wood was imported from the sawmill area in Fredrikstad in Norway, where plank-end (and other waste-wood) building was dominant, particularly in the 1880s and '90s. During this period wood masonry spread to less well-off people and a number of lower quality houses were built. This was probably a reason it fell into disrepute.

Our Personal History *by Rob Roy*

My wife Jaki and I have been building cordwood homes since 1975—about a quarter of the time since Wisconsin's first documented house—so I guess we're part of cordwood's history.

Back Story

During our 1974 land search, we fell in with the Weedy Rough intentional community near Fort Smith, Arkansas, and actually got hired for a week to help build a log home for Joe Mayo of Minnesota's Mayo Clinic. Joe had a copy of the April, 1974, *National Geographic* with a picture essay called "Winter in Snowy Stehekin" (Washington) by Bruce Dale and Pat Hutson. On page 580, we see a picture of Judy Breeze in her cordwood house, with 12-inch-thick walls. The article suggests that Ms. Breeze built the house with her son about 1971. Well, we'd been struggling with Joe's 14-foot pine logs, so as soon as we saw that picture, we said to each other, "That looks a whole lot easier." Joe told us it was an old style of building in Wisconsin and produced a copy of Eric Sloane's hand-drawn book *An Age of Barns*, with two pages of line drawings of old "stovewood" barns in Wisconsin, Montana and Indiana.

Our land search ended with buying property on Murtagh Hill, West Chazy, New York, where we still live. A sawyer near us said that he knew of cordwood houses up in Ontario, not too far from our homestead. One Sunday, Tom Lavarnway, then 75, and from whom we'd bought our land, offered to drive us up to Ontario to find examples of "stovewood masonry." "I'm not too old to learn new tricks," said Tom, a lifelong builder. First, we came across a large dairy barn built in 1956. The owner was happy to show us around, but, as he hadn't built it himself, could give us little information about its construction. It surprised us that the 10-inch cordwood walls were load-supporting, and it didn't look like the barn was in any danger of falling. The farmer's house was also built of log-ends, but they had been plastered over, so we could learn little of its construction.

A little later, we found an old log-end school house, which had been converted to a horse barn. The owner told us it had been built "about a hundred years ago" which would have been in the 1870s. The 11-inch log-ends were mortared up with a lime mortar, with horse hair mixed in as reinforcing.

By late afternoon, we started home. To our amazement, we came across a man laying up the walls of a cordwood masonry barn within a timber frame. The builder told us that he had built quite a few cordwood structures, including the gable ends of an A-frame for a client much further away. Our new builder friend came across the A-frame's owner several years later and asked him how the place was holding up. Grand, said the owner, no problems to report. All of this was encouraging.

We asked the builder if he could give us any advice.

"Not much to it, really," he said. "Use dry wood, wet mortar, and throw an extra shovel of lime in with your mix."

Jaki dutifully scribbled down notes: "Extra lime in the mix…"

We returned to our temporary shelter—a small shed Tom had helped us build—intoxicated with the idea that, yes, it could be done, and, if done right, a cordwood building could last a century, even in an area with long hard winters.

We began with Log End Cottage, and over the years built three more houses, described in Chapter 1.

Notes

1. Paul B. Jenkins, "A Stovewood House," *Wisconsin Magazine of History*, 7 (1923), pp. 189–192.
2. Richard W.E. Perrin, "Wisconsin's Stovewood Architecture," *Wisconsin Academy Review*, 20, No.2 (1974), pp. 2–9; and *The Architecture of Wisconsin*, State Historical Society of Wisconsin, 1967, pp. 27–32.
3. Sibyl Moholy-Nagy, *Native Genius in Architecture*, Horizon Press, 1957, p. 194.
4. Michel Lessard and Huguette Marquis, *Encyclopédia de la maison québécoise: 3 siècles d'habitations*, Les Editions de l'homme, 1972, p. 107.
5. Eric Sloane, *An Age of Barns: An Illustrated Review of Classic Barn Styles and Construction*, Voyageur Press, 2001.

Introduction

What is Cordwood Building?

We had best start with a definition.

Cordwood masonry: That style of construction by which walls are built of short logs—often called *log-ends*—laid up transversely within a matrix of mortar mix or other binder, much as a rank of firewood is stacked.

But Why Build with Cordwood?

Since the 80s, I have been answering this fundamental question with my list of "5-E" advantages of cordwood masonry. The list did not find its way into the first edition of this book back in 2003, so I am going to dust it off and polish it for this new edition, because the five points still hold true.

1. **Economy:** Cordwood masonry walls are low in cost, particularly when the owner-builder has a local source of appropriate wood. If clay is readily available on site, "cobwood" construction is an option, saving on Portland and lime. Sand and sawdust can usually be found quite inexpensively, and sand might even be indigenous to the building site.
2. **Energy efficiency:** Built properly, and with a wall thickness appropriate to the local climate, cordwood homes are easy to heat in the winter and stay nice and cool during the summer. The secret is the wonderful juxtaposition of insulation and thermal mass, discussed in Chapter 3.
3. **Easy to build:** I like to say that children, grandmothers and beavers can all build with cordwood masonry…and do so time and again. Our oldest son, Rohan, built his first little cordwood playhouse at age seven and was teaching cordwood masonry to Chicago's inner city youth when he was nine. His brother Darin grew

up with cordwood, has taught it with us at Earthwood and lives in his owner-built home, which he calls Driftwood.

4. **Esthetically pleasing:** "A cordwood wall combines the warmth of wood with the pleasing relief and visual interest of stone masonry." I wrote those words in 1992. It's still true, but build quality is getting better all the time. Many builders have taken cordwood to an art form in the past ten years or so.
5. **Environmentally friendly:** Cordwood makes use of wood which might otherwise go to waste, even tipped into landfills. I have used ends and pieces from sawmills, log cabin manufacturers and furniture makers. Hollow log? Not much good for the sawmill, but an interesting feature as a special log-end with a "bottle-end" at its center. See also Chapter 5: Is Cordwood Green?

How?

"Why" is a very important question, but once the decision is made to "go cordwood," the equally important question becomes "How?" The answer to this one is the main thrust of this book.

Now, cordwood masonry may sound to some like an oxymoron, like painless dentistry. There is a popular but misguided legend in the building field that you can't put wood up against mortar and expect it to last very long. Full stop, end of story. To which I say, respectfully: "Bunk!"

Deterioration in wood is caused, first and foremost, by fungi, little beings who use the cellulose as food. To propagate, fungi require a constant damp condition. Cordwood masonry, with its log-ends laid up transversely in the wall—on end grain—have a remarkable ability to breathe. The wall may get wet in a driving rainstorm, but it dries very quickly thanks to excellent breathability through the longitudinal fibers and cell structure. The wall gets wet. The wall dries out. Wet, dry. Wet, dry. The fungi do not get a foothold to create offspring.

Cordwood masonry has been used on both sides of the Atlantic for around 200 years, maybe more. (See Prologue: History of Cordwood Masonry). And there are examples of existing buildings where the log-ends are still in good condition since the nineteenth century. In fact, in some cases, a kind of petrifaction seems to have taken place.

The building technique was passed down from generation to generation in North America and Scandinavia, but never took off, so to speak. This began to change dramatically in 1977 when three how-to books appeared within months of each other, each dealing with a different cordwood masonry methodology. They were: Jack Henstridge's *Building the Cordwood Home* (load-bearing round and curved-wall homes); the University of Manitoba's *Stackwall: How to Build It* (stackwall or built-up corner method); and my own *How to Build Log-End Houses* (cordwood as infilling within a strong timber frame). Magazines like *Mother Earth News*, *Farmstead*, *Harrowsmith*, and, later, *BackHome* took the ball and ran with it. Cordwood became a staple of the owner-builder movement, although it never experienced the sudden rapid rise in popularity of earth-sheltered (underground) housing or strawbale construction.

Cordwood's growth has remained steady since 1977, and has been spurred on by five Continental Cordwood Conferences (CoCoCo), the first at our Earthwood Building School (West Chazy, New York) in 1994, followed by: Cambridge, New York, in 1999; Merrill, Wisconsin, in 2005; the University of Manitoba in 2011; and Earthwood again in July of 2015, just months ago as I write these words. These conferences have brought together cordwood masonry's shakers and movers from all over the world, sharing their new discoveries, techniques and case studies. Now there are websites, blogs and chat rooms devoted to cordwood masonry; the main ones are listed in the Bibliography.

The most recent collection of CoCoCo papers has yielded brand-new information and stories of interesting projects around the world, and these papers have been redone for this book by the authors and myself, particularly Chapters 13, 14, 16, 17, 18, 19, 20, 21 and 22. Any chapter without a byline was written by me.

"Part One: Cordwood Basics" contains the fundamental information that a builder needs to be able to construct a sound, beautiful, long-lasting cordwood wall.

"Part Two: The New State of the Art" expands upon the basics, and shares new techniques, mortar and insulation options, electrical and structural considerations, and the like.

"Part Three: Case Studies from Around the World" showcases projects from North America, Australia, Sweden, Latin America and Hawaii.

"Part Four: Economics and Code" discusses the economics of cordwood building and how to satisfy code requirements.

Most of this book is completely new. But, in the name of fair disclosure, Part One has quite a bit of rewritten and expanded information from *Cordwood Building: The State of the Art* (New Society Publishers, 2003). The color section is entirely new, and illustrates the latest cordwood masonry developments in a strikingly visual manner.

— Rob Roy, Author/Editor

PART 1

Cordwood Basics

CHAPTER 1

Three Cordwood Masonry Styles

There are three different ways that cordwood masonry can be used in building: as infilling within a strong timber frame; with curved load-bearing walls; or with load-bearing stackwall corners with regular cordwood masonry between them. Jaki and I have used all three styles over 40 years and have the following observations to share.

Cordwood Infilling Within a Strong Timber Frame

A strong timber frame—sometimes called post and beam—allows a roof to be built before the cordwood walls, protecting the masonry work as well as the builder during wall construction. This strategy also protects the building through the winter in case the walls are not completed in a single season. This can happen, especially with inexperienced owner-builders. When we built Earthwood—round, with load-bearing cordwood walls—our work was exposed to the elements. We'd constantly have to build temporary covered work stations, or not work at all. We love Earthwood, but the one change we would make would be to build it under a roof umbrella supported by a 16-sided timber frame, virtually round.

Our first home, Log End Cottage, was framed with posts recycled from old barn timbers. Their dimensions varied from 8 inches by 8 inches up to 9 inches by 9 inches. The sidewall girts—the timbers that join the tops of the posts, sometimes called plate beams—were of similar dimensions. The post and girt system compartmentalized the exterior of Log End into 18 "panels" of cordwood masonry: seven on each side of the building, and two larger ones at each end. To provide rigidity to the frame, we installed permanent diagonal bracing into 12 of the panels, composed of two adjacent 3-inch by 10-inch recycled timbers, with a 3-inch insulated space between them. We were also trying to simulate the pleasing appearance of the old English "black and white" houses from the middle ages. Although we accomplished

1.1. Log End Cottage.

both goals, we would not use the permanent diagonal bracing again. It was a pain to build cordwood masonry up to the underside of the diagonals. And the structural rigidity we wanted—to resist against wind shear—is easily accomplished with temporary diagonal bracing screwed diagonally onto the frame and removed when it is time to build that particular panel. When the panel's cordwood masonry is complete, it accomplishes the same purpose as the diagonals: resistance against strong winds.

In 1975, we cut our cordwood into log-end length—about 9 inches—and stacked it up loose within the frame, without mortar, for a full year's drying. We actually moved into the unfinished building in December of 1975 and tacked a half-inch of insulation board on the exterior to see us through that first North Country winter. Was the house cold? *Very.* But we were young and freshly married and, with two woodstoves and two large dogs, we toughed it out. In 1976, we kicked one panel at a time out onto the grass, and rebuilt it in one day, before the mosquitoes came in. Sometimes we were pointing our mortar joints by car headlight and kerosene lamps.

Mistakes

We made mistakes and they are worth reporting, even though they are not related to the Cottage being a timber-framed building. My father was fond of saying that a smart man learns from his mistakes and a wise man learns from the mistakes of others. So these are for you:

1. **Thin mortar joints:** This made pointing difficult and actually reduced energy efficiency, as discussed in Chapter 3 and expanded upon in Chapter 14.
2. **Mortar shrinkage:** We solved this one on the very last panel. Again, see Chapter 3.
3. **Wall thickness:** The walls were too narrow for our cold North Country winters. To match our framework, we decided on log-ends 9 inches long. While the cottage had charming comforts of its own, energy efficiency was not one of them. In the three years that we lived there, we consumed an average of seven full cords of hardwood each winter. Too much.
4. **Basements:** We built on a basement, not a success in either practical or economic terms. Half of our total $6,000 expenditure went into the basement, which was used maybe five percent of the time. Since Log End Cottage, I have

not spoken very highly of basements, although I am very much in favor of high-quality earth-sheltered space—a totally different concept—which we achieved with our next two homes, Log End Cave and Earthwood. The difference, and the construction details, are detailed in my *Earth-Sheltered Houses* (New Society Publishers, 2006).

5. **House shape:** The Cottage was twice as long as it was wide, yielding a poor relationship between its perimeter and enclosed space. Much more on the impact of house shape on cost and efficiency will be found in Chapter 23.
6. **Poor orientation:** The Greeks knew thousands of years ago that the orientation of any home can make a 35 percent difference in energy efficiency. Log End Cottage ran north-south. An east-west orientation would have greatly increased solar gain in the winter, another deficiency that we cured at Log End Cave and Earthwood.

Only the first three mistakes above were cordwood related, and none of them directly related to the timber frame, but feel free to be wise with all of them. How to build thicker cordwood walls within a timber frame is discussed in Chapter 4.

After Log End Cottage, we built Log End Cave and Log End Sauna, all on the same 23-acre homestead, and all using cordwood as infilling within timber framing.

1.2. Log End Cave.

1.3. Log End Sauna.

Log End Cave also introduced us to earth-sheltered housing.

Before leaving this style of cordwood construction, I must say that beside the umbrella protection afforded, there is another potentially valuable benefit from doing cordwood within a timber frame: it could very well be a real plus if you have a tough building inspector. He or she will understand the structural value of the timber frame, but might be more difficult to convince with regard to cordwood's load-bearing ability.

Cordwood as Curved Load-bearing Walls

Why don't I just say round? Well, most buildings in this category *are* round, but not every one. Chapter 16 shows a curved wall example that is not. But we have done six truly round load-bearing cordwood buildings, and there have been hundreds of others around the world.

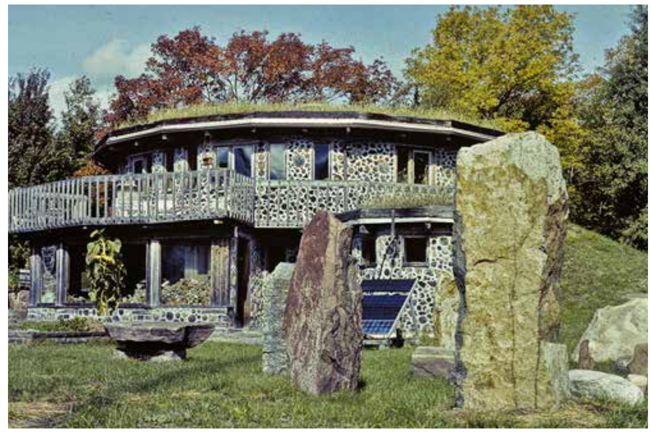
On the plus side, round is great for enclosing maximum space for the least amount of wall materials (and, therefore, labor). Plus, they have a great feel to them, a comfort hard to describe. Is it a back-to-the-womb thing? Or does our human DNA have our long history of living in round buildings built in? Even today, many so-called "primitive" people would not think of living in any other shape.

Downsides to round? Well, unless you have the luxury of building under a geodesic dome—something we were able to do with both our office building at Earthwood and our summer home, Mushwood—you will be at the mercy of the weather throughout wall construction. At Earthwood, we constantly moved a temporary cover around the building to work under. Also, we had to be very careful that the tops of the cordwood wall were covered each night with plastic and weights so that water would shed away and wind wouldn't blow our cover off the wall. At our 10-foot-diameter round sauna, we installed a 16-foot-square posted plastic tarp over the whole site, but still used a plastic cover directly on the cordwood wall in case of driving rain.

Arguably, another downside is that furniture might not always fit neatly up to the wall, particularly with smaller buildings. Rooms may be tricky to fit furniture into, particularly bedrooms, which frequently assume a trapezoidal shape. Here's another good reason for the 16-sided timber frame strategy already mentioned: on a house of Earthwood's size—38 feet 8 inches outside diameter—you get 16 8-foot-long perimeter walls for easier placement of countertops, sofas, bookcases, etc.

Some students coming through Earthwood express a fear that round will be too difficult for them, despite the fact that most birds, bees and beavers would not think of doing it any other way. I think it is because a round building is out of the ordinary, at least for most westerners. But the fact is that once you get over the mental block, round is surprisingly easy, in some ways easier than rectilinear: laying out the foundation and walls, for example.

It all starts with the center. Every point on both the foundation and the cordwood wall footprints—inner and outer surfaces—is equidistant from the center. I drive a stake firmly into the ground or, better, the center of my sand pad upon which I am going to "float" my footings. In the case of a small building, a monolithic floating slab (footings and floor poured at once) might be appropriate. I put a nail in this stake, the precise center, upon which I can clip one end of a measuring tape. Now, with a stick, I simply describe a circle in the sand corresponding to the radius of the component I am building: the inner and outer edges of my concrete footings, for example, or the outer radius of the monolithic round slab. When the foundation is in place—generally concrete in the case of a round building, although stone or earthbags can be used—I use an indelible marker to show the inner and outer radii of the cordwood wall itself. And we're ready to build. It's that simple! (Almost.)



1.4. Earthwood, circa 1990.

1.5. Mushwood, present day.

The only thing that remains is to keep the wall going up vertically and there are two ways to do this.

Plumb bubble method. After the first couple of courses of cordwood masonry, frequent use of the plumb bubble of a 4-foot or 6-foot level will assure that the wall is going up vertically. My personal rule is to check for plumb every five or six log-ends, particularly the larger log-ends. Place the level vertically so that one surface is up against the first course that you laid according to the indelible crayon marks on the foundation. Place a higher part of the level against the log-end you want to check. The newly laid log may have to be tapped slightly in or out so that its inner surface is absolutely plumb to its fellow below. Use the impact strike of a hammer to move a log slightly in its fresh mortar joint. A fist can shake the whole wall. Always use the level on the inside of the wall so that any log-end length error takes place on the exterior.

Center pipe method. (I have heard that this was used in medieval castle turret construction.) At the time of pouring concrete, place a short 1-inch-diameter pipe with a threaded end at the very center of the building. In the slab, drill three half-inch holes, 2 inches deep, into the slab, each at about 6 feet from the center and equally spaced every 120 degrees around the circle. Place leaded expansion shields into the holes. When you are ready to build your round cordwood wall, place a female union fitting onto the pipe. To this, insert a pipe as high as the wall you want to build, seven feet for example. Pre-drill quarter-inch holes all the way through the pipe, every 9 inches along its length, so that a 16-penny nail can be inserted through at frequent height intervals. In the three expansion shields, screw in O-ring screws of the correct diameter for the expansion shields. Now plumb the pipe perfectly vertical, with cables stretched from its top to the three O-rings sticking out of the slab. You can plumb and tighten the three cables with turnbuckles.

Place a bull's ring around the pipe so that it can easily slide up and down. Tie a nonstretch line to the bull's ring and put a plumb bob at the other end, so that, when extended horizontally, the total length of the line from the center of the building to the tip of the plumb bob is exactly the same as the inner radius of the circle. Now build in courses. Lay the inner surface of each log-end up to the plumb bob at the end of the extended line, assuring that each is equidistant from the center and that the course is round. To keep the line horizontal—and the wall plumb—move the bull's ring up as needed and support it by a 16-penny nail. Now your wall will be

1.6. The center pipe method.

1.7. Equipment needed for the center pipe method: leaded expansion shields to insert into slab (*upper left*); eye bolt to go into the expansion shield (*upper right*); turnbuckle for tensioning the guy wires (*lower left*); opening O-ring to slide up and down the center pole (*lower right*).

curved correctly...and plumb. Thanks to Pythagorean trigonometry, it is not imperative that the line be perfectly level; within five degrees is fine. But if you don't move the bull's ring up at all, your building, after a while, will start to look more like a dome than a cylinder.

This may seem like a lot of work, but it will assure quality control. We have seen it done, on a 32-foot diameter home in central New York, and the system worked very well. But we have had good results with the plumb bubble method. Choose the technique that appeals to you.

Finally, while a cylinder is inherently stronger against lateral (sideways) load than a box shape, there is almost no tensile strength between log-ends and mortar. I would not use load-bearing cordwood masonry in seismic zones, and no competent code enforcement officer would either.

Cordwood with Stackwall Corners

Stackwall corners are built-up of criss-crossed "quoins" of regular log-ends. (The word derives from the regularly-shaped stones found at corners and around windows and doors in stone masonry.) This style has been most prevalent in Canada because it enabled builders to construct very wide cordwood walls—24 inches or more—appropriate for cold climates. Many stackwall-cornered barns were built in Ontario, Quebec and Wisconsin in the 19th century.

Quoins can be made from timbers milled to square or rectangular cross-section, such as: 4 inch by 4 inch, 6 inch by 6 inch, 4 inch by 8 inch and the like. Quoins made from logs milled on three sides, or two opposite sides, work well and can be quite attractive. Sometimes, useful short pieces can be obtained at low or little cost from log cabin manufacturers. Another option is quartered logs, either sawn or hand-split. And several old-time and modern builders have used regular cylindrical log-ends as quoins, but it is my strong opinion that these have an inherent instability, particularly as there is no lasting chemical bond between wood and mortar. Finally, some builders have successfully used decorative cast concrete or concrete blocks as corner quoins. Back in the 80s, Jaki and I saw a cordwood building in North Carolina with stone quoins.

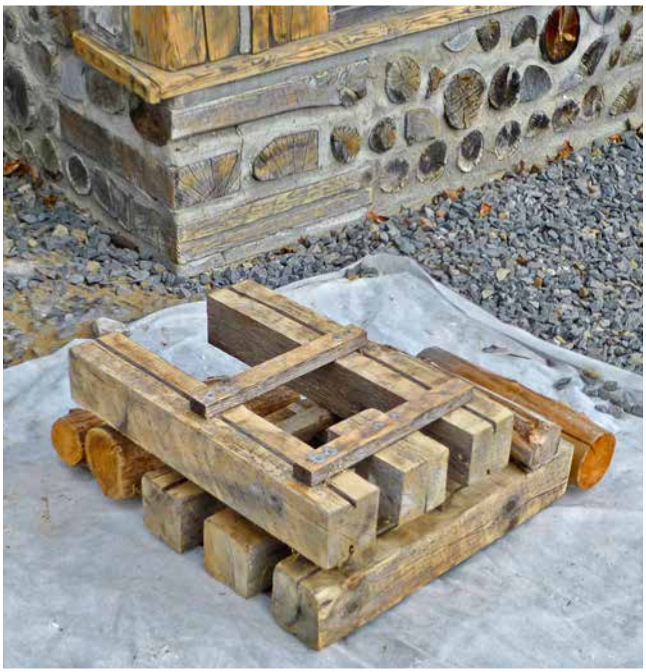
But the best of the wooden quoin options is undoubtedly a system developed by Gary Lomax in New Brunswick back in the 1980s, and now called the Lomax Corner.

No matter which corner quoin system you use, the order of events is the same: build your stackwall corners up about three feet, give or take. Use your plumb bubble on each side of the corner. Stretch a mason's line from one corner to the next, using clips made for the purpose. The clips hold the line a quarter-inch away from the wall. Build the cordwood walls between stackwall corners according to the

The Lomax Corner

Lomax Corner units facilitate the building of straight, strong, regular, well-insulated stackwall corners. The corners rise at a constant rate with these regular units, pre-made full-width quoins. They are composed of regular squared quoins and stabilizing cross-pieces made from full-sized 1-inch by 1-inch or 1-inch by 2-inch wood, as seen in Figure 1.8.

The advantages of the Lomax system are: (1) stronger than individual quoins, (2) faster and easier to level and plumb the corners, as fewer pieces are handled and (3) each corner goes up at exactly the same rate—6 inches in the example pictured in Figure 1.8—so that all four corners wind up at the same height. For example, sixteen Lomax units, each building the wall up 6 inches, totals 96 inches, or exactly 8 feet.



1.8. Two Lomax corner units, made from 4-inch-square timber stock , are stacked one upon the other. Note the tie pieces and chainsaw grooves for better friction bond to the mortar, not shown in this model. The short block is simply a decorative filler piece and helps retain the sawdust insulation which will be placed in the continuous inner cavity of the corner. In the background is a stackwall corner at Earthwood, made from 4-inch by 8-inch quoins for this 16- inch cordwood wall. The wall continues above with the cordwood supported by a "double-wide" pair of adjacent 8-inch-square posts.

line, keeping a quarter-inch space between log-end and line. If you touch it, you will begin to push the line out of straight.

There is one more important development in stackwall corners, developed back in the 1980s. It is best to make two lengths of quoins, be they Lomax units or not, half of the quoins being about 6 inches longer than the shorter ones. Now, when mortaring up the stackwall units, alternate short and long quoins on each side of the corner, so that you do not have a weak long vertical joint from the end of one quoin to the next. The longer quoins break up this weak joint, especially important in corners, which are subjected to greater settling loads than the rest of the wall. An example of alternating lengths of quoins can be seen in Figure 1.9.

There have been some beautiful and successful stackwall-cornered homes built in the United States and in Canada, but I am compelled to list what I have observed, over the years, to be upsides and downsides of this method.

Stackwall Corners: Upsides

1. Stackwall corners might be a good choice if you haven't got access to affordable heavy timbers for a timber frame. (But see Item 1 in Downsides below.) You can make quoins from quartered

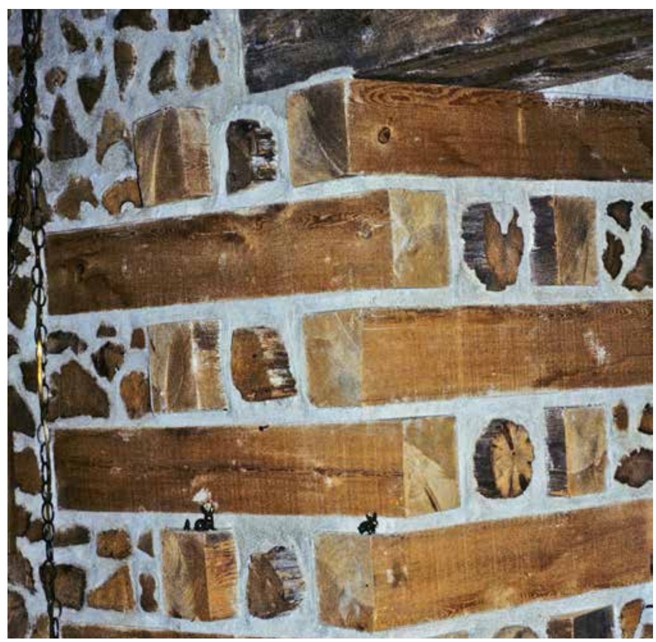
1.9. This small pump-house in North Carolina was made with single-wide quoins, cut from tulip poplar with a chainsaw, then water-sealed to minimize water absorption from mortar to wood. The staggered length of the quoins is clear in this image.

logs or by ripping two slabs off a log with a chainsaw, as in Figure 1.9. Do not be tempted to use weak quoins made from cylindrical logs.

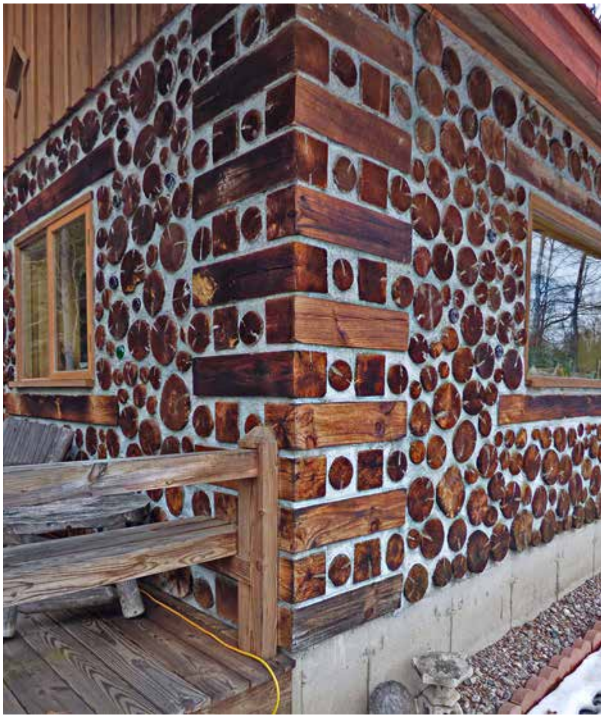
2. You can build any thickness of wall you like with stackwall corners. I have visited several cordwood homes with 24-inch-thick walls, most of them in Canada.
3. Done with care, stackwall corners can be very beautiful, as seen in Figure 1.11.

Stackwall Corners: Downsides

1. It takes more milled lumber to build stackwall corners than a single post. Also, in common with a timber frame, stackwall corners need to be tied to each other with a strong plate beam (girt) system, upon which floor joists, trusses or roof rafters are placed. Single 8-inch by 8-inch posts can be used as corners and vertical posts



1.10. An internal stackwall corner on a house in Thornton, Ontario.



1.11. A beautiful stackwall cornered addition in Peru, New York, built without staggered-length quoins.

every 8 or 10 feet along sidewalls to support the plate beam, even on walls 16 inches thick or greater. For details, see Building Thicker Cordwood Walls Within a Timber Frame in Chapter 4.

2. Building stackwall corners takes a lot longer than erecting a timber frame for the same size of building. Some of this extra time is spent on covering and uncovering the work every day, but the biggest time-killers are the rainy days that completely stop work. True, there is an additional skill set required to do the timber frame, but this is also the case with stackwall corners. See my *Timber Framing for the Rest of Us* (New Society Publishers, 2004) for tips on how to build a strong timber frame quickly and easily with inexpensive commonly available fasteners.
3. You can't get the roof on (or the building site covered) until all the cordwood is completed. Electric, windows and doors, and other building components are exposed to the elements. (This is also true of curved wall buildings not built under cover.)
4. There is a very real possibility of quoins swelling from mortar moisture or rain causing an outward tilt to the wall. We have seen this on a 16-inch-thick stackwall cornered home in Northern New York, even though the building employed strong Lomax units. The danger is that squared timbers readily absorb moisture through the sawn edges. This danger can be significantly diminished by the application of a water seal product on all parts of the sawn quoins that will be in contact with mortar. My favorite sealer for the purpose is Cabot's Silicone-based Waterproofing.

Door Frames

With all three methods of building with cordwood, there is one common denominator, and that is the need for very strong door frames, composed of two side members, called jambs, and a header tying them together on top. Cordwood is heavy and plastic during its first couple of days of curing, even longer with lime putty mortar and cob. The wall imparts a strong lateral load on a door frame, which can cause it to bow inward. Even a full-sized 2-inch-thick frame may not be strong enough, and a "2-by" bought from a box store or most lumber yards is actually only 1.5 inches thick and almost certain to bow and make it impossible to use the door. A full-sized

3-inch-thick member should be considered the minimum, which you can procure on order from local sawmills. Planed smooth, a 3-by-8 will actually be 2.5 inches by 7.5 inches. Having said that, I tend to use full 4-inch-wide framing. Earthwood, for example, has door jambs composed of two 4-inch by 8-inch timbers scabbed together with a vertical 1-inch by 6-inch key piece along its full height. The key does double duty; it ties the inner and outer door jambs together for construction and it provides a positive locking key for the cordwood masonry later on. Likewise, the door's header should be made of the same material.

With narrower cordwood walls, a single-wide set of jambs with header will do—4-by-8 inch material for an 8-inch wall, 4-by-10 stock for a 10-inch wall, etc. I always like to extend my header out about 4 inches proud of the door jambs on each side, as seen in Figure 1.12. It looks good, yes, but it also lends a little extra bending strength to the header, particularly on wide door frames, such as a 6-foot sliding glass door unit. In fact, on wide doors, I will extend the header as much as 8 inches both sides. Fasten the header to the posts with two strong structural screws, such as TimberLok or—my favorite—GRK structural screws.

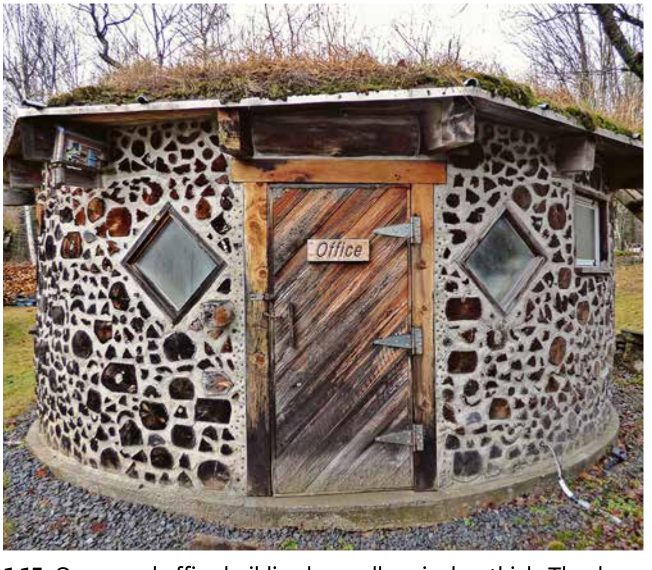
1.12. Top of door frame at Earthwood, made from doubled 4-inch by 8-inch jambs and header.

The various methods of fastening posts and heavy door jambs to a concrete foundation are beyond the scope of a book about cordwood, but are discussed in detail in Chapter 4 of my *Timber Framing for the Rest of Us.*

When building cordwood within a strong timber frame, it is very worthwhile to plan your timber frame to accommodate door frames and windows, as we did at Log End Cottage and Cave, as well as several of the outbuildings at Earthwood. At the Cottage, our 8-by-8 inch posts served double duty as door jambs. The heavy girt that joins the top of the sidewall posts can also serve as the door header (or the tops of window frames). A lot of time and money is thus saved at the design stage. Four examples from four different shapes of building, are shown in Figures 1.13 to 1.16.

1.13. Log End Cottage, built in 1975. Doors and windows are enclosed by the timber frame itself, mostly 8-inch by 8-inch recycled barn beams.

1.14. Strawbale (and cordwood) guest house at Earthwood. The door is exactly framed by the 4-inch by 8-inch jambs which extend from the foundation to the 8-inch by 8-inch girt.



1.15. Our round office building has walls 12 inches thick. The door frame is made from full-sized 6-inch by 12-inch timbers. Note that the header carries a few inches into the cordwood masonry. Yes, this door opens out.

1.16. Stoneview is an octagonal guesthouse with eight 8-inch by 8-inch girts joined over eight special posts. Both the door jambs and the long window frames (all 4-inch by 8-inch stock) extend from the floating slab to the underside of the girts. Full framing details are in my book *Stoneview: How to Build an Eco-friendly Little Guesthouse* (New Society Publishers, 2008.)

Although windows can be framed by the timber frame, as in Figures 1.13, 1.14 and 1.16, heavy frames—called "window bucks"—can also be floated in a cordwood wall, like the diamond-shaped ones in 1.15. The technique is explained in Chapter 3.

Summation

When I step back and hear myself lecturing on the three methods of using cordwood masonry, I realize that I am biased towards cordwood as infilling within a timber frame. We like round buildings—we have several—but they are best done under a protective cover. The stackwall corner's downsides seem to outweigh its upsides. In a seismic zone, the timber frame method is the only safe route. If you decide on stackwall, consider these three points very carefully: (1) Use Lomax Corner units. (2) Treat sawn (or split) quoin edges with a good waterseal. (3) Allow an extra 20 to 40 percent more time to build.

Finally, Lonnie J. Sobeck, of Coleman, Wisconsin, presenting at CoCoCo/15, developed a new cordwood building method which combines curved and straight walls with something he calls "bull-nose corners." His paper, "Bull Nose Cabin," appears in *The Continental Cordwood Conference Papers 2015*, along with 24 others. The collection is available from Earthwood Building School, cordwoodmasonry.com.

Bull-nose Corners

Lonnie is the only person I am aware of to use this method in a load-bearing structure, although Jaki and I wrapped similar bull-nose corners around a timber frame at a La'akea Community Cordwood workshop on Big Island, Hawaii.

1.17. Lonnie's 20-foot by 24-foot Bull Nose Cabin, Coleman, Wisconsin. Credit: Lonnie Sobeck.

1.18. Interior of Bull Nose Cabin. Note that the corner logs have all been tapered. Credit: Lonnie Sobeck.

1.19. Tapered logs at the corner, with barbed wire reinforcing in the mortar joint for extra strength. Credit: Lonnie Sobeck.

1.20. Exterior view of a "mini" bull-nose corner, wrapping around an *ohia* post in a timber-framed home in Hawaii. Small log-ends and chunks of lava helped fill large mortar joints.

1.21. Interior view of the home in Hawaii. The timber frame protected the workshop participants—and the cordwood—in a location with about 100 inches of rain per year.

CHAPTER 2

The Wood

First and foremost, the building of a cordwood home requires…wood! Over the years at workshops, I have found that eight questions come up time and again about the cordwood itself. We'll examine them one at a time.

What Kind or Species of Wood Is Best?

The best choices for cordwood building are the more stable woods, the kind that shrink and expand the least. The problem that occurs most often is shrinkage. However, log-end shrinkage—while irritating and esthetically disturbing—is not a critical problem. There are things that can be done about it (see Chapter 4). Wood expansion, however, while much rarer, *can* be a critical problem, as we learned in 1981 when we tried to build the back wall at Earthwood with very dry hardwood log-ends.

When wood wants to expand, there is nothing we can do to resist it. Granite quarrymen in the 19th century would drill several three-quarter-inch holes behind the face of rock they wished to split. They would insert dry, three-quarter-inch hardwood dowels (such as oak), water them, and after a while, the swelling oak dowels would break off an 18-inch face of granite. With a curved cordwood wall, this expansion will cause the wall to go out of plumb. At Earthwood, despite careful building, the expanding log-ends sent the wall 3 inches out of plumb, at 6 feet of height! With heavy timber frames, the expanding wood can push corner posts out and/or cause uplifting of plate beams (girts) at the top of the cordwood wall. Stackwall corners, described in the previous chapter, will be pushed out in both directions by expanding cordwood. Although uncommon, I am personally aware of critical expansion problems with all three methods of using cordwood masonry.

Expansion and shrinkage are directly related. In general, woods most prone to shrinkage are also the ones most prone to expansion. The more stable woods are what I call the light and airy woods, such as white cedar, white pine, larch (tamarack), spruce, cottonwood, lodgepole pine, quaking aspen and the like. These woods can be used dry without critical expansion problems. And, if they are dry—a year or more at log-end length—they will shrink very little after that. Red pine, Virginia pine and red cedar have been fairly successful.

Hard dense woods such as oak, maple, birch, beech and elm, as well as some dense southern pines have potential expansion problems, particularly if they have dried too long before building. I don't know all of the woods in different parts of the world, but, in general, look for lightweight airy woods. Avoid dense, heavy, fine-grained woods, which tend to shrink and expand a lot. Look for local woods with low shrinkage characteristics. As a bonus, airy woods have a better insulation value than the dense hardwoods.

Rot resistance is not as big a factor in choosing wood species as one might expect. Wood rot is caused by fungi, which need nutrients, air and constant moisture to propagate. With a cordwood wall, only the first two requirements are present, not the third. Because log-ends are constantly breathing along end grain, moisture is never trapped. See the sidebar on the five things to do to prevent wood rot.

Comments on a Few Representative Wood Species

Admittedly, most of my cordwood experience has been in northern New York and the Midwest. However, I have conducted many workshops in the south (Texas, North Carolina, Virginia) and the west (Colorado, Oregon, California, Idaho, British

Five Rules to Prevent Wood Rot in a Cordwood Wall

Log-ends, because of their breathability, are not prone to deterioration in a cordwood wall in the first place. And if these five rules are followed, the chance of wood rot will diminish to almost nothing.

1. Keep the cordwood masonry elevated at least 4 inches off the ground on a good concrete block, concrete, or stone foundation. In wet climates, up this to 1 foot.
2. Use a good roof overhang all around the building. I like a 16-inch overhang, but 24 inches or more is even better.
3. Don't allow two adjacent log-ends to touch each other or a surrounding post and beam frame. Moisture can get trapped there and promote the growth of fungi.
4. Build only with log-ends that are sound in the first place. Reject wood that shows any sign of existing rot or deterioration.
5. Debark the wood. Insects love to get between bark and the outer layers of the wood.

Some Representative North American Wood Species, Ordered by R-value

Species	R-value (s) side grain[1]	R-value (e) end grain[2]	% radial shrinkage[3]	% tangential shrinkage[4]
Northern white cedar	1.50	1.00	2.2	4.9
Atlantic white cedar	1.41	.94	2.9	5.4
Eastern white pine	1.32	.88	2.1	6.1
Western white pine	1.32	.88	4.1	7.4
Quaking aspen	1.32	.88	3.5	6.7
Balsam fir	1.27	.85	2.9	6.9
Lodgepole pine	1.20	.80	4.3	6.7
Cottonwood	**1.20**	**.80**	3.0	7.1
Ponderosa pine	1.16	.77	3.9	6.2
Eastern hemlock	1.16	.77	3.0	6.8
Eastern spruce	1.16	.77	**4.0**	**7.4**
Yellow (tulip) poplar	1.13	.75	4.6	8.2
Western red cedar	1.09	.73	2.4	5.0
Eastern red cedar	1.09	.73	3.1	4.7
Red pine	1.04	.70	3.8	7.2
Douglas fir, interior north	1.04	.70	3.8	6.9
Western larch	1.00	.67	4.5	9.1
Eastern larch (tamarack)	**1.00**	**.67**	3.7	7.4
Redwood (young growth)	1.00	.67	2.2	4.9
Douglas fir, coastal	1.00	.67	4.8	7.6
Southern yellow pine	.90	.60	4.8	7.4
Maple, sugar	.78	.52	4.8	9.9
Red oak	.78	.52	**4.5**	**10.0**
White oak	.76	.51	5.6	10.5
Beech	**.75**	**.50**	5.5	11.9

[1] Side grain R-values for various woods are commonly available, but—except for corner quoins in stackwall corners—log-ends are laid up in the wall on end grain, so we won't really derive the full side grain value.
[2] End grain R-values, more useful for cordwood builders. See Note 1.
[3] Shrinkage following the radius of a log, from the outside to the center. Gaps will be at the edges of the log-ends.
[4] Shrinkage tangent to the edge of the log. In a round log, this causes a number of small checks (cracks) from the outside to the center. Finally one of these breaks through with a loud audible popping sound—the "primary check." Now, with the pressure released, the wood can truly shrink the way it wants to: tangentially. The primary check gets bigger and the other secondary checks actually close up. Split wood can shrink tangentially from the outset, which is why you don't see checking in a split piece. Duck carvers always used quartered logs for their carvings. No one wants to see a duck with a check.

Comments on the R-values and Shrinkage Chart

R-values. Heat loss is greater on end grain, because of fewer transfers of heat through longitudinal fibers and air infiltration due to shrinkage. Estimates from different sources vary from 40 percent of the side grain (which I think is too low), up to no difference at all, which is definitely wrong. I am going with the consensus of about a two-thirds value. For calculating your wall's real R-value, use this second (end grain) column of figures. While not exactly right, these values will be much closer to the truth than using side grain values. However, if you are trying to sell the wall's thermal performance to a code inspector, and you are a little short, you could use the first column. These are the numbers the inspector will find if he/she checks for wood R-values in an engineering manual. Is this dishonest? I don't think so. The codes give little or no credit for a cordwood wall's exceptional thermal mass characteristics, discussed in more detail in Chapter 3.

Shrinkage values were taken from a variety of sources, including the U.S. Department of Agriculture. Bolded values are an "educated guess" based on comparing samples. Other dense hardwoods like elm, hickory, black locust, birch, white ash and sweetgum could be fairly grouped with the woods at the bottom of the R-value list, along with beech, oak and sugar maple. Note that, in general, the wood species with the better (higher) R-values are also the more stable. Don't forget that the woods with the greatest shrinkage are also those prone to expansion problems when the dry wood gets wet. Wood expansion problems are covered in detail in Chapter 4.

Columbia), as well as all over the world: Chile, New Zealand, Australia, Quebec, Labrador, Alaska and Hawaii.

In the Northeast and Midwest, white cedar is definitely the wood of first choice—for its insulation value and stability—but it is not always available, particularly in the southern parts of the region. White pine and spruce are good choices. Balsam fir is light and airy, but sticky with pitch, not a problem after it is seasoned. Quaking aspen, technically a hardwood, performs more as a light airy softwood when dry.

In the south, loblolly and Virginia pine are good choices. The red cedar can be quite hard and dense like a hardwood, so use the hardwood precautions listed in Chapter 4.

In the west, lodgepole pine, ponderosa pine, western red cedar, cottonwood and quaking aspen are all good choices. Douglas fir is good, too, but varies a great deal depending on whether it grows on the wet or dry side of the mountains, which affects its density. The coastal Doug fir shrinks more.

On Hawaii's Big Island, Captain Cook pine, a plantation species, has worked well. In Australia and New Zealand, radiata pine has proven to be a good choice. See Chapter 20.

How Long Should the Wood Dry?

It depends on the wood. With the most favorable light and airy woods, there is generally no problem with drying the wood a year or more. A year's drying at log-end length will go a long way toward preventing undue shrinkage with these woods, and expansion is not likely to be a problem. If you must use the denser species of wood because that is all you have on your land or in your area, just dry the wood for six weeks or so. Yes, there will be shrinkage, but this can be taken care of a year or two down the road. (For methods, see Chapter 4.) It really isn't worth taking a chance with expansion, which can ruin your work.

It is important to note that wood dries roughly ten times faster on end grain than through its outer layers (side-grain.) Therefore, the real drying takes place after longer logs are cut into final log-end length: 8-inch, 12-inch, 16-inch or whatever. If you don't see a split (called a "check") lengthwise along the side of 10-foot logs that have been lying around for a few years, the chances are that only the ends of these logs are dry and they are still going to do a lot of drying and shrinking after they are cut up. Split wood also dries faster than unsplit wood.

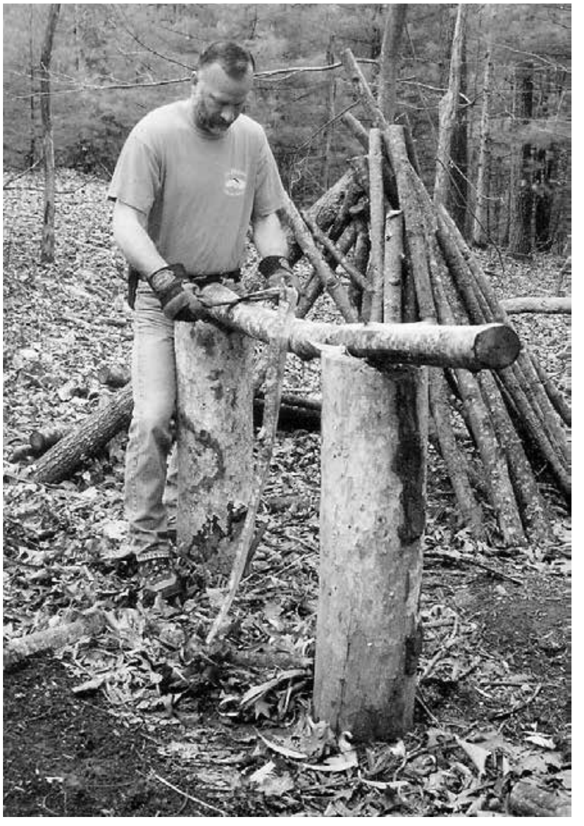
The best drying procedure is to stack the wood in single ranks, kept off the ground on wooden pallets, often available at local businesses for free or at low cost. Leave a space between ranks. Typically, if I am drying 16-inch log-ends, I will have a row of my face cords stacked along each edge of the 48-inch-wide row of pallets, leaving a 16-inch air space for breathing in between. Cover only the top of the ranks, not the sides. Covering the sides creates a greenhouse effect, trapping moisture and making the rot-producing fungi very happy indeed.

Should I Bark (or "Debark"—Means the Same Thing) the Wood?

Yes, definitely. The space between the bark and the cambium (epidermal) layer of the wood is a great place to trap moisture and provide habitat for unwanted little houseguests. It is easiest to bark the wood in the spring when the sap is rising, hardest in late autumn. The rising sap in the springtime creates a kind of greasy layer separating bark from wood. This beneficial layer gradually turns into glue which makes barking difficult. When barking is easy, almost any sharp or flat metal tool will serve as a peeling spud: a hatchet, pointed trowel (my personal favorite), scraper or sharp stiff knife. Simply lift the bark off at one end of the long log with the pointed tool, and pull wholesale strips off, sometimes from end to end. Sabre, our German shepherd, would pull wholesale strips off a log. That dog could really bark!

When barking is difficult, the tool of choice is a drawknife, a tool with a blade with two handles. The user pulls the tool towards him/herself, cutting the bark off.

Working at a convenient height is easy on the back, as shown in the picture. The drawknife does not do well where branches come in to the main log. For this reason, it is best to trim the branches as close to the edge of the main log as possible. Don't leave any little nubs sticking up, which not only make barking with a drawknife difficult, but also get in the way during the masonry work later on.



2.1. Steve Coley removes bark with a drawknife. The tops of the posts are notched, and the rear post has a stop carved into it to provide resistance, thus holding the log steady. Credit: Barbara Coley.

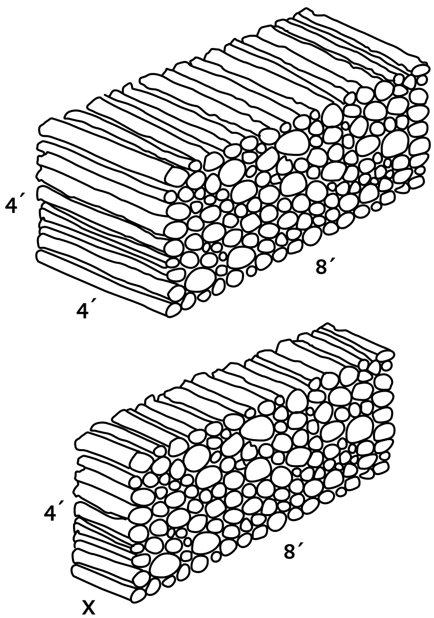
Learning from the following true story might save the reader a lot of grief. Years ago, in the spring, neighbors cut a large quantity of white cedar for their log cabin. When the wood was first cut, the bark peeled off easily, but our neighbors were in production mode, so they waited until all the logs were cut before commencing serious debarking. When, after a couple of weeks, they returned to the early logs, they found that that the sap was now effectively gluing the bark to the wood, and they had to remove it with a drawknife, a much more tedious process. Cutting into the cambium can also promote water absorption from mortar to wood later on. Again, cut the trees when the sap is rising in your area, and commence barking as soon as you've dragged the logs out of the woods. Don't delay.

It is useful to cut the fallen trees into 50-inch and 100-inch lengths, depending on whether they are heavy or light to carry. These two lengths allow the logs to be cut into 8-inch, 12-inch, 16-inch or 24-inch lengths, with a couple of inches extra to trim the ends and allow for the kerf of the saw blade when the wood is finally cut into log-end length. (For other wall thicknesses, choose a convenient log length, but don't forget to add a couple of inches for trimming ends and for the kerf.)

If you missed the best time for barking logs, there is another option. If the bark is reluctant to be removed, soak the logs in a pond, lake or stock tank for a few days. Upon removal from the water, you will find the bark much more cooperative.

How Much Wood Should I Cut?

Firstly, the best measure to work in is—no surprise here—the cord. Now, a true cord, a *full cord*, is actually a stack of wood 4 feet wide by 4 feet high by 8 feet long or 128 cubic feet. But full cords and cubic feet confuse the issue. The calculations are easier and more accurate if we work in *face cords*. Face cords are also 4 feet high and 8 feet long, but the depth—or thickness—of the cord is whatever uniform length the wood is cut: 12 inches, 16 inches, et cetera. In reality, when firewood is sold by the cord, the seller is most often dealing in face cords, typically 4 feet by 8 feet by 16 inches. You always have to ask what cord is being sold. In any case, the side of a cord or face cord is always 32 square feet and this is the magic number we can use in our calculations.



2.2. Above is a full cord, below is a face cord, where "X" is whatever length of wood the seller is supplying: 12 inches, 16 inches, etc.

From your elevation (side view) plans, determine the area of wall which is actually cordwood masonry. Subtract doors, windows and heavy timber framing from the gross wall area to arrive at this figure. A building with a perimeter of 125 feet has 1,000 square feet of wall, gross. Say the windows, doors and timber frame make up 20 percent of the wall. (You can determine this accurately from your elevation drawings.) Subtracting 20 percent—200 square feet in our example—leaves 800 square feet of actual cordwood masonry. Now divide by the magic number 32, yielding, in the example, 25 face cords. Finally, you can safely discount 20 percent from this number, because cords swell by at least that much when they are restacked with mortar. So, if you have 20 face cords laid by, at whatever length matches the thickness of your wall, you will have plenty of wood, enough to reject misshapen pieces that you don't like or are troublesome to use.

How Thick Should the Walls Be in a Cordwood Home?

There are lots of unspoken variables in this question: climate, kind of wood, size and shape of house, etc. We are pleased with the performance of our 16-inch white cedar cordwood walls at Earthwood, in a heating climate about the same as cold Montreal. Our cordwood walls have an average insulation (R) value of about R-19 or a little better, which meets New York State energy code. In much of Canada and Alaska, 24-inch walls are quite common and make sense. In warm climates, where the energy cost of cooling can equal or exceed the heating cost, 12-inch walls may be adequate, but the thermal mass of thicker walls might also make the home easier to keep cool. Cordwood builder George Adkisson tells me that the 12-inch-thick cordwood masonry walls of his home on the hot and humid Gulf Coast of Texas reduce his air-conditioning costs to about half that of similarly sized conventional homes in the area.

Because of varying R-values, the species of wood impacts wall thickness. Had we used white pine at Earthwood, for example, we would have had to have built 20-inch walls to achieve the same R-19 wall insulation value as the 16-inch white cedar. But a thicker cordwood wall generally means more insulation in the mortared portion of the wall as well. The discussion of wall thickness choice gets complex and is discussed more fully in Chapter 4, Building with Cordwood 202.

Both the size and shape of the house have an impact on cordwood wall thickness. A very small building—say 300 to 800 square feet—does not need the same thickness of cordwood walls as a medium-sized or large house. For example, we can heat our 10-foot diameter round cordwood sauna from sub-zero temperatures to 165 degrees Fahrenheit in about two hours. The walls are just 8 inches thick. Twelve-inch walls would be redundant. On the other hand, our 22-foot diameter octagonal guesthouse, with its 8-inch walls, is fine for its intended use as housing for our students from May until September, but if I were to build it again as a year-round residence, I would increase the wall thickness by 50 percent to 12 inches. Sixteen inches would be overkill, though, and a high percentage of the building's footprint would be lost in the thickness of the walls.

The shape of a house has a lot to do with heating it. The energy code requires a certain insulation (R-value) for the area where you live—walls of R-19 in New York state, for example—but doesn't care what silly shape you build your house. The relationship between skin area and floor area, for example, is critical, and is covered in detail in Chapter 23. For the moment, suffice it to say that a sensible house shape may be a cheaper and easier method of achieving energy efficiency than building thicker walls.

How Should I Cut the Wood?

Most people use a chainsaw to cut long logs into log-ends, and I do, too. Using a lumber crayon, I simply mark the long pieces—remember the 50-inch and 100-inch pieces we carry out of the forest?—every 8 inches or 16 inches or whatever size I want. Then I destroy the crayon mark with my chainsaw cut, being careful to go as straight through the log as I can. The saw cut will take about a quarter-inch kerf out of the wood, so a 16-inch log-end will actually be about 15 and three-quarter inches long, and I figure that a quarter-inch variance either side of that is acceptable. It makes your masonry work better—and easier—if you keep a fairly close tolerance on log-end length.

Another good way to cut cordwood is with a large circular saw, typically 30 inches or so in diameter. These saws are commonly connected to a tractor's power take-off (PTO) by way of a belt. The long length of wood is set onto a hinged movable support platform. The platform, with the log on it, is tilted into the saw's rotating blade, which cuts the ends off quickly with a smooth straight cut. An adjustable stop on the platform assures that every log-end is the same length.

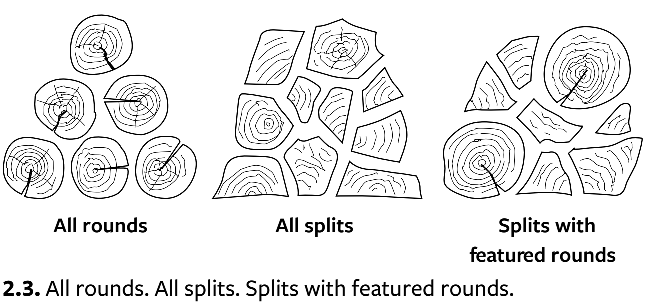
For really precise lengths, and a safe and easy method of cutting, make a cordwood cutoff table for your chainsaw, the subject of Chapter 15.

Cutting log-ends by any means has risks. Use proper ear and head protection. Logger's safety chaps are a good idea for leg protection. Keep animals and unnecessary people—especially children—away from the cutting area. Be careful. Your safety is up to you. Before using any saw with which you are unfamiliar, get training from an experienced operator.

Split Wood or Round Log-ends?

The three main reasons for splitting wood are to reduce the drying time, eliminate the large primary check seen in rounds and reduce the size of shrinkage gaps. Shrinkage is proportional, so the smaller the log-end, the smaller the shrinkage gap between wood and mortar. But the total air infiltration due to shrinkage is the same. Also, smaller pieces require more handling of materials, and mixing more mortar, too.

Jaki and I have built beautiful cordwood walls of all split wood (Earthwood main house), all rounds (Log End Cottage, Stoneview, Mushwood) and a mixture of splits and rounds (our sauna and outside office). We liked the ability to keep a constant mortar joint by using a variety of splits.



2.3. All rounds. All splits. Splits with featured rounds.

2.4. All rounds (*left*). All splits (*center*). Mixed splits and rounds (*right*).

But since the turn of the century, we have been using cedar rounds, almost exclusively. We like the appearance of the various sizes of rounds, the ease of pointing and eliminating the splitting step. We are careful to keep the primary checks down, though, somewhere between 4 o'clock and 8 o'clock, so that rainwater doesn't collect.

Split woods can have ragged or irregular ends due to the splitting process, but they don't usually have any radial checking. Some species, like red pine, grow spirally in the forest, so the axe can take a 20-degree turn—or more—as it makes its way through. Twisted log-ends are difficult to use.

2.5. Former students built this beautiful cordwood wall of mixed splits and rounds in central Pennsylvania. Note how the rounds are featured, each surrounded by a variety of splits.

2.6. Our Log End Sauna walls were mixed rounds and old split cedar fence rails. The large log-end was a varnished elm. It stayed nice for over 30 years on the inside, but the sun's UV rays wore the varnish off on the exterior. The two rounds at the top had handles on the inside and could be removed for ventilation.

Mixing splits and rounds can be very effective, if care is taken to maintain a consistency of texture and style, as seen in Figure 2.5.

Having said all that, if you have a strong preference, go with it. All three styles will work. The important thing is to maintain a consistency of style, which means making a conscious effort to deplete the various sizes and shapes of your log-ends at a steady rate.

Can I Mix Species of Wood in the Same Wall?

Certainly, as long as they are good species choices. Again, maintain a consistency of texture and style.

CHAPTER 3

Building Cordwood Walls 101

The previous chapter covered wood and wood prep. Now it is time to build. And that starts with…

The Mortar

Over the first six years of our cordwood masonry experience, Jaki and I gradually refined a mortar mix which has worked very well for us, and we continue to teach it at our workshops. This mix makes use of saturated softwood sawdust as a cement retarder. A mortar that dries slowly will shrink less (or not at all), eliminating mortar shrinkage cracks between log-ends.

The problem is that suitable sawdust is not always available, and there is always a little bit of doubt about whether or not the sawdust is right for the job. "Suitable" sawdust, in our experience, is the larger and less dense particles of softwood sawdust that come from a sawmill where logs are made into lumber, as opposed to what you get from sanders or planers at a cabinetmaker's shop. White cedar, white and red pine, lodgepole and ponderosa pine, spruce and even quaking aspen have worked well. Note that species which make good log-ends are generally the ones that work well as sawdust additives. Oak and other dense hardwood sawdusts have not been successful. The hard little cubes of oak do not seem to hold and store the moisture the way the softer, lighter softwoods do, and mortar shrinkage results. In fact, hardwood sawdust makes the mortar grainy, crumbly and difficult to point smoothly. If you cannot get suitable sawdust—or are unsure—use one of the commercially available cement retarders, discussed in Chapter 4. But if you do have good sawdust, here are two mixes that have both worked well for us, one with Portland cement and one with masonry cement. The proportions given are equal parts by volume, such as rounded shovelfuls.

Portland Mix	**Masonry Cement Mix**
9 parts sand	9 parts sand
3 parts soaked sawdust	3 parts soaked sawdust
3 parts lime	3 parts masonry cement
2 parts Portland cement	2 parts lime

These two mixes are similar in terms of hardness, strength, workability, plasticity and smoothness. The main difference is in color. The Portland mix tends to be very light in color—which is a good thing—kind of a green-gray. The masonry mix is darker and more of a blue-gray. But even these generalities can vary when different brands of cement are used.

The sand should be washed masonry, or "mason's" sand, not the coarse-grained sand used for drainage applications. You may have to pay more for the finer-grained masonry sand (which has the texture of brown sugar) than for the coarse stuff, but it is worth it. Besides, haulage is usually the greater cost, not the sand itself. Coarse sand yields crumbly mortar, frustrating to work with. Also, the color of the sand will affect the color of the mortar. Light-colored sand gives light-colored mortar. Dark sand, dark mortar. On Hawaii's Big Island we used black sand and got very dark mortar. Cordwood masonry walls are a "light sucker." As 40 to 60 percent of the wall's area is mortar (see Chapter 14), a lighter mortar can go a long ways toward making lighter brighter internal space. If you can only obtain coarse or grainy sand, adding an extra part of lime to the mix will help with plasticity and cohesiveness.

The sawdust should be the softer, lighter-weight type, as already discussed. Plus—and this is important—it should be passed through a quarter-inch screen and thoroughly soaked at least overnight in a non-leaking vessel, such as an open-topped steel or plastic drum, old bathtub, etc. So, the last thing to do each day is to make sure that enough sawdust is soaking for the next day's work.

Portland cement, Type I or Type II (air-entrained), is full-strength cement. Masonry cement varies according to type, but you can always be sure of the strength of Type M or Type S. A bag of Portland cement always weighs 94 pounds. Masonry cement can vary from 70 to 80 pounds depending on type. No matter which cement you choose, make sure it is fresh. If the bags are hard, that's bad. If you open a bag and find that part of it is nice powder and part has set (as if it got wet), return the bag to the supplier for a replacement. Some suppliers have a good turnover and their cement is fresh. Others have cement bags that have been lying around for years.

Be careful. More than one new cordwood builder has gone into a building supply and asked for masonry cement, only to be given "mortar mix." Not the same. Mortar mix is a pre-mixed mortar, with a ratio of about three parts sand to one part masonry cement. Just add water. If you substitute mortar mix for the masonry cement in the masonry cement mix formula above, the result will be an untenably weak mortar. However, mortar mix alone can be used in combination with a commercial cement retarder, but it will have a dark color. See Chapter 4.

The lime is builder's lime, also known as Type S or hydrated lime. You get it where masonry products are sold; it is different from non-hydrated lime used in agriculture, which will not work as a mortar admixture. To be absolutely sure, the bag should reference masonry or building on the bag. Once or twice, when doing workshops in other parts of the country, I have seen lime without such a reference. I called the 800 number on the bag and spoke with an engineer to be sure that the lime was for building, not agriculture. Builder's (or "mason's") lime will calcify (harden) over time, but its main purpose is to make the mortar more plastic and easier to use right out of the wheelbarrow.

For forty years Jaki and I have been mixing our "mud" in a wheelbarrow. Why not a cement mixer? Well, a wheelbarrow is quieter and does not upset the karma of the site. Quality control is easier with a wheelbarrow. A wheelbarrow is less expensive. A mortar mixer requires either electricity or an "infernal frustration" engine, which, as Murphy's Law tells us, breaks down. Finally, to get the mortar to the wall, you need a…wheelbarrow! Now, it is true that hand-mixing will make you rediscover some muscles you've forgotten about, but, in the long run, you will be fitter for the effort.

We add the ingredients to the barrow by the shovelful, using the following cadence, which greatly reduces dry mixing time. For the Portland mix:

- 3 shovels sand / 1 shovel sawdust / 1 shovel lime / 1 shovel Portland
- 3 shovels sand / 1 shovel sawdust / 1 shovel lime / 1 shovel Portland
- 3 shovels sand / 1 shovel sawdust / 1 shovel lime

Introducing the constituent ingredients in this manner places the Portland cement one-third and two-thirds of the way into the mix. As only two shovels of Portland are used, there is none in the third line. Using this cadence is like premixing; much less time is needed on your dry mix. Make sure that the shovelfuls are equal-sized for all ingredients. Use a sturdy industrial barrow, not a flimsy garden type. We're still using the same two metal wheelbarrows that we used at Earthwood in 1981. But at the end of each day, we have always been very careful about cleaning them with a scrub brush and doing a final clean rinse. Use two spade-type shovels of the same size, one for the dry goods, one for the wet sawdust. Don't put the wet shovel into the cement or lime bags; this makes a mess out of the shovel.

With the masonry cement mix, a good cadence for adding material is:

- 3 shovels sand / 1 shovel sawdust / 1 shovel masonry cement / 1 shovel lime
- 3 shovels sand / 1 shovel sawdust / 1 shovel masonry cement / 1 shovel lime
- 3 shovels sand / 1 shovel sawdust / 1 shovel masonry cement

The numbers in these mixes refer to equal parts by volume, so always use the same size of shovel and load it the same way each time—small, medium or heaping—depending on the size of batch you want. Tip: a little wiggle of the shovel yields consistent medium-sized shovelfuls, and makes a nice wheelbarrow load.

Use strong cloth-lined rubber gloves throughout the project, including during the mixing process. Cementitious products, wet or dry, will eat nasty little holes in your hands. These alkaline burns ("cement holes") develop slowly, become painful and take forever to go away. Most of our students get used to working with the gloves in a day or two. You have to do it. I knew a stone mason whose hands were always covered with boils because he hated working with rubber gloves. He died way too young of skin cancer.

In an industrial-strength wheelbarrow, dry-mix the goods with an ordinary garden hoe until the mix is a uniform color. (Expensive heavy-duty mason's hoes used for making brick or block mortar—the ones with the two holes in the blade—are not worth their cost, and are more difficult to use.) Then make a little crater in the center and add water. How much? Well, that depends on how wet the sand and sawdust is. On one (rare) occasion, the sand was so wet that I didn't have to add water at all. For the first batch of the day, go easy on the initial splash of water, say a quart or two. Mix it thoroughly and conduct the "snowball test." Toss a snowball-sized glob of mortar three feet in the air and catch it in your gloved hand. If it shatters, it is too dry. If it goes "sploot!" like a fresh cow pie, it is too wet. If it holds its shape, doesn't crack or crumble and is nice and plastic (cohesive), it is just right. (Note to experienced masons: You want *stone* mortar, not brick or block mortar. You folks know what I mean.)

3.1. Cordwood students learn to mix mortar in a wheelbarrow, using ordinary garden hoes and, importantly, cloth-lined rubber gloves.

If the mortar is too dry, add more water, remix and test it again until it is right; if too wet, you can add more dry goods in the same proportions until it is right. Leave additional soaked sawdust out if the mix is really soupy, or you might have trouble getting it stiff enough.

Other Mortar Options

The Portland and masonry cement mixes described above are the ones we have used the most and are the primary ones that we teach at our classes. They are the safest mixes, the ones that are the most forgiving. But there are other good options, and some of them have more "natural" appeal: energy and environmental advantages. Lime putty mortar has its own chapter (10), while using cob mortar—a clay-sand mixture—is covered in Chapter 11. Paper-enhanced mortar is the subject of Chapter 12.

Insulation Options

A cordwood wall derives its exceptional thermal characteristics from the insulated space between the inner and outer mortar joints. If this space is not insulated, the house will be expensive to heat when it is cold outside. See the sidebar "Cordwood Masonry Thermal Characteristics," coming up soon, for a full explanation.

There are several choices for insulation in this space. Jaki and I did our first three buildings with fiberglass from a roll, but it was nasty stuff to work with. Use eye protection and a respiratory mask. Also, it has a high embodied energy in its manufacture, and, if it mats down with moisture from any source, it may or may not fluff back again. Vermiculite, Perlite and other loose-fill insulations can work quite well, but can be costly. Shredded expanded polystyrene (bead board) may seem, at first, to be a good way to recycle materials, but, thanks to static cling, it is very difficult to direct the stuff into the insulation cavity. The little beads go everywhere except where you want them, and the slightest wind is a disaster. So, thanks to the advice of our friend, the late "Cordwood Jack" Henstridge, we changed to using sawdust about 1980, and have been very pleased with the results ever since.

Sawdust is cheap, makes use of a waste material, and has an R-value of about R-3 per inch, about the same as fiberglass. And it is easy to pour into the cavity with a small spouted bucket, or, in tight spaces, with a tin soup can. We pass the sawdust through a quarter-inch screen, which catches bark, chunks of wood, and other detritus which inhibit easy pouring into the cavity. To prevent vermin, we treat our sawdust with builder's lime at the ratio of 12 parts sawdust to 1 part lime. Also, if the sawdust gets wet from rain during (or after) construction, the lime will set up with the sawdust, dry it out, prevent mold and leave an effective bead board type of product in the cavity. About 25 years after building Earthwood, we had occasion to take out a panel of cordwood in order to expand a window space into a door. The sawdust insulation was just as good as the day it was installed.

The best sawdust would be from the same species of wood which are good for log-ends, but even hardwood sawdust will work, though perhaps at a somewhat lower R-value. Use sawdust from a sawmill using a circular saw—it pours more easily than fine sawdust from sanding, such as from a cabinetmaker's shop. Wood shavings are not as good, or as easy to use, but, if sawdust is unavailable, they might be a viable choice with cavities 8 inches wide or more.

We mix the sawdust and lime in a wheelbarrow. In this case, it can be an old clunker, or a lightweight garden barrow. A mixing tip: screen six shovelfuls of sawdust into the barrow. Use quarter-inch mesh screen. Add one shovelful of lime, then top this with six more screened shovels of sawdust. The lime is in the middle of the batch, like the cream filling of the famous cupcake. Now you can quickly mix with your hoe until the entire batch has the same color throughout. If the sawdust is too dry, spray a little water in as you mix, so that the finished product does not blow all over your mortar. Plus, you're less likely to inhale the lime dust. The lime will soon dry it up in the wall. (If you do spill some sawdust insulation on your mortar during building, brush it off and press a little fresh mortar onto the area to promote continued mortar adhesion.) Finally, using a good dust mask or respirator is advisable when shoveling dry lime—or cement—whether you're mixing sawdust insulation or mortar.

Other more contemporary insulation materials have also been used. Ivan McBeth, building in Vermont, used cellulose insulation which comes in a 30-pound bag. His cavities were about 8 inches wide, so it went in quite easily. Ivan told me that his lady friend reported some allergic rash when using it, although he did not, so rubber gloves might be advised. The price per R is favorable on cellulose insulations compared with other manufactured products. The insulation is "green" in that it uses recycled paper and has much lower embodied energy in its manufacture. Treatment with borates protects against fire and insect infestation.

Recently, in New Mexico, Jaki and I built a wall of "cobwood"—cordwood with cob as mortar. For insulation, we used straw which had been cut to 1-inch pieces in a chopper made for the purpose, and hemp, which has been used in Canada. Both worked well, and I would think yield R-values similar to sawdust, right around R-3, give or take.

Another insulation option, sprayed-in foam, has been used by several cordwood builders with good results, and its use is covered in Chapter 7.

Cordwood Masonry Thermal Characteristics

Insulation is only part of the story when it comes to evaluating a cordwood wall's thermal performance. Thermal mass, the ability to absorb and store heat, is the other part. The proper juxtaposition of insulation and thermal mass is particularly important, and this is where cordwood's insulated mortar matrix really shines.

The log-ends have both mass and insulation characteristics. Oak has more thermal mass than white cedar, for example, but much less insulation value. It is reasonable to think of the insulation values of the various species as being inversely proportional to their values as thermal mass. The diagram below, with insulation values on the left and thermal mass on the right, is something I scribble on the board at workshops to show students the relationship of insulation and mass. The center portion, labeled wood, is deliberately positioned to unite the left and right sides. Styrofoam has excellent insulation value and virtually no thermal mass, while cast iron can store a lot of heat, but conducts it rapidly, virtually zero insulation value. Those are extremes. Other items on the list, including the sample woods, lean closer to one end of the diagram, or the other.

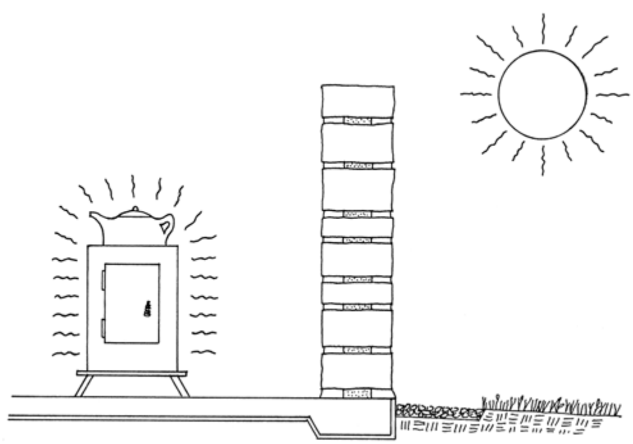
INSULATION			**WOOD**			**THERMAL MASS**
Styrofoam		White cedar		Oak	Water	Concrete
Fiberglass		White pine		Beech		Granite
Sawdust	Papercrete		Douglas fir / Red pine		Mortar	Cast iron

The mortar matrix—mortar, insulation, mortar—has qualities of both insulation and thermal mass, and in excellent juxtaposition. That is to say, there is good thermal mass on each side of the insulation. How does this grace our lives? Well, a cordwood wall's thermal performance is illustrated in Figure 3.2.

In the winter, the internal heat source, such as the woodstove shown, radiates heat to the cordwood walls, charging up the inner mortar joint (and the log-ends) with heat. The heat does not readily transfer through the mortar joint to the outside, thanks to the sawdust-filled insulation cavity. How fast it transfers through the log-ends is a function of the wood's density: its insulation value. A solid mortar joint, without the insulated space, would transfer heat rapidly through the wall, a classic "energy nosebleed."

As interior temperatures start to drop, heat absorbed and stored in the inner mortar joint—several tons of mass in a medium-sized home—is readily given back into the room. The inner mortar joint is warm, the outer mortar joint is cold. There is a gradual decrease in temperature through the log-end portion; its inner surface is warm, its outer surface is cold.

Does the outer mortar joint have any value? Yes, in the south, or on hot days in the north, it helps to keep the



3.2. Cordwood masonry thermal characteristics.

house cool. The direct rays of the sun (or maybe just the heat of the day) cause the outer mortar joint to heat up. But, again, the heat is not readily conducted to the interior because of the insulation-filled cavity. At night, the day's heat gain is lost back into the dark atmosphere by something called *radiational cooling*. The inside of the wall is little affected by extremes. Cordwood houses stay naturally cool in the summer.

Incidentally, a dead air space between the inner and outer mortar joints has very little value as insulation. Yes, it provides a thermal break, stopping direct conduction, but it is only valued at R-2. Eight inches of fluffy sawdust is worth about R-24, a huge difference.

Let's do a quick R-value for a cordwood wall which is 50 percent wood, 50 percent mortar, by unit area. We'll say it is a 16-inch wall, with 4-inch inner and outer mortar joints, and 8 inches of insulation at R-3 per inch. We'll assume a white cedar wall, which, on end grain, yields an honest R-1 per inch. So, half of the wall's area has an insulation value of R-16 (16 inches at R-1 per inch). The mortared part is a little trickier. The mortar has very little insulation value per se, but engineers assign a value of R-2 for the absorption of heat into one side of it and then its transfer out the other side. The insulation cavity is worth R-24 (8 inches at R-3 per inch.) Then you have the absorption and transfer of the heat through the outer mortar joint, another R-2. Add it all up and we've got R-2 plus R-24 plus R-2, or a total R-28 insulation value for the mortared portion of the wall. Surprisingly, the mortared portion of the wall is much better insulated than the wooden part. Averaging the wood and mortared parts—remember that its half wood and half mortar in this example—we get a value of R-22 for the wall taken as a whole (R-16 plus R-28 divided by 2 yields R-22).

There is more about tested R-values in Chapter 24.

Building a Cordwood Wall

While cordwood walls have been built on railway ties, pressure-treated wood foundations, stone foundations and even sand ("earthbag") foundations, the vast majority of them, over 90 percent, are built on concrete: on footings, on a monolithic floating slab or on a course (or more) of concrete blocks.

Sweep the foundation of dust. For the first course, it is a good idea to mark—right on the foundation—a guide line where the inner and outer edges of the wall are to be. Use a crayon or an indelible marker. Any place where mortar is to be placed should be dampened slightly with water or, even better, a bonding agent such as Acryl-60 from Thoro Corporation or DAP Bonding Agent, which is usually cheaper. You can actually place the mortar down before the bonding agent is fully dry, and it will still work, giving the best possible chemical bond from mortar to foundation.

Carry the mortar to the site in the same wheelbarrow you used for mixing. You can work out of the wheelbarrow, or load up a metal or plastic mortar pan for convenient access to the mud. Plastic feed pans from the farm store make great mortar pans, as do the plastic pans used for changing the oil in a car. Several different diameters of prepared log-ends should be within arm's reach. I like to store them vertically on the slab, so that I can grab any log-end without upsetting, for example, a rank (stack) of wood.

For discussion and illustration, we'll assume a 12-inch-thick wall. Picture the width of the wall's footprint divided into thirds, like a French or Mexican flag. One-third mortar, one-third sawdust insulation, one-third mortar. We pass out patterns called "MIM sticks" to our students to help them gauge this proportion. So, Mortar, Insulation and Mortar are graphically marked right on the stick, which can be a 12-inch piece of scrap board.

By the third day, students are doing pretty well without consulting the MIM stick. Make two or three for your project.

The building mantra is: Mortar, Insulation, Wood. This is the order of events. If you depart from this order, there is wasted time in an already labor-intensive process. Often, we will see a student trying a log-end on the mortar before the insulation has been installed. "I was just seeing if it would fit," is the common excuse. We point out, in our friendly way, that if the insulation was already in place, and the log-end fits, it could be left in place, instead of placed on the floor again while the insulation is installed.

So, using your gloved hands, grab a glob of mud from the wheelbarrow or mortar pan and plunk it down on the foundation, about 1 inch thick and 4 inches wide. (If your MIM stick is made from a full 1-inch board, it can double as a mortar depth checker.) Keep adding

3.3. Any desired piece can be grabbed quickly if the log-ends are stored vertically near the work area.

Preparing the Log-ends

Log-ends usually need their edges rasped before laying them into the wall. This is best done on site, when they are dry, as opposed to doing them before they are stacked in ranks for drying. The purpose of the rasping is to clean the little "hairs" off the end of the log. Our preferred tool for the purpose is a Stanley Surform Scraper, as in Figure 3.4.

These little hairs, caused by the chainsaw—and often on just one side—get in the way of pointing and make the wall untidy.

3.4. Holding the rasping surface of the scraper at a 45° angle to the log end, cut the little quarter-inch "hairs" off the edge of the log with a firm pulling motion.

3.5. The MIM stick is used as a guide for new builders to gauge their mortar width.

more mud, extending the 4-inch-wide mortar bed for 3 or 4 feet. Now do the same thing for the other parallel mortar bed, leaving the insulation space—the *I*—free of mortar. If working within a timber frame, place mud up the sides of the post a couple of inches.

Now, with a small spouted bucket, pour the lime-treated sawdust insulation between the two mortar beds, up to the same level as the mortar. Select a log-end and set it on the mortar, spanning the insulation. A slight vibrating motion back and forth is all that is needed to establish a suction bond to the mortar. (Later, this suction bond becomes a friction bond, which is the best you can hope for with cordwood. There is no chemical bond between wood and mortar.) It is easiest to place a little mortar up against the previous log-end now, as opposed to trying to squish it between log-ends later. The next log-end is placed next to the first, leaving about an inch between them. Continue until all the mortar is covered.

The first course is the best place to get the wall started toward what I call the "random rubble" style of masonry. With cylindrical units, use a random mix of various diameters. With splits, randomness can come from various shapes as well as sizes. Once you have a good pool of random log-ends standing nearby (see Figure 3.3), deliberately choose a variety of sizes (and/or shapes) as you build that first course.

The mantra doesn't change with the second course. Put the mud down first, following the little hills and valleys formed by the first course of wood. Then comes the sawdust. Use your gloved fingers to pre-settle the sawdust in the spaces between log-ends. Bring the sawdust up to the level of the mud. You will have formed a number of small hills and valleys in your random first course. Now, always build down in the lowest part of the first course, the valleys. We call little single-unit valleys "cradles." Select a log-end that has the same shape as defined by the previous mortar course. We call this "filling the cradle." If you keep a good variety of log-ends at hand, this will become easy with a little experience. I speak of taking a mental picture of the cradle shape, then turning to the stored wood—Figure 3.3 again—and picking out exactly the right one.

Again, place the log-end with a gentle vibrating set. You don't have to pound it in, although sometimes a gentle tap with a small hammer is helpful. If a log-end doesn't seem to want to "sit," it is almost always the fault of too much sawdust trying to spring the log-end back up again. Remove a little sawdust and try again. The other possibility (rare) is that an irregularity on one or both log-ends is getting in the way. This is why I always saw off the nubs (where small branches joined the log) before standing them on the slab for use.

Use log-ends that fit the valleys or cradles of the second course, and the wall will begin to build itself. As you proceed through subsequent courses, keep using your various sizes of log-ends at a consistent rate. Be aware of the wall building itself into a trap, often manifested by using lots of log-ends of the same size in close proximity, like the similar sized bubbles in the head of a beer. This gets the wall out of the random rubble style.

Be sure to leave about an inch of space between log-ends, so that you can get between them with your pointing knife. It's frustrating trying to get a three-quarter-inch-wide pointing knife into a half-inch space. See "Pointing," coming up after an important discussion about windows.

3.6. These students have created two adjacent cradles. After installing insulation, they will find log-ends to fit.

3.7. This student kept turning the large log-end until the right curvature matched the shallow cradle below. Now, he supports it with a small log-end in its own cradle.

Window Bucks

All cordwood buildings have windows, and it is important to know how to incorporate them into the build. One of the nice things about cordwood is that you can use almost any size or shape of window in the wall, which means that you can go to a local manufacturer of thermal pane glass and buy units which were unsold for some reason (maybe they were cut the wrong size). You can buy perfectly good units for 10 or 20 cents on the dollar. Likewise, you can pick up windows which were removed from a building during remodeling. Jaki and I have found lots of perfectly good windows at roadside garage sales. Doors, too. Son Darin scored three large sliding glass door units this way…free! One of them will eventually be replaced, but it is serving nicely in the meantime. Oh, and

Key Pieces

Because there is no chemical bond between wood and mortar, it is necessary to lock the cordwood masonry panels to the surrounding timbers with a mechanical key, particularly the vertical posts, but also up against the girt (plate beam) on longer panels. Similarly, door and window frames are keyed to the cordwood masonry. See Figure 3.8.

Positive wooden key pieces are screwed or nailed to the edge of the posts to which the cordwood masonry will bear. They are made from full 1-inch-thick boards, their width being the same width as the cordwood wall's insulated space. For example, on a small building framed with 8-inch by 8-inch posts to accommodate 8-inch log-ends, the inner and outer mortar joints would each be 2.5 inches and the insulated space would also be 2.5 inches. Three times 2.5 inches is 7.5 inches. Why not eight inches? Well, the log-ends are "proud" of (protrude from) the mortar by a quarter inch, both on the interior and exterior, accounting for the other half inch.

It is okay for log-ends to actually touch the key pieces, which, in this case, are attached to the middle vertical third of the wall. One inch is a perfect mortar joint. It is the mortar matrix which is mechanically locked to the post, because of the vertical wooden key. If this were a small horse barn, and the horse wanted to kick the wall out with his hooves, he would have to break the mortar matrix to do so, and it would still be difficult. With no locking key, and no chemical bond to the post, the horse could easily kick the wall out. Besides horses, the key pieces give support during seismic events. A key piece can be seen in Figure 3.5.

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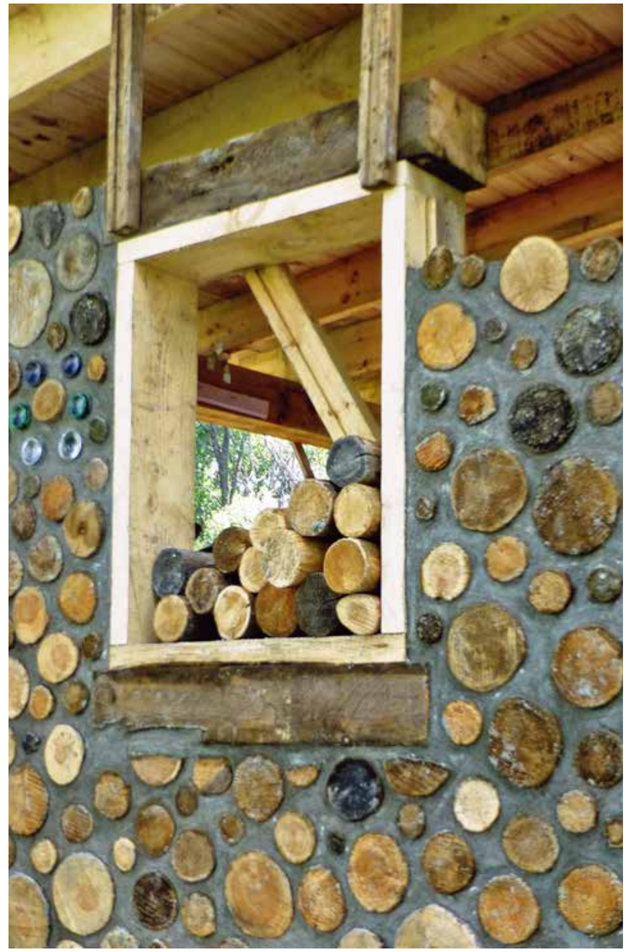
speaking of doors, the door jambs are installed before any cordwood masonry is done, as already discussed in Chapter 1.

Whether the window is a fixed unit (non-opening thermal pane, for example) or opening, (such as a double-hung, casement, slider, etc.), you will need a heavy frame around it, called a "window buck." With cordwood masonry, I always make the window bucks out of full 2-by material: 2-by-8 inch planks, for example, with an 8-inch wall. Or 2-by-12 inch stock for a 12-inch wall. At Earthwood, with its 16-inch walls, we made double-wide window bucks from two individual 2-by-8 inch bucks scabbed together with vertical 1-by-6 inch key pieces on the right and left sides, which also mechanically locks the buck into the cordwood masonry. (Install key pieces on the right and left sides of window bucks, not on the top or bottom, where they are unnecessary and make installation more difficult.)

For thermal pane units, make the rough opening (inner dimensions) of the window buck a half inch greater than the dimensions of the window unit itself, both in width and in height. So, a thermal pane actually measuring 30 inches wide by 40 inches high will require a window buck with an internal space of 30.5 inches by 40.5 inches. For this example, you will need two uprights of 40.5 inches, plus a top and bottom piece each measuring 34.5 inches (the 30.5-inch rough opening

3.8. This window buck is made of full-size 2-by-8 inch lumber. The heavy 6-by-8 inch sill and lintel were an optional design feature which the owner requested. The entire unit was leveled and plumbed, then vertical braces held it plumb against one of the rafters. Note the diagonal brace to hold the buck square, and the key piece on the side.



3.9. The bracing to hold the buck vertical is seen clearly. The buck is a good place to store log-ends and mortar pans during construction. Note also the good random rubble placement of log-ends.

width plus 2 inches for the lap of the top and bottom pieces over each of the side pieces.) Nail or screw the top and bottom pieces into the side pieces. Finally, and importantly, square the buck perfectly with a framing square and fasten a wooden diagonal as shown in Figures 3.8 and 3.9. Try the unit in the buck, to make sure it fits, then store the unit safely—and vertically—so that it does not lose its airtight seal. A friend of ours lost the seals in about a dozen beautiful large thermal pane units that he stored horizontally, causing them to go cloudy.

When it comes time to actually install the thermal pane units, they are placed on quarter-inch neoprene shims that look like dominos. You get them where the units are made. By positioning the glass equidistant right and left, it is easy to establish a quarter-inch air space all around the unit, standard practice for safety. Finish both sides of the unit with 1-by-1-inch wooden trim or—more expensive—molding made for the purpose.

Purchased or recycled opening windows come in their own lightweight frames, generally three-quarter-inch finished stock, not strong enough for laying cordwood masonry against. Once again, make a window buck of dimensions a half-inch greater—up and down, right and left—than the unit itself. Later, you will install the window with the aid of tapered wooden shims (like wooden shingles) to tighten the window's own lightweight frame to your buck. Then trim the unit around its edges, both sides. Small packages of these shims are sold at building supply stores.

Installing Window Bucks in the Wall

When building within a timber frame, it is often possible to fasten the window bucks to the underside of sidewall or endwall plate beams (girts), or even against posts. Large windows might fill the space between vertical posts or uprights, as we did at Log End Cottage and Stoneview. In these cases, simply fasten the window buck to the frame with structural screws, and, after checking for level and plumb, hold the buck squarely in place temporarily with scrap diagonal bracing screwed, for example, from a post to a girt.

Often, particularly with curved-wall and stackwall-cornered buildings, it is necessary to "float" a window buck somewhere in the cordwood wall itself, like the unit shown above in Figures 3.8 and 3.9. It is not difficult to do if you take care in following these steps:

1. From your elevation plan, determine the height of the cordwood wall to the underside of the window buck. (For the sake of appearance, common practice is to keep the tops of the windows at the same height.)
2. Make a little "idiot stick" out of a common wall stud or piece of straight scrap. Measuring from the bottom of the stick, draw the location of the actual window buck. Then, an inch below that, make another line, which I call the "no-wood-higher-than" (NWHT) line. Draw a log-end on the stick, if you like, right up to this line.
3. Now, build your cordwood up from the foundation in the regular way, but, as you start to get closer to the NWHT line, you will need to start to influence the wall—which has been happily building itself—by planning log-end sizes so that you will be creating a mesa, a series of log-ends with all of their tops correspond-

ing to the NWHT line. This mesa needs to be at least two inches longer than the length of the window buck, but more is okay.

4. If it still early in the day, you can place long mortar joints and insulation upon this mesa—it takes quite a bit of mud—and set the window buck on it like a giant rectilinear log-end. Check for level and plumb. If all is well, temporarily install scrap wooden bracing from the buck to the girt (or nearby post) to hold it in place. No frame to tie to? Drive a stout stake in the ground and hold the window buck plumb and level with a long diagonal brace screwed to the stake. If it is late in the day, just finish with the tops of the mesa log-end uncovered by mortar. Install the window buck the first thing the next day, giving the masonry a chance to set before loading it with fresh mortar and the buck. After installing the buck, it is a good idea to build up against both sides of it with cordwood masonry, to stop it from getting displaced by "things that go bump in the night." Remember that a vertical key piece on both sides of the window buck locks it to the masonry.
5. A final tip: I have found it useful to make my mortar just a wee bit less stiff than usual, more like brick or block mortar. I'll put it on just over an inch thick. Then, with a 4-foot level as my guide, I can tap the top of the buck to set it level and plumb, so that I have the desired 1-inch mortar joint. A level is a necessary tool for all aspects of cordwood work, especially when installing door jambs and window bucks.

Log-ends and window bucks in place? Now, you're ready for…

Pointing

Pointing, also known as "tuck-pointing" or "grouting," is a critically important part of cordwood masonry, and accomplishes several purposes.

First, good stiff pointing maximizes the friction bond between wood and mortar. Remember that there is no chemical bond between the two, so a good friction bond is imperative.

Second, pointing beautifies the wall. Jaki can point a poorly laid wall and make it look better than a well-laid wall that is not pointed or poorly pointed. Do both: lay it up well and point it well. I have seen the opposite, a non-pointed poorly laid wall, which can give cordwood masonry a bad name.

Third, good pointing smoothens the mortar, making a more water-repelling surface on the outside, as well as a less dusty interior.

Fourth, if the pointing is recessed slightly, say one quarter to half an inch, and all or most of the log-ends in the wall shrink, it will be easy to conduct a repair (see

Chapter 4 for repair suggestions). Recessed pointing also looks better. The log-ends are the defining feature of a cordwood wall. Having them stand proud of the mortar is what gives the wall a pleasing texture, similar to the relief found in good stone masonry.

You'll need a few pointing knives. The tools made for brick and block raking are not suitable. They are designed for straight ⅜-inch mortar joints. Jaki and I continue to get pointing knives from thrift stores and garage sales. We recently purchased four nice ones from a second-hand store for a dollar. We look for non-serrated butter knives, like Grandma used to have. We like the ones that are almost an inch wide, but it is good to have a variety, and we even keep one or two with narrower blades for use where log-ends were laid too close together. Bend the last inch or two of the knives to about a 15- or 20-degree angle, so that you can get the business end in close to the work without your knuckles getting in the way.

Jaki, queen of the pointers, does a "rough pointing" first, using just her rubber gloves. She removes excess mortar and catches it in her gloved hand. Then she uses her knife to press it off her hand into any gaps. "Borrow from Peter to pay Paul," she says—not good economics, perhaps, but it works with cordwood pointing.

3.10. Jaki finishes the pointing on a mostly split-log wall.

For the finished pointing, press quite stiffly with the knife blade while drawing it along the mortar joint. Draw the mortar out smooth, removing knife marks, if possible. How meticulous you want to be is up to you but keep a consistency of style. *Do not over-point*. You can be so fussy, going over and over the work, that you will simply bring a lot of water to the surface, which will cause cracking of the mortar within a few days. Been there, done that.

Also, do not finish-point the wall too early or too late. How do you know? It is too early if the mortar is slumping from a log or if little air bubbles are forming. (Slumping could also be a sign that the mud was not mixed stiff enough.) It is too late if you can't take irregularities out easily. Exactly when to point will depend on the drying conditions for that day. In hot dry conditions, you may have to finish-point within an hour. Damp cool days may allow pointing two or three hours later.

Some builders like the slightly rougher texture of "brush pointing." Do a good rough pointing with the gloves, maximizing the bond, then go over the work by drawing a three-quarter-inch paint brush over the pointing. This works better when there is no sawdust in the mortar

Cleaning the Log-ends

Mortar does not adhere well to wood, so it is very easy to clean off any excess mortar which might have stuck to the ends or side edges—the "reveal." Wait until after the mortar has set hard, say a week. We have used both stiff plastic-bristled brushes and wire brushes for the purpose. With bottle-ends though—discussed in Chapter 8—mortar must be cleaned off the same day the bottle units are installed. See also Chapter 21, which speaks to how log-ends can be sanded and sealed in place, if desired.

Oh, and finally: *Please*…don't forget to wash your tools, wheelbarrow and gloves, and cover the top of your work for the night. If you need soaked sawdust for the next day, get that ready, too.

Well, that's basic Cordwood 101. Chapter 4: Building with Cordwood 202 will expand on this chapter, with lessons and tips we have learned over the years, and some more advanced techniques. Specific topics, like double-wall cordwood, bottle-ends, wiring a cordwood wall, lime putty mortar, cobwood, sprayed-in foam insulation with cordwood and cordwood-to-mortar ratio all have their own chapters.

CHAPTER 4

Building with Cordwood 202

This chapter expands the methods and considerations raised in Cordwood 101. In Part Two: The New State of the Art, we'll deal with other specific cordwood building techniques deserving of their own chapter, updated with the latest advancements.

We'll start by trouble-shooting some of the problems which can occur.

Wood Expansion

The single most serious problem in cordwood masonry is the danger of wood expansion. I know this because it happened to me, and at a most importune time. But it is a problem which can be avoided. Listen…

In 1981, Jaki and I decided to build a load-bearing round cordwood masonry house—Earthwood—with 40 percent of its cylinder earth-sheltered, mostly on the northern part. On the southern part of the building, we would use the white cedar log-ends for their superior insulation value, but on the north we would deliberately use dense hardwoods for greater thermal mass. The wood had been cut into log-end length, barked, split and dried under cover for three years. When we cracked two of the log-ends together, they had the ring of ice hockey sticks battling for a loose puck.

The plan was to plaster over the outside of the below-grade portion of the cordwood masonry—two coats—and to apply a good quality waterproofing membrane (W.R. Grace Bituthene) over that. Extruded polystyrene (Styrofoam) insulation placed over the membrane would enable us to store heat in tons of mass on the warm side of the membrane and insulation. Good drainage would carry most water away from the building, protecting the Styrofoam and taking pressure off of the Bituthene. Two large 4-foot-square concrete buttresses placed at the southeast and southwest points of the circle had been installed as a demarcation between the cedar and hardwood walls, and to resist lateral load when the northern hemisphere would be loaded with hundreds of tons of the earth.

Up to that point, our modest six years of experience in cordwood masonry had been with using the very stable white cedar, which we have in abundance in northern New York. We'd always used the cedar as dry as we could, and there was never a problem with shrinkage or its antithesis, expansion. Little did we know that we were heading into the perfect storm. As the walls were load-bearing, there was no timber frame supporting a roof to protect our work. Plus, we were building on a concrete slab, so rainwater could collect on it and stand against the bottom course of cordwood masonry during construction.

Cordwood work commenced on June 10, 1981, and we made great progress, with hired hand Dennis Lee mixing mud and Jaki and I laying wood and pointing. We were completing 30 to 40 square feet of wall per day, a beautiful variety of log-end shapes, colors and textures. Maple, ash, beech and red cherry, split and unsplit, played in perfect harmony together.

It rained on the night of June 21, but we were always careful to cover our work at the end of the day, so didn't anticipate a problem. On the 22nd, we discovered a small continuous crack on the inside surface, between the first mortar course and the first course of wood—but only on the hardwood wall. On the 23rd the crack was wider and we could see that the northern hemispherical wall was beginning to tilt out. By the 25th, we had joined the two buttresses with a wall two feet high all around, although some parts were as high as six feet. But now the crack had opened to a half-inch gap. Other stress cracks were forming in the wall as a result of the large crack, and the wall was three inches out of plumb at six feet of height. We still had another story to build and a heavy earth roof to go on top of that. If the downward line of thrust through the walls were to wander out of the middle third of its thickness, we would have an unstable and dangerous structural situation.

"Smile," it is said, "things could get worse." Well, I wasn't smiling, but things got worse anyway.

Prior to our first dismantling of the wall, a structural engineer visited the site. He speculated that the sun's heat reflecting off the white slab was causing heat expansion in the cordwood wall, so we tried expansion joints of half-inch homosote insulation board every 20 feet around the back (north) wall. We tried mortar that would set faster and a solid first course of mortar on the foundation. Nothing worked: the crack came back. Again, we dismantled our work. In July, embarrassingly, we were conducting cordwood workshops with still no clear idea of the devil we were fighting.

Finally, a friend with a stone quarry explained how old-time quarriers broke off a face of granite. In the days when labor was cheap and explosives expensive, they would drill three-quarter-inch holes down into the rock parallel to the face. They would jam the holes with very dry tight-fitting hardwood dowels. They watered the dowels and—presto—the dowels would swell and break off the face of granite. What chance did our poor walls have? An inch of rainwater collecting on the slab would dampen the first course of hardwood, causing the wood to swell. When swelling occurs on a curved wall, the wall takes the line of least resistance: it tilts outward, hinging on the outer mortar joint. Later, we learned from other builders that when cordwood swelling takes place within a timber frame, it will cause the girts to rise and the posts to lift off the foundation. With stackwall corners, swelling will push the corners out in two directions.

Identifying the problem was one thing; formulating a solution was another. We'd lost 30 workdays building walls and tearing them down again, and about $1,500 in labor and materials, a lot of money for us in 1981. Jaki and I decided to abandon the hardwood wall in favor of a tried and true method of building an earth-sheltered wall, which we had employed successfully at our previous home, Log End Cave: the surface-bonding of dry-stacked concrete blocks. (The complete story of the successful construction of Earthwood appears in my *Earth-Sheltered Houses*, New Society Publishers, 2006.)

Now at workshops I show students a step by step slideshow of the debacle and go over four different ways we could have avoided the problem.

1. **Don't use dry hardwood.** But if hardwood is all you've got, dry it no more than six weeks, knowing you will have a shrinkage situation, something you can attend to a year or two down the road.
2. **Don't build on a slab.** Even with a timber-framed roof umbrella overhead, driving rain can collect on the slab with no place to go. "But I want a slab for my (slate, tile, whatever) floor," one student pipes. Okay. Build the cordwood walls on footings, but hold off on pouring the floor until the cordwood is completed and the building is closed in. Later, you can shoot the concrete through doors or window openings or wheelbarrow it in.
3. **Build under cover.** Get a stout timber frame up first, get the roof on, and do your cordwood under cover, as we did at our first home, Log End Cottage. At Mushwood, we built a 22-foot-diameter load-bearing round cordwood building under the umbrella protection of a 29-foot-diameter plastic-covered geodesic dome.
4. **Use the more favorable wood down low.** Of all of the wood expansion cases that I know of—ours and a half dozen others—the problem always seems to start at the base of the wall. If you have a limited amount of good (non-expansive) log-ends, use them on the first course or two.

There are other things you can do, such as creating a method of draining the slab so that water won't collect on it. Rain will still make the slab wet, but water won't stand against the wall. Building the cordwood up on a course of 4-inch solid concrete blocks laid up on the footing will also protect the cordwood. And treating the log-ends with a waterseal-type product will eliminate a good part of the absorption and, therefore, swelling. But the four methods numbered above are the best, and probably in that order. If we had taken any of these measures, we would have avoided a nasty situation. We didn't…but you, dear reader, will not have this problem because you will enter into your project with something we lacked at the time: *awareness*!

Before tearing the wall down for the last time, we experimented with our intended waterproofing method. With a flat trowel, we applied two coats of plaster to the wall, composed of three parts sand, one part masonry cement. The first coat was scratched in a diamond configuration with the trowel. The second coat, the "finish" coat, turned the wall into a smooth round cylinder. When the plaster dried, we applied a section of W.R. Grace Bituthene Waterproofing membrane, which adhered very well. A year later, we applied this technique to a small earth-bermed section of our round cordwood sauna, and it has held up well.

4.1. We tested our intended waterproofing technique on the hardwood wall before tearing it down.

Wood Shrinkage after the Build

We have experienced two situations where wood shrinkage needed to be attended to a year or two after building.

The primary checks in some of our larger round cedar log-ends—at Mushwood and in the Earthwood solar room—got larger as time went by. After two years, we figured the gaps were not going to get any larger. Before caulking the check, we stuffed it with gray backer rod, a 25-foot coil of foam that is used to close off drafts around doors and windows. It comes in various diameters, but the ⅜-inch choice works well with cordwood. With a flat-headed screwdriver, we stuff the backer rod into the primary check, leaving it recessed about a half-inch. Then we apply a bead of clear caulking over the backer rod, almost level with the log-end surface. I like clear caulking for this purpose, as opposed to trying to match the color of the mortar. Your chances of matching the mortar color are slim to nil, unless you use Geoff Huggins' method described in the sidebar. A check looks natural in a round log, and, with clear caulking, the check still looks like a check. I use a siliconized caulking, such as Red Devil Lifetime caulking, as opposed to the more expensive pure silicone caulk, which is also messier to work with. Incidentally, the method described in this paragraph works for volumetric shrinkage gaps—the gaps around the edges of the log-end—as well as for radial checks.

The other shrinkage we had to attend to was to repair several large pine, beech and elm log-ends at Earthwood that we knew would shrink, but that we wanted to

4.2. A large primary check needs to be filled.

4.3. Push backer rod into the check with a flathead screwdriver.

4.4. Caulk with clear siliconized caulking.

4.5. Jaki seals the caulk with her finger. The end result looks very much like a round log with a check in it. In fact, it looks exactly like Figure 4.2.

When It Shrinks, Stuff It! A Case Study by Geoff Huggins

My cordwood construction evolution is the subject of Chapter 17, but Rob wanted me to share my solution for volumetric wood shrinkage here.

Since I'm a meticulous type who wants a neat-looking mortar face as well as clean mortar-free log-ends at completion, our cordwood walls probably required even more labor hours than most. So when it came to stuffing the gaps that occurred—despite my best efforts to minimize them—a low-cost but labor-intensive method seemed appropriate.

I originally chose latex caulk because it's cheap, adheres to both wood and mortar, is flexible and long-lasting, and is easy to apply with a squeeze gun. While the latex is fresh, you can smooth and mold its surface. The main drawback of white latex, of course, is that it is quite visible, leaving a stark white ring around the log (Figure 4.6). So I mixed up a batch of dry mortar—from sand, lime and cement, but not sawdust—in exactly the same proportions I'd used in the walls. I then added plenty of water to create a soupy mix called a slurry of mortar. Using a small paintbrush, I "painted" the slurry into the white latex, blending it into the surrounding mortar (Figure 4.7). It stuck nicely to the face of the fresh, still gooey latex. When dry, the latex patch was quite invisible (Figure 4.8), looking as if the mortar had always been right up to the logs. No gaps.

When I used this technique back in 1986, white latex was all that was locally available. If you can purchase a clear or gray caulking inexpensively, those color choices might be easier to cover nicely with the mortar slurry. Other caulks besides latex would probably work, too. For me, the operative word is "cheap."

This was not a quick and easy method. I had lots of mortar painting to do. But 30 years later, the patches still look good and have held up very well. I demonstrated this technique on some of the large log-ends at the Pompanuck Community round house during the 1999 Continental Cordwood Conference in Cambridge, New York. Within 20 minutes of application, the repair was practically seamless and looked great. My method was given rave reviews by all the cordwood gurus present, although I was probably lucky with matching the color of the Pompanuck mortar.

4.6. A small wedge beneath the log pushes it up so that the biggest gap is on the bottom, where it is less visible. Next, the gap is cleaned of loose mortar with any sharp tool, such as a nail (not shown). Particles and dust can be blown away with a small rubber hose. A bead of latex or acrylic caulking is applied and then smoothed with a popsicle stick, pointing knife, or finger. Credit: Geoff Huggins

4.7. The slurry or mortar is painted on and pressed into the caulk, then blended out to the surrounding mortar. Credit: Geoff Huggins

4.8. Presto Farino! When dry, it is not easy to see the patch, particularly when the little wedge is removed. Credit: Geoff Huggins use as special design features. The 16-inch-diameter beech log-end next to our front door had volumetric shrinkage of about a half inch after a few years. We repaired it as described above: backer rod topped with clear caulking. Ditto five large 10-inch elm rounds and two 13-inch red pine rounds. Curiously, a lovely 13-inch-diameter quaking aspen log-end did not shrink at all, but it had dried for a couple of years before we used it.

Mortar Cracks

There are fewer mortar cracking problems in cordwood walls nowadays, in large part due to the advice that we and other experienced builders have given to newcomers over the years. Mortar shrinkage cracks still occur, however, due to:

1. **No mortar retardant:** The addition of the appropriate soaked softwood sawdust or a commercial cement retarder slows the set, which greatly reduces mortar cracks.
2. **Direct sun:** Sun beating down on the work can dry even good mortar too quickly. Always try to work on the shady side of the building, or build a protective shelter from sun.
3. **Over-pointing:** This pulls water to the surface causing rapid drying, resulting in surface cracking. The problem is further exacerbated by pointing too soon.
4. **Mortar mixed too wet:** The more water that transpires from the mix, the greater will be the shrinkage . . . and cracking.

When Everything Shrinks—A Solution

Joe Goesalone did everything wrong. He didn't season his wood properly for his chosen species. He didn't do anything to slow the mortar set. He didn't take a cordwood class, watch a video or read a cordwood book. But, still, he built. The wood and mortar shrunk, leaving cracks and gaps between and around all the log-ends. Disaster? Surprisingly, not so bad as you might think.

Consider: Despite the mortar cracking and wood shrinking, Joe has cast hundreds or thousands of masonry units filling the gaps between log-ends more perfectly than any dry-stone wall outside of Machu Picchu. If he built within a timber frame, the walls are in no danger of tumbling down. But it looks bad and can promote air infiltration.

There is actually a solution to this dilemma, the application of one of the products made for log cabin chinking. One brand I have experience with is Log Jam from Sashco. I have heard of other cordwood builders using Permachink Log Cabin Chinking (Permachink Systems) and Weatherall Triple-Stretch Chinking (Weatherall Company). These products are all designed to do the same thing. Applied to log cabin chinking or to the space between log-ends on a cordwood wall, they will fill gaps of a quarter-inch or a little more and span mortar shrinkage cracks. The products stay flexible and will move with any further expansion and contraction of the wood. Buy these products in 5-gallon pails, much cheaper than in caulking tubes.

You can apply these chinking products to the interior or exterior mortar joints, or both. Appearance and cost are the main considerations. These chinkings cost between $210 and $260 for a 5-gallon pail.

The possible need to apply some sort of repair, due to mortar cracks or log-end shrinkage, is yet another good reason to leave the logs "proud" of (protruding from) the mortar matrix by a good quarter-inch. This "reveal" makes application of chinking products much easier, with much less likelihood of smearing it on the ends of the logs. To apply the product, take the cover off the pail and dip your pointing knife into the gooey chinking. Pull up a comfortable working amount and smear it on the mortar joint, pushing it with the knife into any large shrinkage cracks. You can greatly extend the coverage of these expensive chinkings by drawing the material along the mortar joint with a three-quarter-inch paint brush, dampened with water. A sixteenth of an inch thickness is enough to bridge mortar shrinkage gaps, and this thin layer is easier to feather out with a brush than to establish with the pointing knife alone. And you get better coverage with a brush.

Coverage will depend on the width of the mortar joints, the severity of wood shrinkage and the skill of application. Assuming $\frac{1}{16}$-inch application thickness and walls which are 60 percent wood and 40 percent mortar, you should be able to repair 500 to 600 square feet of wall area per 5-gallon bucket of Log Jam. Log Jam is smooth, has excellent adhesion and is very flexible even after ten years on an exterior application.

One of the extra benefits of using a chinking product in this way is that it returns any color irregularities from different mortar batches to a single consistent color. And, if you choose a light color, like Log Jam's "white white," the cordwood wall will be very much brighter and light reflective. For this reason, you might consider starting with the interior first, and learn what your actual coverage is for a 5-gallon pail. Just doing one side of the wall will greatly reduce air infiltration around log-ends with shrinkage. Then you could decide about doing the exterior, with a view to improving appearance, getting even more infiltration protection and discouraging insect attack.

Commercial Cement Retarders

When suitable sawdust is not available for use as a cement retarder, use a commercial product made for the purpose. Most commonly, it is a liquid, available in gallon or 5-gallon containers, but it can also come as a powder. The mortar mix is slightly different when using a retarder: an extra part of sand replaces the three parts of soaked sawdust. So, with Portland, the recipe is 10 sand, 2 Portland, 3 lime. With masonry cement, it is 10 sand, 3 masonry cement, 2 lime.

I have used three or four different retarders over the years, all with good success. One was Sika Plastiment, now known as SikaTard-R. Another was Daratard-17 from W.R. Grace and Company.

After the dry mix is complete, make a crater in the center of the wheelbarrow and pour about a half gallon of water into it. Now add the cement retarder to the water, three ounces with the ones named above, and stir it around. Do the wet mix, adding water as necessary to achieve the same stiffness and plasticity described in Chapter 3. Do an experimental batch and watch it for five days. If there has been no mortar cracking, continue. Sometimes you may have to try a little more or a little less retarder to get the favorable result.

The Fingernail Test

Have you slowed the mortar set sufficiently? Here's a good test, suitable for soaked sawdust mortar or mortar with retarder added.

If you cannot scratch fresh mortar easily with your fingernail the next morning, it is curing too fast. You should still be able to scratch it, but not so easily, the second day. By the third day, you will not be able to scratch it with your fingernail. That's properly retarded mortar.

Sometimes it is hard to find cement retarder at your local building supply. You may be met with a blank look by the clerk. But concrete batch plants always have a large vat of cement retarder which they add to concrete when they are pouring certain jobs that require a slow set, such as bridges. Walk in to the concrete dispatch office with a plastic gallon milk bottle in one hand and a six-pack of a good micro-brewed beer in the other. Offer the beer for a gallon of their best draft cement retarder. Usually works. Once, in Asheville, North Carolina, I didn't have the beer, but offered to pay for a gallon. It took four guys in the office about a half hour to figure out that it would be $7.50. They would have been better off giving it to me free the moment I walked in.

Here's another true story (all my stories are true). At the Boscabel, Wisconsin, cement plant, I procured some Grace retarder, but not the Daratard 17 I was accustomed to. I used it at a workshop, but the mortar was setting fast. I went back to the plant to ask for advice and told a helpful fellow that I was putting three ounces in per wheelbarrow load. "No," says my new friend. "You need five ounces." "Thanks," says I. "I'll put in six, just to be sure." "No," he says. "Five." He was right. The mortar performed perfectly.

Other cement retarders are listed in the Appendix. Their listing does not constitute an endorsement, and you may find others at local suppliers, such as Home Depot. Once again, allow a week or two to experiment when using a retarder for the first time.

I mentioned that you can actually use a pre-mixed sand-and-cement product known as "mortar mix" with cordwood masonry. Just use one of the commercial cement retarders along with it, and experiment with a bag. We tested mortar mix at Stoneview and found it to be rather dark in color and the mortar to be somewhat grainier than when we use mason's sand, so it is a little more crumbly and doesn't point as smooth. However, if sand is hard to come by where you are building and mortar mix is available, it might be your way out of a dilemma.

Finally, do not combine wet sawdust and cement retarder in the same mortar batch. One builder near us made this mistake. He had a work party and did ten batches of nice work, a good day's progress…except the mortar never set.

Building Thicker Cordwood Walls Within a Timber Frame

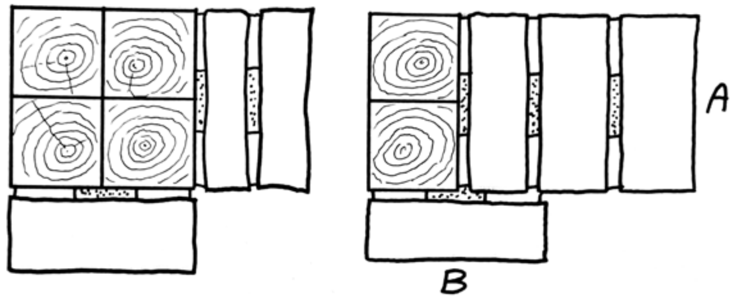
At Log End Cottage, our first cordwood building, we built walls of about the same thickness as the posts and beams that we built out of—old recycled barn timbers, for the most part. It makes a certain amount of sense. And we have done the same thing on many buildings since, mostly small ones, such as saunas, which are inherently easy to heat because of their small size. People who wanted thicker cordwood walls, usually for homes in cold climates, often turned to stackwall corners, where walls of 16 inches, 24 inches (60 centimeters) and more were possible.

Some homes have been built with massive timber frames in the single-wide style, where the wall thickness is a function of timber size. One builder in Pennsylvania sent me photos of his frame as well as his beautiful finished cordwood home. Corner posts were 16-inch by 16-inch. Sidewall posts were 8-inch by 16-inch. Logically, the cordwood walls were 16 inches thick.

Years later, Joey Zinni built with the same post dimensions in Tenino, Washington, except that his 8-inch by 16-inch sidewall posts were composed of two 8-inch square posts scabbed together. Joe called his home his Rocket Research Landing Pad and a photo essay of the project appears at pages 101 to 105 of my *Timber Framing for the Rest of Us* (New Society Publishers, 2004).

Several builders, beginning with Cliff Shockey in Vanscoy, Saskatchewan, began building "double-wall" cordwood, with walls of 24 inches and more composed of two separate 8-inch cordwood walls with 8 inches or more of insulation between them. This is a different topic, however, and covered on its own in Chapter 6.

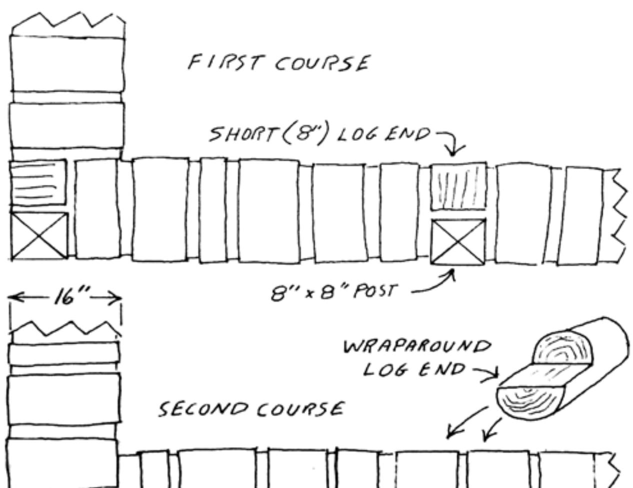
The early wide-wall timber frames, with their massive 16-inch by 16-inch posts, made sense and worked well, but how many people have access to timbers like that, or could physically move them if they did? With my limited imagination, I could envision 16-inch-square corner posts made up of four 8-inch by 8-inch posts fastened to one another, and it could be done in place, so that huge timbers did not have to be maneuvered by Mom and Pop. But Jeff Cora of Parkersburg, West Virginia, came up with a better idea, cutting his corner post material in half. See Figure 4.9. What



4.9. Instead of four 8-by-8 posts in the corner to do 16-inch walls (*left*), use two. Then build wall A before wall B (*right*).

makes this system possible is to build Wall A first, against the double-wide corner posts, and then build Wall B up to Wall A and the 8-inch dimension of one of the corner posts. Sidewall posts could also be double-wide 8-inch by 8-inch posts, or, to save money and timber, they could even be doubled 4-inch by 8-inch or 6-inch by 8-inch timbers.

But it gets even better. You can further cut your corner post schedule in half by a method used by my neighbors Alex and Renee Blaise. They used single 8-inch by 8-inch posts in their corners, got their roof built, and then proceeded to weave their 16-inch cordwood walls around the single corner post, as seen in Figures 4.10 and 4:11.



4.10. A single 8-by-8 inch post will suffice in the corner or the side of a 16-inch cordwood wall, by weaving successive courses as shown.

4.11. External corner detail of Alex and Renee Blaise's house near Earthwood.

At the corners, Alex knitted short half-length (8-inch-long) log-ends with full-length (16-inch) log-ends as shown, alternating the placement of the short log on each successive course. By using different diameters of log-ends, he was able to weave the logs in such a way as to prevent a long vertical mortar joint from occurring one vertical course away from the post. Alex says that it only took him about an hour to figure it out.

A single post is sufficient along the sidewalls, as well, also illustrated in Figure 4.10. To fill the space on the inside of the wall, regular log-ends are combined with half log-ends, as shown at the top, first course. On the second course, Alex used a technique developed by friend Bruce Kilgore back in 2004, called "wraparound" log-ends. Wraparounds are full length log-ends which have had a piece taken out, so that they can wrap around the external post, as shown. Similar to what he did in his corner, Alex alternated a short log-end (first course in the diagram) with wraparounds coming in from both sides on the second course. It is good to make a variety of wraparounds—some with half the diameter taken out, some with a third, some with two-thirds. With careful weaving, it is possible to completely eliminate long vertical mortar joints on the interior, as Alex did. In fact, from inside the building, the walls look like they are built entirely of cordwood: no posts are seen at all. You only see the structural frame on the exterior.

With careful selection of log-ends around the corner posts, and by knitting various lengths and diameters, the builder would be able to use 8-inch by 8-inch posts with a 24-inch-thick cordwood wall. The wraparound log-ends would still have 8-inch chunks taken out of their 24-inch lengths.

Finally, even with the methods described here, it is important to use inch-thick key pieces where the mortar is laid up to any vertical post, door frame or window frame.

Time Efficiency

Cordwood masonry is easy to do, but it is labor intensive. Getting the order of events right, and developing efficient handling of materials are both extremely important in minimizing time and labor. Unless you have a source of truly dry log-ends, it is best to cut, bark and dry your wood this year with a view to building next year. There is so much of value that you can do in the meantime: foundation, access, well, septic system, procurement of materials. You could also do what Bruce Kilgore calls a "practice building." He particularly suggests a storage building, a valuable space to keep all the materials and tools you will need to build. If log-ends shrink a little on the practice building, that's not so bad.

When you finally start the cordwood of the main building, have the site well organized: a good mixing area near the site and log-ends stored under cover, but close by and easily accessible. Move log-ends around as little as possible. Finally, it is worth repeating the mantra: *mortar, insulation, wood*. Do not deviate from this order.

I would like to finish Cordwood 202 with Jaki's excellent checklist, which the reader is encouraged to use frequently during the first few days of work on their own project. It is called:

Stand Back from the Wall

At the beginning of the second day's hands-on session at our cordwood workshops, we gather the students around the first day's work and have them go over the list below as we critique the wall. Many of the points are most effective if contemplated from a point of view about ten feet back from the wall.

1. Don't forget the insulation! It is easy to place the log-ends quickly while forgetting the insulation. Follow the mantra: Mortar, Insulation, Wood.
2. Place the log-ends over a vertical mortar joint. Stone masons say, "One over two, two over one." This rule prevents long vertical mortar joints from forming. (Except, of course, next to a post, door frame or window buck. Remember that the vertical key pieces on the posts provide strength against lateral load: kicking mules, earthquakes, etc.)
3. Maintain a constant thickness of mortar joint. About an inch is good. Avoid the "three to four inch trap," where you can't fit a log-end in. *Using the largest log that fits in a space* is one good way of avoiding very large areas of mortar.
4. If you place mortar down, be sure to install the insulation and the log-ends before the mortar starts to stiffen. Don't wander off for lunch or to do some other task. *Get that mortar covered!*
5. Place the mortar down quickly and let go of it. Don't "pitty-pat" it, which wastes time, brings water to the surface and promotes mortar shrinkage cracking.
6. Step back once in a while and look at the work to see how it is shaping up. Do you have a good balance of sizes and shapes? Are you maintaining a constant thickness of mortar joint? Are bottle-ends pleasing with regard to position and color?
7. Always work on the low points of the wall first, the valleys. This will create new hills…and new valleys. Log-ends need support from lower down, so always start from the bottom of a slope. Mortar placed on peaks is likely to stiffen long before it gets covered with wood.

8. Work with someone on the other side of the wall for feedback. This is particularly important with walls of 16 inches thick or better. Talk with each other. Are the mortar joints too big or too small? Are log-ends too close to each other or touching? If working alone, go to the other side of the wall once in a while to check things out.
9. Maintain a consistent textural style: random rubble, patterned courses, whatever you like.
10. Eyeball from post to post—or stackwall corner—to see if log-ends need to be tapped one way or the other with the sharp impact of a hammer. You can only adjust today's work, not yesterday's. With a curved-wall building, use the plumb bubble on your 4-foot level to check for plumb…and errant log-ends.
11. Keep some mortar in reserve for the end of the workday to assist in pointing.
12. Finish the top of the active wall each day with log-ends supported on each side by mortar, giving protection against things that go bump in the night. Never finish with mortar on top of wood, which would result in a double-thick mortar joint the next day.
13. Leave flat full-width mortar joints between log-ends to support the next day's mortar. Don't leave a chamfered or sloped edge on the mortar, as this will not provide adequate bearing for the next day's mud.
14. If you are using sawdust as a mortar-retarding agent, be sure to get enough of it soaking for the next day's work.
15. Clean all gloves and tools at the end of the day.
16. Have fun. Be creative. Enjoying the process will improve the build quality.

PART 2

The New State of the Art

CHAPTER 5

Is Cordwood Green?

I write a Q and A column about cordwood for Kelly Hart's excellent Green Home Building website, greenhomebuilding.com. The following question inspired me to reply in detail.

Question from Anonymous: How can you consider cordwood as "green" when it uses so much cement in the mortar?

My reply?

Great question, one I'm glad to have the opportunity to answer. First, I guess we have to come up with an understanding about what "green" means, with regard to building. My own view is that a green building must have a significant degree of the following elements: sustainability, leaving little impact on the planet, energy-efficiency in the making (often referred to as "embodied energy") and energy-efficiency in performance (fuel efficiency for heating and cooling.) A closely related element would be that the building is healthy, particularly not chemically toxic.

Sustainability

Cordwood masonry "stacks up" very well here. With hybrid poplars, and other fast-growing woods, you can grow your own house in five to seven years. And these lightweight woods are good with respect to both their insulation value and their volumetric stability (expansion and shrinkage). A related consideration is that cordwood masonry can make use of scrap wood which is unsuitable as firewood or for taking to the sawmill: curved logs, hollow logs, shorts, driftwood, fire-killed wood, logging slash and ends and pieces from the sawmill. With 8-inch to 16-inch pieces, you can get a lot of log-ends from "waste" woods. I clean up the yard at a local log home manufacturer every now and again, and get nice dry white cedar pieces—12 inches to 60 inches long—for free. In fact, I haven't paid for cordwood in many years. Try any company that makes wood products: log cabin builders, sawmills, furniture makers, fence post makers. Ditto landscapers or tree clearing companies. The amount of wood that gets tipped into the landfill is both a shame and a minor environmental disaster. Surely it is green to make good use of this waste.

Extend yourself when it comes to creative cordwood procurement. Nothing ventured, nothing gained. You'll be amazed with the results.

Leaving Little Impact on the Planet

Eventually, all our structures must return to the earth from which they came. When its useful life is done, a cordwood building will biodegrade better than most, particularly when one of the greener binder options is used, as discussed below. But, given protection and good build quality, a cordwood home will last a long time indeed—a hundred years or forever, whichever comes first. "Protection," incidentally, comes from keeping the cordwood masonry off the ground and guarding the walls against constant dampness by employing a decent roof overhang.

Low Embodied Energy

Classic cordwood masonry walls have three material components: the log-ends, the mortar matrix and the insulated cavity within the mortar. Let's see how these components measure up on embodied energy.

The cordwood measures up very well indeed if it is local. If you haul it in on a flatbed truck from 1,500 miles away, well, there's a lot of fossil fuel that goes into haulage, so a good part of cordwood's advantage in this category would be lost. Use local woods, maybe even trees that you need to clear for the building site. The other embodied energy in the cordwood itself is the energy required to cut the trees into short log-ends. Typically, this is done with a chainsaw, so gas and oil are consumed, but not a great amount for the quantity of building material you get out of the process. Cordwood can also be cut with a large diameter crosscut saw (buzzsaw) powered by the power takeoff (PTO) from a tractor, or by a gas or electric motor. This type of saw can cut a lot of wood quickly—and accurately—with a lesser amount of fossil fuel.

The mortar matrix is what binds the wall together and gives cordwood masonry its pleasing textural appearance. It is also a key element in energy efficiency, discussed in the next section. Your question implies that we are using a lot of Portland cement in the mortar, and fair enough. The manufacturing process with Portland makes up something like ten percent of man's energy use on this planet, a shocker.

I do not claim to be a purist with regard to green building, although green and natural building are near and dear to my heart. I also drive a car to get from A to B, and even get on a plane if I have to go as far as C. In 69 years on this planet, I have learned very little, if anything, that I would categorize as "absolute truth." But these come close: (1) Everybody's different. (2) Be wary of dogmatism, because truth—thanks to (1)—is both personal and transient. (3) Embrace tolerance, a logical corollary, perhaps, of (1) and (2). And, finally, I like this one from my father: (4) Exercise moderation in all things. You can have too much of almost anything: water, food, money, purity of ideals…

So I use Portland cement in the mortar, a material that uses a lot of embodied energy in its manufacture and transport. But I use it in moderation. My Portland-based mortar recipe is 9 sand, 3 soaked sawdust, 2 Portland, and 3 hydrated lime, the amounts being equal parts (shovelfuls) by volume. With a standard pointy-ended spade, and consistent medium-sized shovelfuls, this recipe yields a wheelbarrow load of mortar, sufficient to lay up 2 square feet of a 16-inch-thick cordwood masonry wall. As I get 12 shovelfuls out of a standard 94-pound bag, I can do 12 square feet of 16-inch cordwood masonry from a bag. A house of 960 square feet of external wall, then, will require 32 bags of Portland cement, not a huge amount, and a whole lot less than the amount used in concrete foundations or concrete block buildings. Using smaller mortar joints and a narrower wall, I still marvel that Jaki and I did the cordwood masonry at Log End Cottage in 1975 with just six bags of Portland.

Lately, we have had good success with using lime putty mortar, with no Portland at all. This is very similar to mortar as it was made before 1843. Lime putty mortar has lots of advantages, not the least of which is that it contains very much less embodied energy than the cement variety. This use of lime putty mortar is the subject of Chapter 10.

But, greenwise, it can get even better. Quite a few cordwood builders in the past five years have been doing cordwood masonry with cob as the binding matrix, instead of mortar. We even did some of this at Earthwood Building School when the famous cobbers Ianto Evans and Linda Smiley (Cob Cottage Company) came to visit. It worked well, but is not sustainable for us, as there is no ready source of clay nearby. But for anyone with accessible clay as an indigenous material—probably half the country, I'm guessing—then cob is a viable alternative. Cob's constituent ingredients are: clay (about 25 percent by volume, if the clay is fairly pure), sand and (for use with cordwood) chopped straw as reinforcing binder. The clay is the cement of cob and the sand is where the strength and hardness come from, so coarse sand is okay. The straw ties the matrix together, much like the polypropylene fibers in reinforced concrete. This type of cordwood masonry is sometimes known as "cobwood" and is very popular with natural building purists. Jaki and I demonstrated the construction technique at the Natural Building Colloquium in Kingston, New Mexico, in October of 2015. See Chapter 11.

For insulation, we use sawdust, a waste product from sawmills. It has an insulative value of about R-3 per inch. The insulation cavity of a 16-inch cordwood wall, then, has an R-value between R-18 and R-24. We treat the sawdust with hydrated lime as a preservative, one part of lime mixed in with 12 parts of sawdust. We once put a doorway through a 25-year-old exterior cordwood wall, and we were able to salvage and reuse both the cordwood and the insulation on a new cordwood wall. In short, sawdust insulation is the greenest kind I know.

Energy Efficiency

It's hard to call a building green which uses a lot of energy for heating and cooling. Thanks to the thick log-end walls and the wonderful juxtaposition of insulation and thermal mass (the mortar matrix) in cordwood masonry, cordwood homes are very energy efficient. Moreover, they maintain a steady and comfortable temperature, summer and winter. We use about 4 full cords of wood to heat the 2,400 square feet of living space at Earthwood. And that's *usable* square feet. Using exterior dimensions, as an assessor might do, the place is over 2,800 square feet. We burn hardwood slabs—a waste product from our local sawmill—through our masonry stove. For our other two woodstoves, we buy local firewood, and cut some deadwood to improve our five acres. All told, we spend an average of $600 a year on fuel, and nothing on air-conditioning. (In complete fairness, I have to say that the round shape and the earth-sheltered feature of the home contribute to the home's energy efficiency, too, but the cordwood masonry is a big part of it.)

The Healthy Home

Cordwood masonry is inert. There is no off-gassing, outside of normal wood aroma, which is not unpleasant (with the exception of certain stinky elms, which I would not use anyway.) Lime and Portland mortars can cause skin damage when they are fresh, so we always use cloth-lined rubber gloves during the building process, and insist upon this with our students. But, once it has cured, the mortar presents no more of a health hazard than, say, limestone. We rarely use any coating on log-ends, and never any chemical or petrol-based preservative like, for example, Thompson's Waterseal. I have occasionally used two or three coats of water-based urethane on certain special feature log-ends. And I have had good success with siliconized sealers on the exterior, such as Cabot's Silicone-based Waterproofing, discussed in Chapters 1 and 21.

So, Is Cordwood Masonry Green?

Well, in this author's admittedly biased opinion, it compares very favorably with any other building method.

CHAPTER 6

Double-wall Cordwood

by Cliff Shockey and Rob Roy

Introduction

In 1976–77, I took a course in conventional log building through the local community college, but after the course, I wasn't convinced that horizontal log construction would be practical for our severe prairie winters. I was also a member of the Solar Energy Society of Saskatchewan, where I learned a lot about energy efficiency.

One day, while thumbing through an issue of *Mother Earth News*, I came across a picture of a cordwood house built by Jack Henstridge of New Brunswick. "I can do that!" I said. The wheels immediately began turning, and soon I came up with the concept of double stackwall (hereinafter "cordwood masonry" or "cordwood") construction, and knew that I should combine the idea with sound solar design principles. With our cold winters, anyone building a home should design it to be as warm and as comfortable as possible. The double cordwood technique has worked extremely well for us and ensures security, warmth, and comfort in extreme climatic conditions.

Solar Design

Energy efficiency in construction requires a little common sense at the design stage. For example, the sun is a great source of energy, so why not take advantage of it? Design and build to let the sun's rays help heat your home. Figure 6.1 shows how I used a 4-foot overhang on the south side of my buildings to take advantage of

(*Author's note:* The first part of this chapter is taken from friend Cliff's Chapter 4 in my original *Cordwood Building: The State of the Art* (New Society Publishers, 2003). Cliff originated the double-wall technique, but many other cordwood builders have followed, including Alan Stankevitz, and Bruce Kilgore and Nancy Dow, whose home is featured in Chapter 19. Cliff opens this chapter, and then I chime in.)

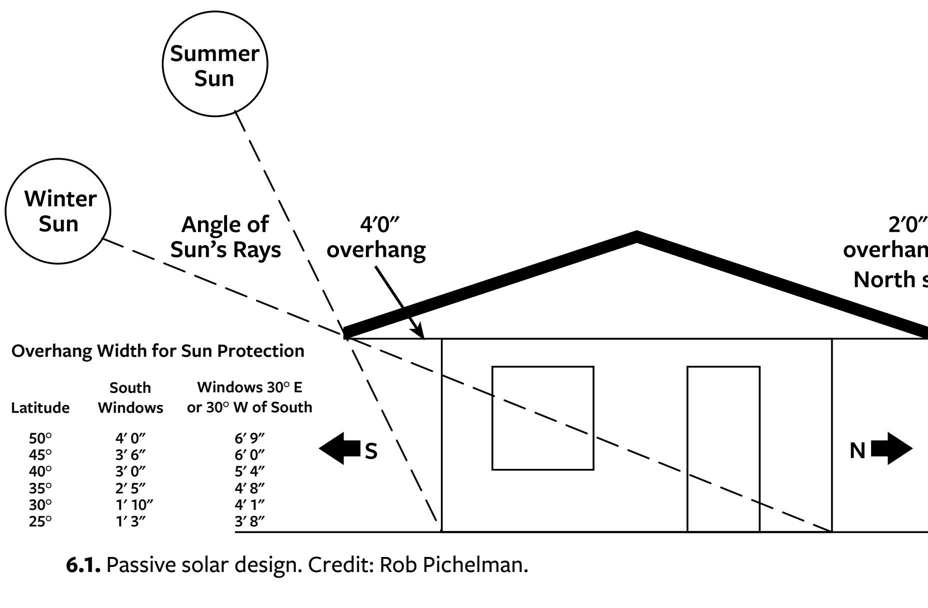
the sun's energy. When the winter sun is low, it floods the large south-facing windows for passive solar gain. As the sun rises higher in the spring, less heat enters the house because of the extended overhang. Therefore, the house remains cooler during the warm months.

We eliminated windows on the north side of the house because there is no solar gain from that direction. Also, heat loss through north-facing windows would be heavy because of the prevailing north winds.

Foundations and Under-floor Radiant Heat

The foundation has to be broad enough to support a wide cordwood wall. Our double-wall technique has 24-inch-wide walls, so the foundation choice is particularly important, and will probably mean spending a fair amount of money on concrete. The best method of doing this is with a thickened edge floating slab.

If the concrete floor is poured independently of the footings, you can also incorporate a radiant heating system in the concrete slab, as we did in 1985 in our stackwall insurance office building in Vanscoy, Saskatchewan, and again in our house addition built in 1990. Rubber or plastic tubes are laid in the concrete in a kind of a labyrinthine pattern to circulate hot water through the floor. At the insurance office, the water is heated by a small natural gas-fired boiler and is circulated by an electric pump. We are very pleased with this system, as it has proven to be a very comfortable and efficient way of heating. In February of 1999, I checked to see how much it costs to heat this 814-square-foot office building. The natural gas bill for



Overhang Width for Sun Protection

Latitude	South Windows	Windows 30° E or 30° W of South
50°	4′ 0″	6′ 9″
45°	3′ 6″	6′ 0″
40°	3′ 0″	5′ 4″
35°	2′ 5″	4′ 8″
30°	1′ 10″	4′ 1″
25°	1′ 3″	3′ 8″

6.1. Passive solar design. Credit: Rob Pichelman.

the month of November 1998 was C$32.90 and for January 1999, it was C$40, so you can see that the building is very energy efficient. Keep in mind that we are in an extremely cold part of North America.

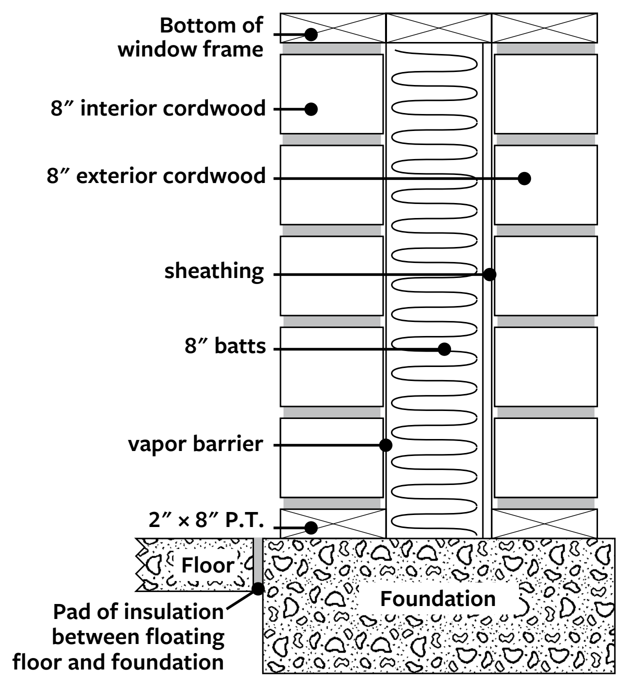
Under-floor radiant heat should be professionally installed. The installers will insist upon 2 inches (R-10) of extruded polystyrene insulation under the slab, which is typically 4 to 6 inches thick. A thermal break of insulation is also placed between the slab and the footings. The floor can be painted, stained, or covered with tiles or slate.

Incidentally, cordwood masonry is a good choice for commercial buildings. The pleasing esthetics of the building has a positive impact on the people who work and visit there. The building is comfortable in terms of its intangible "atmosphere" as well as in its thermal characteristics. With buildings such as stores and restaurants, the curiosity value of cordwood masonry could actually serve as a drawing card to attract new customers.

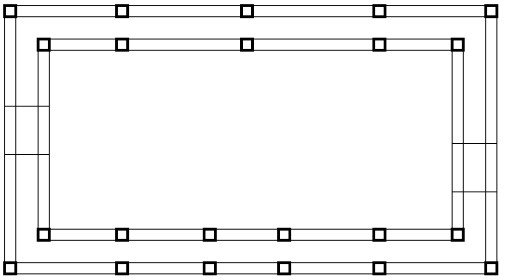
The Double-wall Cordwood Technique

The double-wall technique involves building an 8-inch-wide outer cordwood wall and another inner cordwood wall of the same width. The space between the cordwood walls is also 8 inches, and is occupied by: some inexpensive sheathing on the inside of the outer wall; 8-inch fiberglass batts; and a tight polyethylene vapor barrier just behind the inner wall. Figure 6.2 shows a cross-section of the layers of a 24-inch-wide cordwood wall built using the double-wall technique.

On my first 600-square-foot cordwood house, built in 1977, I used built-up corners for the outer wall and laid up the inner wall within a post and beam framework. On my larger 1300-square-foot second house, I used the same method. In 1985, I decided on post and beam framing for both the inner and the outer walls of the insurance office, and did the same thing in a 392-square-foot addition to our second house in 1990. I now recommend the newer method, because it is faster and easier and enables you to get the roof on first and then work under cover. I used 8-by-8-inch timbers for my framing, but you can adapt your framing design to take advantage of material that



6.2. Cross-section of Cliff Shockey's double-wall technique. Credit: Rob Pichelman



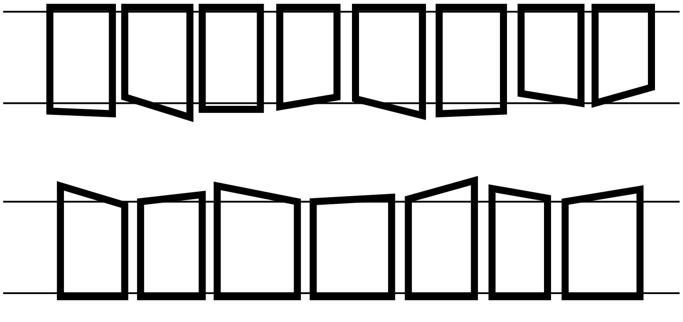
6.3. Plan view of simple post and beam frame for the double-wall technique.

you have salvaged or purchased at a good price. Figure 6.3 shows a simple post and beam frame as it would be built for the double-wall technique.

If you really like the appearance of the stackwall or built-up corners on the outside—they are very attractive—you could probably support a roof truss system by the inner post and beam frame, get the roof on, and build the outer wall afterwards with built-up corners.

With the post and beam method, the exterior cordwood masonry should be laid up first (using methods described in Chapter 3). Always work with heavy cloth-lined rubber gloves and leave between three-quarters and one inch of mortar between log-ends. The mortar mix I used is slightly different from Rob's and has worked well for us. It is, simply, 3 parts sand and 1 part masonry cement. On the exterior wall only, we add 1 part of screened and soaked sawdust. The sawdust slows the set on the outer wall, but the inner wall does not set too quickly if the outer wall is built first.

Another detail I do a little differently from Rob is to fasten a 2-by-8 pressure-treated plank to the foundation as the base of my cordwood wall. This keeps the first course of the wood a little further off the concrete foundation, and on the inside, provides a place to fasten the vapor barrier. These plates can be fastened with anchor pins or concrete nails. My cordwood for all our buildings was cut from untreated cedar utility poles that I obtained for removing them along 6 miles of road. They were fairly regular of size, but I split some that had excessively large checks. These pieces were handy whenever a full round log-end wouldn't fit, such as at the end of a course, where the masonry meets a post or door frame. With a little imagination, you can make some very attractive patterns.



6.4. Plan view of double wall. Log-ends do not have to be cut perfectly in order to keep the interior and exterior surfaces straight.

When the rough door and window framing is in, and the outside wall is complete (with all the additional features in place such as glass bottles, wagon wheels, dryer vents, etc.), I like to put $\frac{5}{16}$-inch particle board (or any inexpensive sheathing) on the inside of the exterior wall. This acts as a backing for the insulation batts to come. Also, if you happen to be building higher than 8 feet, the sheathing helps to stabilize the wall. It also serves as a barrier to help keep bugs or mice out of the insulation cavity.

The next step is installing the insulation. I like to use 8-inch (R-28) batts because they are fairly rigid. I find that they will stand on end without sagging down the wall. If you decide on thinner batts, you can pound nails part way into the wall and then, for stability, push the batts over them.

6.5. Cliff's addition, shown under construction, was built in 1990. Credit: Cliff Shockey.

Next comes the vapor barrier. I feel that a tight polyethylene air vapor barrier is important for making an airtight, draft-free home. The vapor barrier is fastened to the pressure-treated 2-by-8 base plate already mentioned, and also to the inner post and beam frame, the top plate, and all window and door frames. All seams in the vapor barrier must be sealed together with acoustical sealant over solid backing. With the vapor barrier in place, it is like living inside a big airtight bag, with openings only for things like doors, windows, plumbing, vent pipes, chimneys, etc. It is important to seal around all openings in the vapor barrier. Make sure that every seam is sealed before the walls and ceilings are finished, as it is impossible to get at it later. Some people have suggested that a very tight house necessitates the installation of an air-to-air heat exchanger to prevent stagnant air and promote sufficient air changes. I must say that we do not use an air-to-air heat exchanger and have not observed any problems with air quality.

After installing the vapor barrier, build the inner wall. Remember that the sawdust admixture is optional on the inner wall, providing that you are building within

6.6. Cliff's main house, where he now lives, built 1978–80. Credit: Cliff Shockey.

the plastic tent of the vapor barrier, which itself helps to retard the mortar set. Eliminating the sawdust results in a smoother finish to the mortar. You can do fine recessed finish pointing like Jaki Roy, or you can do a rough pointing with your rubber gloves like I did. Later, we cleaned the log-ends of loose mortar with an electric rotating wire brush, and then sprayed the wall with a spirit-diluted mixture of polyurethane. This brings the color out of the cedar in a very attractive way, and provides a surface that is a little easier to clean. The choice is yours.

One advantage of the double-wall system is that any irregularities in log-end length or straightness of cut can be hidden out of sight toward the center of the wall (see Figure 6.4).

People have asked me if the double-wall technique isn't twice as much work as regular cordwood masonry. It isn't. Actually, you will need only two-thirds as much wood as with a standard 24-inch-thick cordwood masonry wall. You'll mix only slightly more mortar. And you will have exactly the same amount of pointing.

On the upside, you have a highly energy-efficient structure, providing you use ceiling or roof insulation in scale with the wall insulation. As the double-wall technique yields an insulation value of approximately R-40, we used R-56 insulation in our roofs.

Before you begin any building project, gather information from several different sources. In this way, you will be more likely to make well-informed decisions.

Above all else, take time to enjoy your project. Designing and building your own home can be one of the most satisfying endeavors you will ever experience.

The Evolution of Double-wall Cordwood

by Rob Roy

The energy efficiency of the double-wall technique cannot be denied, but I must give another point of view to Cliff's answer to the time factor question. First, the reader should know that Cliff is the most methodical cordwood builder I have ever seen. In 1994, during the first Continental Cordwood Conference at Earthwood, Cliff did a demonstration of his double-wall technique on a makeshift foundation. Meanwhile, cordwood builders Jack Henstridge and Richard Flatau showed the single-wall technique. Cliff, alone with his double wall, kept up with friends Jack and Richard—working together—on their single wall. In fairness, Jack liked to stop and tell wonderful tales of cordwood and humorous anecdotes while Cliff proceeded like a machine, though still able to carry on a conversation with onlookers. He didn't let talk slow him down. However, I must report that other builders have taken very much longer to build their double-wall houses than single-wall builders typically take for the same size of house. Alan Stankevitz built one of the finest cordwood homes in the world, but it took him ten years to do it. Bruce Kilgore and Nancy Dow

6.7. Alan Stankevitz built this beautiful 16-sided double-wall cordwood home near La Crescent, Minnesota.

(Chapter 19) took five years, just on the cordwood masonry. Again, their home is one of the finest around. In fairness, both Alan and Bruce and Nancy had comfortable places to live and regular jobs while they built, so it was part-time cordwooding. Still, Cliff's admonition that the double-wall technique "isn't twice as much work as regular cordwood masonry" has been true when the builder was Cliff.

Alan Stankevitz, in his paper "Foam Home" from the *CoCoCo/05 Collected Papers*, says:

> Following in the footsteps of Cliff Shockey, I decided to use the double-wall technique at our 16-sided home in southeast Minnesota, where the climate is balmy compared to Cliff's Saskatchewan. Some may consider this overkill, but with the words "conserve first" repeating in my head, Cliff's approach won out over single wall.
>
> There's a lot to be said for double wall. The inner walls are totally isolated from the outer walls, breaking the continuous path of energy flow through the log-ends from warm to cold. The cavity between the two walls

> can be filled with various forms of insulation and, just as important, an air barrier sheet to reduce air infiltration, often overlooked by home builders and designers. A wall can have fantastic R-value, but it does little good if Old Man Winter comes blowin' in.
>
> After the timber frame and roof were completed, our goal was to get the walls closed in as soon as possible so that construction could continue during winter months. This meant that as soon as the outer cordwood walls were finished, insulation needed to be applied to the entire wall surface to make the house habitable as quickly as possible. This ruled out loose-fill insulation such as sawdust, cellulose and vermiculite. These products would have been contenders if I were to build the interior walls at my leisure and leave the house abandoned during the winter. Foam seemed the logical choice.

Alan's choice of spray-in foam, a good alternative to using Cliff's 8-inch fiberglass batts is explained in Chapter 7: Foam Insulation with Cordwood, along with viewpoints from other well-known cordwood builders who have used spray foam, including Bruce Kilgore. Bruce and Nancy's double-wall construction is described in Chapter 7 and in their detailed case study in Chapter 19. Bruce tells me that they followed Alan's lead and choices, as well as his reasoning. People who chose to build double wall seem happy with their decision.

CHAPTER 7

Foam Insulation with Cordwood

Four fine cordwood builders who have used spray foam as insulation share their experience in this chapter: Alan Stankevitz in Minnesota and Bruce Kilgore and Nancy Dow in New York, who used it with double-wall construction, and Sandy Clidaras of Quebec, who used it in the insulation cavity of a single wall.

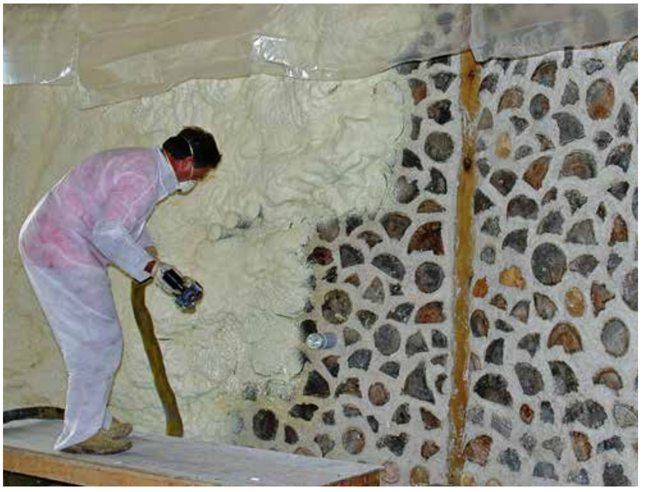
Open Cell Foam

Alan Stankevitz compared various foam choices: urethane-based, water-based, soy or even cement-based. He wanted a foam that would allow the wall to breathe, but would also be healthy, a "green building" product. In his CoCoCo/05 paper, he says, "Urethane products continue to outgas long after they have been applied and I would not recommend them."

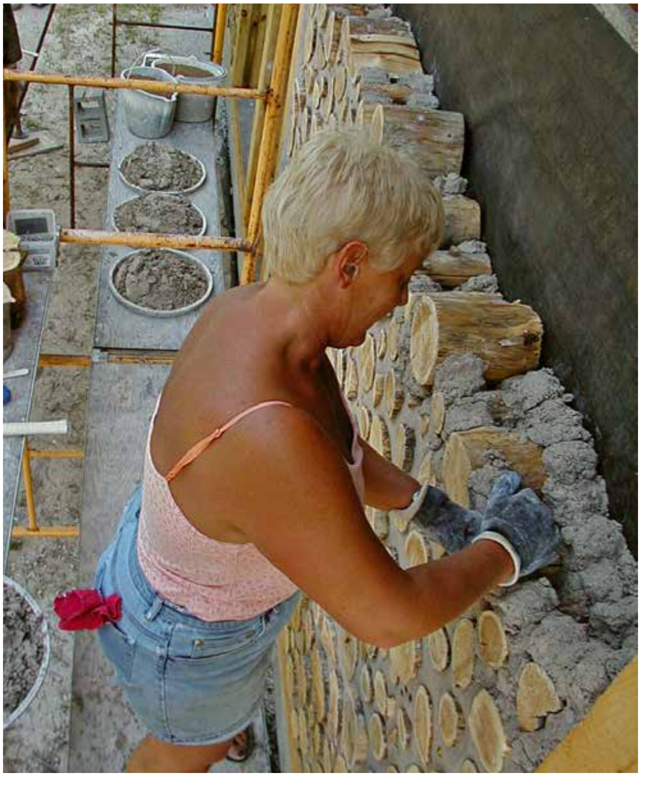
He wanted breathability in his foam, a product that would allow moisture to transpire through it. He found what he was looking for in open cell foam, a sponge-like product and nearly as hard as closed cell foam. After comparing two different products that met his criteria, Alan settled on Demilec Sealection 500.

Alan points out that a disadvantage to using these foam products is that they require special machinery, generally necessitating a contractor, which adds to the cost. But, he reports: "It was a pleasure to work with Mark Malay, the local contractor who installed the foam. I worked out a price based on the inclusion of my own labor to prep the window wells and also to be his assistant on the day the foam was installed. The foam went on very fast and without too much trouble…in one day, all 32 cordwood panels that envelope the house were covered with 5 to 6 inches of open cell foam with an insulation value of R-3.8 per inch."

In 8 hours of work, Alan's large, 2-story, 16-sided house was well insulated and airtight. He reckons that when you add in the value of his two 8-inch cordwood



7.1. Open cell foam is sprayed onto the inner surface of Alan's exterior cordwood wall. Photo by Alan Stankevitz.



7.2. Nancy Dow builds her outer cordwood wall, up against landscaping fabric stapled to wooden lath.

walls, with their lightweight paper-enhanced mortar, he has about R-36 in his walls, nearly twice the R-19 required in Minnesota by code. He is very pleased with the results and would not hesitate to use the foam again in future projects.

Soy-based Foam

Bruce Kilgore and Nancy Dow used a double-wall system a little different from both Cliff Shockey's (Chapter 6) and Alan Stankevitz. Ravenwood, their beautiful earth-sheltered cordwood home, is the subject of Chapter 19.

Like Alan, the couple built a heavy timber frame and got their roof on early. Bruce then covered the outside of the frame with 1-inch by 4-inch wooden laths, spaced 4 inches apart, horizontally. The lath provided attachment points for the log-ends on the outer cordwood wall, important because the cordwood would be completely outside of the timber frame, not compartmentalized by it. Nancy toe-screwed every fifth or sixth log-end to the lath to give the tall, relatively narrow wall stability, much as wall ties are used with brick veneer walls.

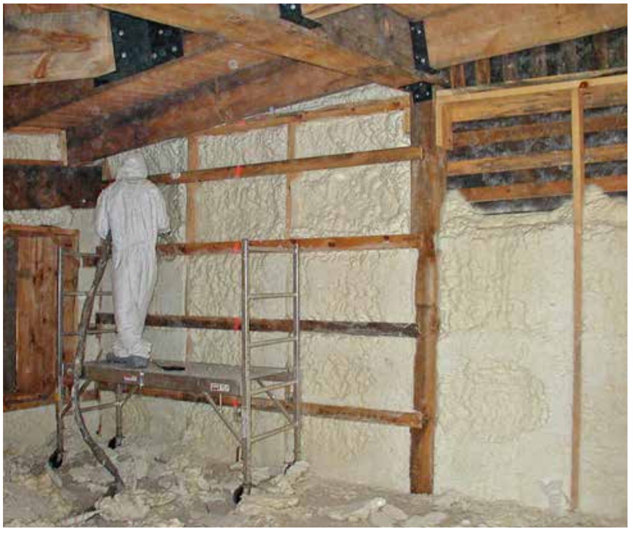
Cordwooding commenced the following year. Bruce and Nancy decided on the M-I-M (mortar-insulation-mortar) method used in single-wall construction. Thus, the sawdust insulation saved a lot on mortar—a third, in fact—and prevented direct energy wicking through the mortar. So their two 8-inch walls added significantly to the R-value.

Nancy was the mason, Bruce the laborer. He kept her supplied with lime putty mortar (see Chapter 10) and log-ends. He cut well-seasoned 16-inch white cedar logs in half with his cordwood cutoff saw (Chapter 15), yielding two 8-inch log-ends, each with bright beautiful fresh cuts to show.

On the first day, the couple realized that they were wasting mortar that fell behind the lath through the 4-inch gap, but overcame the problem by stapling landscaping fabric over the lath. The material is tough, but allows water vapor to pass through.

After all the external walls were completed, Bruce installed some more 1-inch by 4-inch horizontal laths, a full 8 inches from the outer lath matrix. These inner laths were spaced about two 2 apart to assist the installer in placing just the right amount of foam—8 inches—on the wall.

A contractor, Bugbee Insulation from Vermont, sprayed the open cell soy-based foam insulation onto the inside of their external walls. Following Alan's advice and success, Bruce chose the breathable open cell foam, even though it has a lower R-value per inch (R-3.8 versus R-6.8). Bruce told me he was concerned that water might get trapped in a closed cell foam and not have a way out of the wall.



7.3. Spraying in the foam up against the completed outer cordwood wall. Horizontal lath is used to trim the insulation in preparation for building the inner wall.

Later, Bruce cut away the very little excess foam with a handsaw and installed more laths, as many as he did for the outside wall—and, again, the breathable landscaping fabric—so that Nancy could build the inner 8-inch wall, exactly as she had done the outer wall. The finished result can be seen in Chapter 19 and the color section.

Foam Insulation with Single-wall Cordwood

In his CoCoCo/2011 paper, "Expanding Foam Insulation," Sandy Clidaras addresses injecting closed cell foam in the insulation cavity in a regular single-wall system, something he did very successfully himself at his Cordstead home in Quebec. The remainder of this chapter is condensed from his paper, reviewed by Sandy for accuracy, and used with his permission. First he lists the pros and cons:

Advantages of Injecting Closed Cell Foam

Using foam allows you to build the wall more quickly since you don't have to deal with the installation of insulation during the mudding process.

Foam has a high R-7 value per inch and will fill cracks and irregular shapes found between the mortar rows of a cordwood wall. It also bonds well to wood and mortar, has some elasticity and will not absorb water or lose its effectiveness if wet. Closed cell foam sets in 90 seconds to a rigid state. It will not settle or leak out and will neither rot nor mildew. Insects don't like it.

Spray Foam: Open Cell, Closed Cell, Soy-based

I spent hours on the Internet searching "spray foam insulation," "soy-based foam insulation," and the like. As Harry Belafonte crooned in the 50s, "It was clear as mud, but it cover de ground." This sidebar is a distillation of my findings. Before spending thousands of dollars, though, the reader should conduct his or her own search, and, in particular, speak with local contractors who can do the job. Alan and Bruce were both extremely pleased with their installers.

Heather Levin, writing in *The Greenest Dollar* (thegreenestdollar.com), compares open and closed cell insulation: "Open cell insulation is like broken bubbles. The walls are soft, and air gets trapped in the insulation, working like a down sleeping bag. Open cell insulation has a value of R-3.6 per inch, but is usually less expensive. Closed cell insulation is much harder. It's densely packed foam, and its bubbles are not broken. Closed cell insulation is the more expensive of the two because it requires more materials to support its weight. Closed cell insulation gives an R-6.8 per inch in standard walls."

Nick Gromicko, on nachi.org, reports: "Homeowners now have the option to insulate their homes with insulation made from soybean oil, known as soy-based insulation. While more expensive than traditional insulation, soy offers a 'green' and functionally superior alternative." Soy-based spray foam insulation is available in both closed cell type ("dense and rigid, with a bubbly texture") or open celled ("pliable and lightweight, and has a texture similar to broken bubbles"). Gromicko cites the closed cell type as having an R-value of 5.5, whereas the open cell is R-3.6, but is less expensive. However, he also adds this warning: "Don't be fooled into thinking that soy-based insulation is 100 percent soy, or even mostly made from soy; as much as 85 percent of soy-based insulation may be petroleum-based." And: "Homeowners who wish to pay a premium can enjoy the benefits of the newer soy-based insulation available for their homes."

From greeninsulationtechnologies.com, I learned that soy is not the only Natural Oil Polyol (NOP) being used in spray foam insulations—castor, sugar, glycerin, sorbitol and rapeseed are also used. The performance of NOPs is as good as petroleum-based polyols and, "in some cases even surpass those of petroleum-based products by increasing the solubility of the blowing agent and allowing more flexibility in formulating the foams."

Soy-based foam alternatives to petro-based foams are manufactured by BioBased Technologies, a major player in the industry. They make BioBased 501 Spray Foam, an open cell, semi-rigid soy-based foam insulation. It is sprayed in place as a two-part polyurethane. But they also make a closed cell type, BioBased 1701 Spray Foam, "the first water-blown, closed cell foam in the industry." Further, they claim: "Because BioBased 501 Spray Foam and BioBased 1701 Spray Foam (form an) air seal, this moisture movement and subsequent condensation potential is greatly minimized." The R-value of BioBased 501 open cell insulation is 3.83/inch, while BioBased 1701 closed cell insulation has an R-value of 5.5/inch.

This information does not constitute an endorsement of any product. See also the Appendix in the back of this book.

In recent years foams have become available in do-it-yourself kits that don't require heavy equipment or special tooling, and that allow you to control and oversee the installation to insure a complete coverage in the installation process.

Disadvantages

Foam kits are expensive. Supply and availability depends on your location, so shipping can also be costly.

The tanks need to be heated to 75 to 80 degrees Fahrenheit before using, but foam may be installed on cold surfaces or cavities.

How to Estimate Closed Cell Foam for a Single Log Cordwood Wall Application

There are many variables in individual building styles, but here's how to get a ball park estimate. The insulating cavity is coarse and irregular and, since we are only insulating the mortared segment, the percentage of the cordwood wall's surface area which is mortared needs to be established. (See Chapter 14.) Wider mortar joints result in more foam, and you'll need a minimum space between logs to accommodate the foam installation tubes. Foam is sold in kits of 600 board feet (BF). A board foot is 1 square foot by an inch thick, or 144 cubic inches. Here is an example to calculate the required amount:

1. Estimate your finished wall area in square feet, say 1,000 square feet.
2. Estimate wood-to-mortar (visible surface area) ratio. For this example, we'll assume 50 percent wood, 50 percent mortar. So 500 square feet needs to be insulated.
3. Estimate the width of your insulating cavity, say 6 inches.
4. To get the total board feet of foam required, multiply 500 square feet times 6 inches, which equals 3,000 board feet.
5. Divide the total board feet of foam required by 600 BF per foam kit. (3000BF/600BF per kit = 5 foam kits)

Preparation

Read all of the foam kit manufacturer's instructions.

Build your cordwood wall in lifts 2 feet high the full perimeter of your home, with just an empty cavity between the inner and outer mortar joints. Then, from the top of the wall, install one end of the correct plastic tubing for your system every 24 to 30 inches, right down to the bottom of that lift. Leave the other end sticking up 6 inches above the wall top. When placing tubing next to window frames, be sure it is well into the cavity under the frame, and be sure that the tubes are not pinched.

Maintain a clear path completely around the wall perimeter so that you are able to move quickly with the foam. The night before installing the foam, place the tanks in a small space like a closet and turn on a space heater to bring the temperature up to 75 to 80 degrees Fahrenheit before installation. Keep the tanks warm during transportation (in the car with the heater on full) and leave them in the car while setting up. They have to be warm when you are injecting, but their surfaces can be cool.

You'll need several people to make the operation move smoothly, one to help spot the rising foam opposite the installer, another helper to handle any overfill, or other situations, and to move the tanks around.

The injecting gun has a variable rate trigger that allows the two chemicals to flow into the mixing nozzle. Once mixed, the chemicals start to react (expand and cure). Once you start injecting the foam and decide to move further down the wall, you have 30 to 40 seconds to start injecting into the new spot or your nozzle will get blocked with hardened foam. Then you have no choice but to replace it with a new one. The kit comes with several replacement nozzles, but you may want to order an extra package.

7.4. Place the nozzle into the installation pipe, insure a tight fit, and start injecting by pulling on the trigger gradually.

Installation Procedure

Place the nozzle into the installation pipe, ensure a tight fit, and start injecting by pulling on the trigger gradually. Have your spotter keep an eye around where the next pipe is installed. As the cavity fills, you will begin to see the foam rising.

As the foam rises to about half-way up the lift, you can pull up the pipe a little to get it higher. You don't want to remove the pipe completely since this makes a mess; leave it in the wall. Once you have finished, you can go back and cut off all the pipes that are hanging out.

Stop filling the cavity once you can see it is two-thirds to three-quarters of the way to the top and move on to the next pipe and repeat the process.

When you're finished with the second pipe injecting, go back the first pipe you injected and give it a little shot or two to top off any missing foam. Allow for expansion or you will have an overfill mess

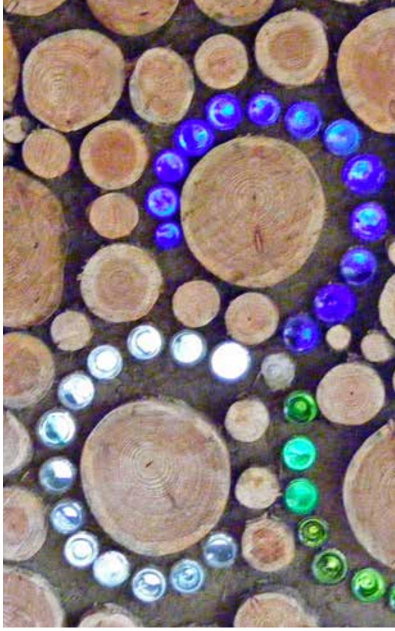
7.5. Spray foam has been completely installed in the first 24-inch-high section of cordwood. Now the second lift of cordwood can commence.

to deal with. Now, move on to the third injection installation pipe and repeat, afterwards going back to top off the second injected cavity area. Repeat this process, always going back one location to top off before starting the new one. Moving quickly and smoothly as a team will eventually be easy once you get a rhythm going.

When you have completed the injecting, go back and cut off all the pipes that are hanging out and cut back any overfilled areas. For really messy spots you can use a drill with a wire brush wheel on the tops of the mortar rows to clean up before mudding the next row.

Conclusion

Super insulating with foam is a one-time fixed financial investment. It requires no maintenance and will last the lifetime of the building, saving you energy costs year after year. The end result is a well-insulated, tightly sealed, water-resistant wall and an enjoyable interior home environment. In my opinion, it is well worth the investment.



CHAPTER 8

Bottle-ends and Other Design Features

One of the primary appeals of cordwood masonry is visual. The log-ends have such a natural beauty of their own that it would almost take a conscious effort to lay up a wall that is *not* pleasing to the eye. But the potential is there to go beyond the basic textural appeal of cordwood, to add special features, such as sculptural features, patterns, shelves and…bottle-ends!

Making Bottle-ends

Bottle-ends—called "bottle-logs" by some builders—are like log-ends, except that they are made of glass, not wood. They have become extremely popular with cordwood builders because of the bright colored light they add to the wall, like a poor man's stained glass. I think I'm safe in saying that bottle-ends are employed in at least 90 percent of cordwood buildings. We've never done one without them. See a variety of designs and uses in the color section.

But first, it is important to know how to make bottle-ends so that they will play well with cordwood masonry and last indefinitely.

There are two distinct methods for making high quality bottle-ends.

Method One: Cut and Tape

With wall thicknesses of 8 inches to 12 inches, bottle-ends are made from two open cylinders—"tumblers"—of the same diameter fastened together with duct tape. (Variations will be discussed below). Usually, this involves cutting the necks off the bottles, reducing them down to a regularly-sized cylindrical tumbler. But how? Well, many years ago, we tried taking the necks off bottles in a variety of messy ways. We would fill a bottle to the desired level with old oil and then put a red-hot poker into it to break the bottle off at the oil line—not always a success. Burning

8.1. Slate and tile cutter used for cutting bottle-ends.

a string wrapped around the bottle was no better, nor was scoring the bottle round and round until it broke. These methods all had a poor success ratio.

But for over 20 years we have had a better than 95 percent success ratio cutting bottles with a slate and tile cutter, which has a diamond-tooth circular saw that rotates through water to keep it lubricated. As I write, Lowe's has a Q.E.P. 7-inch wet tabletop tile saw for $74, and sometimes they come on sale for quite a bit less. They are well worth it—and you can use it for cutting tiles, its intended purpose.

Because almost all bottles have a quarter-inch chamfered bottom surface we tend to make our bottle-ends about a half-inch longer than log-ends, and leave a quarter-inch sticking out on each side of the wall. This facilitates pointing around them. Simply set the saw's stop, (the plastic bar on the left in Figure 8.1) to a quarter of an inch greater than half the length of the desired bottle-end: 4.25 inches, for example, for walls of 8-inch thickness. When joined, the tumblers will form an 8.5-inch bottle-end.

After cutting bottles with the tile saw, soak the tumblers in a bucket with a mixture of water and five percent bleach. If necessary, use a long-handled scrub brush to clean away any yeasty dregs still clinging to the bottom of the tumbler. Rinse the tumblers in a bucket of clean water and turn them upside down to drain for 15 minutes. Then turn them right side up and put them in the sun. When fully dry, place them together and duct-tape them around the middle.

8.2. Bottles have been cut into tumblers (except for two jars, already useful), and are drying in the sun. When fully dry, they can be taped together.

Back in the 70s, we'd glue two clean and dried tumblers together, but we found out that when the unit was sealed *too* well, there is a risk of air inside expanding, which can break the bottle. Now we make sure there is a way for air to escape. After taping the two tumblers together, we puncture two or three holes in the tape so that air can escape into the insulation cavity.

If you happen to have a clear jar of the same diameter as a colored bottle you want to use, you can adjust the stop on your saw. Say you have a 5-inch tall jar; you would cut the companion bottle at 3.5 inches, giving the desired 8.5-inch bottle-end.

Method Two: Plug into a Cylinder

If the wall thickness is 16 inches or greater, we'll plug two uncut bottles—or a bottle and a jar—into a flexible cylinder made from an offset printing plate, aluminum flashing, old vinyl or some similar strong flexible material. (With whole bottles plugged into a flexible cylinder, soak dirty bottles in the bleach solution, then shake it up to get rid of mold, which can grow inside if not removed. Drain and dry the bottles, which might take 24 hours.)

Recycled aluminum printing plates are our favorite; they're free—or very cheap from small print shops—and have just the right flex. (With stiffer aluminum flashing, taping is usually required.) The basic technique is the same with any of the flat materials. Cut them to a rectangle which, when rolled into a cylinder, is long enough to grab the cylindrical part of the bottle by two inches and wide enough that when it is wrapped around the two bottles, it will lap onto itself by an inch.

Use a couple of strong elastic bands to create a "spring-loaded" cylindrical bottle-end holder, which holds the bottles firm until they are put in the wall. If they are loose in the cylinder, use a little duct tape—printing plate to glass—to assist the elastic bands. As the cylinder is not air tight, we don't have to worry about excess

8.3. A green and a clear bottle of the same diameter can be plugged into a flexible cylinder and held fast with two strong elastic bands.

8.4. Adjusting the length of the cylinder allows for bottle-ends from 16 to 24 inches in length.

pressure. Be sure to leave enough glass exposed, at least 3 inches, for the mortar to bond to the glass at each end.

Bottle-ends are laid up in the wall the same as log-ends, but there are some tips we can pass on from years of experience.

1. Combine a clear tumbler with a colored one, to maximize light transfer. A bottle-end made from two dark-colored wine or beer bottles will greatly diminish light transfer. This means that about half the bottles you collect should be clear. People are excited about collecting the nicely colored blue and green bottles and find themselves short of clears to marry them to. An exception to the clear-and-color rule would be when the colored bottles are very light in color, for example, two yellow wine bottle tumblers.
2. We find the color is more vibrant when viewed through the colored end; it looks diffused if the bottle-end is turned the other way. As we usually want to enjoy the design feature from the building's interior, this means colored ends are laid to the wall's inner surface. Exceptions would include, for example, an entranceway, where you want to greet night visitors by illuminating a welcoming design with an internal light.
3. With Method Two, place the bottle-end with the cylinder's overlap down, stopping insulation in the wall's cavity from finding its way in.
4. Bottle-ends take time and care to do them right. Assembly-line the process and get them all made ahead of time. Don't slow down wall building to make bottle-ends. Pair the clear bottles off with colored ones of the same diameter *and keep them in pairs throughout the process*, as seen in Figure 8.2.
5. It is important to clean the ends of the bottles the same day you lay them up! Mortar bonds with glass, but you can remove mud that smears onto the bottle-end during building or pointing. Use a clean dry cloth. For the little raised dots found at the bottom of many bottles, an old tooth brush does a good job. After the first day, you will need a ten percent muriatic acid solution to remove dried smeared mortar. It works, but you really want to avoid that.

8.5. Tracy Matfin and her daughter Ai'ala clean bottle-ends with a dry cloth on a fresh wall at their home near Pahoa, Hawaii.

Creating Bottle-end Designs

All kinds of light features can be created in a wall or panel: random constellations, deliberate patterns, and more. Son Darin has the entire external wall of his shower composed of bottle-ends, as will be seen.

Darin reckons that when someone chooses cordwood as a building style, they have already shown themselves to be individualists. He says, "Let this free spirit really shine in your walls, making your home, guest house, sauna, garage—or whatever building you are working on—a real extension of yourself."

Constellations

Jaki and I started our bottle-end career back at Log End with constellation designs, which are easy to do and pleasing to the eye. They are *almost* self-creating, like real star constellations...but not quite. We wait until the cordwood wall has gotten up to about three feet off the floor, and then look for mortar cradles that are about the right size for a bottle-end. The glass units take the place of log-ends—if the cradle is also in an esthetically pleasing location. Beer-bottle-ends are generally 2 to 2.5 inches in diameter and wine-bottle-ends are usually 3 to 3.5 inches in diameter. You may have other sizes.

As we continue building up, we look for natural places to put bottles. We might try one of a certain color in a likely spot, and then stand back from the wall to see if there is a pleasing balance with other bottle-ends. Maybe we would prefer a different color. Sometimes, two bottle-ends together is part of randomness. Consider Orion's Belt, with three stars of similar magnitude in a perfectly spaced row.

Constellations 202 would be creating a specific stellar constellation, like Orion or the Big Dipper (Ursa Major). These will not build themselves. In fact, they take some careful planning. At Mushwood, we made the Big Dipper in the northern quadrant of the upstairs living room, and even included the North Star itself, which is the last star on the handle of the Little Dipper. Find a good diagram of the desired constellation. Then, on a large piece of corrugated boxboard, or even a sheet of plywood, draw the constellation the size you want, using bottle-end-sized circles to represent the exact location of the stars. Hang the pattern from the outside of the girt, the top timber of the panel you are working on. As you build the cordwood wall, the skilled part is to lay up a variety of log-end sizes between the bottle markers on your pattern, so that the bottle-ends wind up exactly where you want them. By now, you will have

8.6. The two "pointer stars," at the right of the Big Dipper, point to Polaris, the North Star, upper right.

developed good log-laying skills and so this will not be too difficult. Try to keep a constant thickness of mortar joint around every masonry unit, bottle or log. In our Big Dipper, I used all clear bottle-ends, to mimic the night sky, but you might choose a mix of colors.

Paint by Numbers

On another occasion, at Earthwood's Strawbale Guest House—half cordwood, half straw bales—we put a special Magic Tree design in the south (strawbale) wall, filling the space which, otherwise, would have had exactly two straw bales, so the design did not create a problem with the normal placement of the bales. For this one, we made a window buck (see Chapter 3) out of full-sized 2-inch by 10-inch planks, doubled, to create the 20-inch-wide bottle-end frame seen in the color section. We made about 64 bottle-ends of various colors, always a clear and a color, sometimes two clears. Five of the bottle-ends had quarter-inch-thick special pressed glass designs clear-glued to the inner surface: a sun, a moon and three colored fruit designs. We set up the frame on a piece of plywood supported by two sawhorses, so that we could place bottle-ends in the frame from above, and move them around to create the design we wanted. In the end, we created a tree trunk (brown beer bottles) growing up out of green and yellow ground colors. Various fruits grow on this magical tree, and, above, the sun rises in the light-colored sky, while the crescent moon sets in the darker night sky. When it came time to mortaring the design in the wall, we carefully laid up the frame where two straw bales would have gone, and then, starting at the bottom, we installed the first course of bottle-ends, drawing from the design still standing on the plywood bench, and gradually built up to the top. It was an easy paint-by-numbers kind of thing, as the design had already been worked out on the bench, where it was easy to move the bottle-ends around to best effect.

8.7. This flower design, created on a flat table, is made of bottle-ends and basswood log-ends.

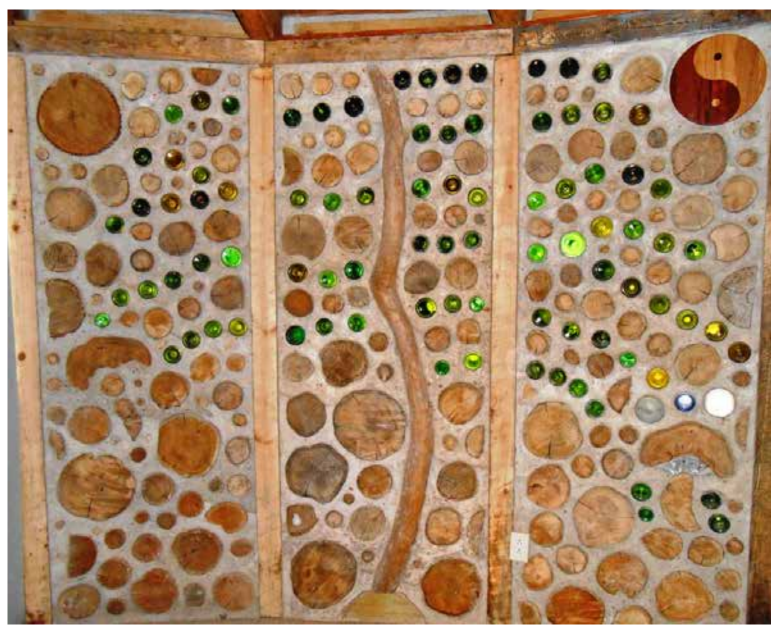
The large flower design in one of our garage panels (Figure 8.7) was done at a workshop, and by a similar method to the Magic Tree, except that we did not require a frame; the design was simply a part of the large cordwood panel. Leonardo and Michelangelo and the boys would make a cartoon for their great plaster frescos and then transpose the design to their wall. We planned the flower design on a piece of plywood very near to the panel in question, moved log-ends and bottle-ends around until everything looked good and fit together with a constant thickness of mortar joint. Once again, we simply transposed our design to the panel, starting at the bottom. Paint by numbers. Silly, but you get the idea. And it really works. It would be very difficult to create this sort of design freestyle, in place, without the cartoon.

My book *Stoneview: How to Build an Eco-friendly Little Guesthouse* (New Society Publishers, 2008), shows some other mixed bottle and log designs that we have done in similar ways, including a 5-by-5 grid diamond pattern composed of 20 regular square log-ends and 5 bottle-ends, built against a plywood cartoon. See that book's color section as well as pages 138 to 146 for descriptions and illustrations.

Darin put lots of bottle-ends in his 20 panels of cordwood masonry: constellations, symmetrical designs and three new features worth reporting. He tells the story of these here, as he reported in a paper he presented at CoCoCo/15.

The Tree of Life

By far the most intimidating feature to create, this idea was formed mostly from my love of one particular piece of cedar that longed to be more than log-end material. The base of the tree, a small trapezoidal shaped section of a 4-inch by 6-inch timber, is held to the floor using masonry nails. The cedar "trunk" is then attached to this using two 6-inch GRK screws; the top is similarly attached to the 4-inch by 4-inch internal girt (small beam). The rest of the wall was built around the cedar trunk. We made the bottle-end branches so that they appeared to be originating from the curved cedar trunk. My friend Bridget and I took pictures along the way each evening to help us mock up a basic idea of how we wanted the finished project to look on paper, preparing us for the next day's work. My mind works much better when I am working with something hands-on, but Bridget's drawings helped greatly, putting an idea on paper so that my version could be more of a second draft.



8.8. The Tree of Life, internally lit. In bright daylight, the bottle-ends become bright green and yellow leaves.

Placing the bottle-ends with correct spacing involved stepping back from the wall constantly to make sure there was always room for logs between bottles. The most difficult aspect of this wall was at the top; fitting the final logs and bottle-ends became quite difficult as the inside girts are 4-inch by 4-inch and the outside are 6-inch by 6-inch, creating the problem of keeping a consistent mortar gap on both sides. The bottles needed to be the full width of the wall, 16 inches, to let the light in from outside, but some of the logs could be "falsies"—short logs used for visual appeal where full sized logs would not fit. These helped greatly to create consistent mortar joint thickness. When looking at the tree, one notices that not all the bottles are green; some are yellow, representative of the late summer/early fall time of completion of this design. The yin/yang symbol made of wood, as well as the varnished basswood log-end on the top left were gifts from my parents. It seems appropriate to have symbols of their love watching over my Tree of Life.

8.9. Shower Island, one of the last walls to be completed, was pointed to a nearly glossy finish.

The Bottle-end Shower

The external wall of the shower enclosure is all bottle-ends, inspired by a similar panel built by Kim Cellura at her Mermaid's Cottage near Del Norte, Colorado. Kim's was a mermaid design. We went for a tropical island motif.

The shower wall was a labor of love, something that I had in mind as soon as I decided to build my home. Luckily I had some help drinking the contents of all of these bottles. (Friends seemed to like helping me most on this part of the wall.) When building this wall, Bridget and I formed a basic idea of how we wanted to proceed with the bottles that we had available. Keeping tabs of how many of each color bottle-end we had ready greatly helped to formulate a plan. In the end, we went with the idea of the ocean meeting an island coast with the night sky above. While this is all quite abstract, and maybe best seen through our eyes, it gave us a flow that we were very happy with. There is a moon above, a couple of cacti and a skull on the island, a geode bay on the southwest of the island, a lighthouse of sorts at the top of the island, and a lonely violin floating in the ocean, perhaps from a shipwreck when a lookout missed the beam of the lighthouse on a stormy night. This is where, for me, there is magic in cordwood. There is an artistry and personality to each design. I am reminded of drinks with friends, browsing through the dump, logistical challenges and eventual successes, gifts of bottles from family and friends, and everything that led to the creation that I am happy to see every day. I really enjoy taking a shower in this space, especially when the sun is shining!

The Cubbyhole

The Cubbyhole was originally intended to resemble something closer to an LED-lit cavern. The project gave me very important lessons in simplicity of design, as well as being able to let go of a feature I had in mind for years. Creating a cavernous space in a cordwood wall was a topic of discussion for a while between my parents and me. We came up with an idea: two logs cut into short shelf-like pieces that could create negative space. It seemed as though this was the answer. However, as soon as it was mocked up in the wall, it became apparent that this did not fit my vision. Despite the work that it took to get to that point, it had to be abandoned. Instead I made a very small version of what I had wanted and it turned into my personal project during a cordwood workshop day. While Mom and Dad taught Cordwood 101, I created a small nook made of mortar and one 10-inch bottle-end to recess the wall by 6 inches in this spot, as my walls are 16 inches wide. I allowed my insulation gap to become quite small (almost nonexistent) in that one area, so this would be possible. Now I have a bottle-end feature that is recessed in my wall, in which I have placed a beautiful green glass mushroom. It is one of my favorite features. I do not look at it as a failure, but as a success of necessity. Readers could create a cubbyhole for some meaningful keepsake of their own, perhaps also made from beautiful colored glass.

Darin's Summation

I hope this glimpse into my thought process with special features helps your confidence when approaching a design you wish to build yourselves. I am exceedingly happy with what has been created in my home: I did not allow myself to get frustrated with the design and building process, because I didn't want to relive that frustration every time I looked at that wall. I love every feature, and everyone who helped me realize my dreams. Enjoy the process!

8.10. Cactus in a bottle, Shower Island.

8.11. The Cubbyhole.

Design Features at Mushwood

Like Darin, Jaki and I had a lot of fun designing and actualizing several different bottle design features at our lake cottage, Mushwood. One was a map of the Chateaugay Lakes Outlet, including the dam, a beaver lodge (the log-end actually made by a local beaver and exactly 12 inches to order), our cottage, surrounding shoreline and even a couple of trout. Another design is our Australian panel, with six truly red champagne glasses mixed in with yellow, blue, green and brown bottles, with special mementos from our Down Under journey. Then there's the Big Dipper design, already discussed above, and a crystal skull and a clock face with lots of geodes, about to be discussed. And more. Not in bottle-ends, but germane to the Mushwood design, are five cute little log-end mushrooms, straight out of Disney's *Fantasia*. But most of the designs were made using the bottle-end techniques already described. The fish and the crystal skull, though, were a little different.

Using Sides of Bottles

Darin's cactus in a bottle above, a tequila bottle actually, is an example of featuring the side of a bottle. Similarly, we have the Easter Island *moai* at the Earthwood sunroom (pisco bottles from Chile: see color section), a blue and a red cat at Stoneview and the Mushwood features. We will use the fish as an example of making "sideways" bottle-ends.

8.12. Three cylindrical bottle-ends made from clear jars or bottles are the right length to support the green fish, a wine bottle.

Bottles laid as full length features in the wall, such as the fish shown, are not necessarily of uniform shape or diameter. We make cylinders of tumblers from two clear bottles of the same diameter. Their length, combined with the thickness of the special bottle feature, equals the width of the cordwood wall, 12 inches in this case. We did not cut the neck of the fish bottle. Rather, we pointed carefully, showing just the gaping mouth. Later, we added three clear marbles above the mouths of each fish, indicating air bubbles.

In our Easter Island panel in the Earthwood sunroom, we included two of the famous *moai*—the huge stone figures. These were lovely olive green wine bottles from Chile with black plastic topknots as the bottle stoppers. I replaced the plastic stoppers with cedar ones which were more in keeping with the cordwood panel. I made three clear 14-inch cylinders from six 7-inch clear coffee jars. The thickness of the *moai* bottle made up the other 2 inches of our 16-inch wall, with the statue still proud of the masonry by an inch or two. I made the *ahu*—the platform upon which the statues stand—out of large blocks of wood, carved to simulate the close-fitting stonework of Easter Island. When the sun rises, particularly from early May to early August, the entire panel comes alive as if there were light bulbs in each bottle-end. At night, we have a little spotlight that lights up the panel for dinner guests. The entire panel can be seen in the color section.

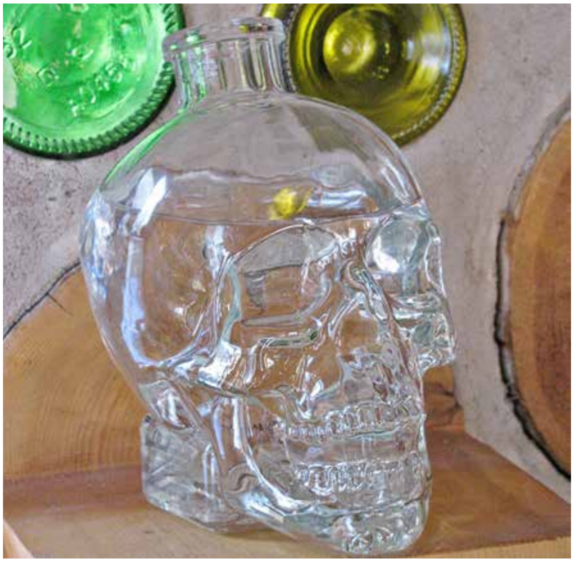
At Stoneview, we have two tall sitting cats—red and blue—also made from wine bottles. To let the light in, there are four cylinders behind each cat, made from baby food jars.

8.13. The fish bottle is supported by the inner mortar joint. A wooden shingle stops mortar or sawdust from falling between the fish and the clear cylinders.

8.14. One of the *moai* on our Easter Island panel.

8.15. The red and blue cat wine bottles at Stoneview.

8.16. The large log-end became home to the crystal skull. The smaller one, still 12 inches in diameter, was used for the mushroom design below.



8.17. Crystal Head vodka bottle.

The Crystal Skull

At Mushwood, we included a special light design that had meaning for us. While visiting Belize, we happened into the ancient Mayan city of Lubaantun. Our excellent guide's grandfather had worked for Mitchell Hedges, a treasure hunter who claimed to have found the famous crystal skull there in 1923. The veracity of the claim has long been a matter of dispute, but we were told a fascinating story that stuck with us. Crystal Head vodka has a wonderful 750 milliliter crystal-like skull bottle and we decided we'd like to have one—lit by LED lights—in our wall. Now this story intersects with another one about three consecutive hollow white cedar log-ends, belonging to Bruce Kilgore of Ravenwood fame (Chapter 19).

8.18. The crystal skull can be lit with a switched LED light.

We had admired a composting toilet that Bruce had made for his round cordwood guesthouse and asked if he would make one for us for Stoneview. He said he would, and, true to his word, showed up with a beauty. His own had been crafted of ordinary squared lumber to enclose the 5-gallon "poop bucket." Bruce said, "I hope you don't mind. I took some artistic license." Indeed. Our new compost toilet was a huge hollow white cedar log-end, the hollow made large enough for the bucket. He had carefully fitted a wooden toilet seat to the top of the log-end. Perfect for a cordwood guesthouse. “Where did you ever find a log like that?” I asked. “Oh, I’ve got more of them,” he said.

A year or two later, I procured the next slice of this wonderful hollow log from my friend and it became the home for our crystal skull. I put a half-gallon clear jug on the outside, set in mortar, and surrounded the skull with a carefully shaped piece of Styrofoam, which could be removed in case the lights ever needed replacing. Finally, I pointed mortar-colored caulk onto the Styrofoam.

Bruce used the next slice of the hollow log to house the raven of Ravenwood, seen in Chapter 19. He has still another of these magnificent log-ends available, earmarked as another composting toilet.

8.19. The log-end toilet at Stoneview.

The Three Mushrooms

In Wisconsin, Jaki and I traded a book for the beautiful 12-inch-diameter hollow ash log-end seen in Figure 8.20. Back at home, I routed the edge of the hollow part, about ⅜-inch in width and ⅜-inch in depth, both ends. Then I took the log-end to a local glass shop and they fitted both sides of the log-end with quarter-inch plate clear glass. Then the fun began.

Working horizontally, Jaki and I laid out the design seen in Figure 8.20. The three mushrooms are made from thin slices of geode from Brazil, looking very like slices of wood. They are thin enough that light passes through them easily and beautifully. Above the mushrooms, to simulate sky, we used clear and blue glass beads, which are kind of like squashed marbles, flattish on one side, curved on the topside. From the stems of the mushrooms down, we used grass-colored beads, greens and yellows. Then we mixed up some clear polyester resin and flooded our design to hold everything in place. When it hardened, we had a fine ash log-end with a mushroom design worthy of a cottage called Mushwood.

We use a lot of geodes in bottle-end walls. You can buy some very nice ones in the $4 to $10 range at rock shops and other outlets. Normally, we simply glue the geode to a clear bottle of the same diameter. Clear caulking works very well as a glue to bond the geode to the bottle-end. Later, we simply point up to the edge

8.20. Three geode mushrooms at Mushwood.

8.21. Geode bottle-ends.

8.22. Dancing mushrooms.

of the geode. Geodes come in various natural looking colors, although most are artificially colored in Brazil. We particularly like the brownish and tan ones that look like log-ends, even to their concentric "growth rings."

The Five Mushrooms

While not actually composed of bottles, our five little log-end mushrooms are surrounded by bottle-ends and are really part of a larger bottle-end mural. The one at the right reminds us of the little mushroom that runs around amongst his larger fellows in *Fantasia's* "Dance of the Mushrooms."

CHAPTER 9

Electrical Wiring in Cordwood Masonry Buildings

by Paul Mikalauskas, Mike Abel and Rob Roy

Electrical wiring in cordwood masonry buildings presents challenges different from wiring in conventional stick frame construction. One functional difference is that many cordwood buildings do not have a basement in which to hide wiring. With a little planning, however, wiring does not have to be very much more difficult than with other building styles. With creativity, one may find many nooks and crannies where wiring can be hidden.

A current copy of the *National Electrical Code* is an excellent investment. The code book will make it easier to assure that the work is both codeworthy and safe, and will give the reader answers about wire and conduit size, how many conductors will fit in a box, and so forth. The code promotes safe wiring practice, good for owner-builders, as well as for any future occupants—thinking about possible resale is not a bad thing.

The service entrance is where the electrical power first enters the building. In many conventional homes, the power company simply stretches a line from the primary pole to a conduit on the house that serves as a mast for the incoming power. Heavy gauge wires run down to the service entrance panel, often in the basement. This panel contains a main breaker and individual circuit breakers for the various lighting and small appliance circuits in the home.

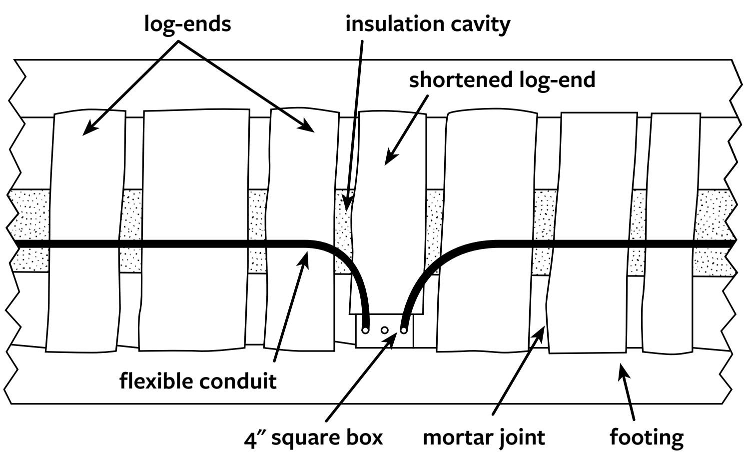
(*Author's note:* The main part of this chapter was written by the late Paul Mikalauskas who built his home, Earthwood Junior, in New Hampshire. The sidebar is by licensed electrician Mike Abel, who built a beautiful cordwood home in Missouri. I finish off with images from our cordwood electric at Mushwood Cottage, done since the earlier edition of this book.)

9.1. Power is brought underground to the service entrance at this suburban cordwood home in Eau Claire, Wisconsin.

Utilities that enter the building from underground, however, may be more in keeping with the natural appearance of cordwood buildings. If the house is to be built on a concrete slab, the builder will need to run correctly sized conduits in the earth and below the slab before the slab is poured. This is also the time to identify and accommodate for any freestanding features in the building not accessible from above or from an interior wall—features such as kitchen islands, a duplex receptacle (wall plug) near a masonry mass, and the like. Branch circuits may be run to the proper locations using schedule 40 PVC conduit.

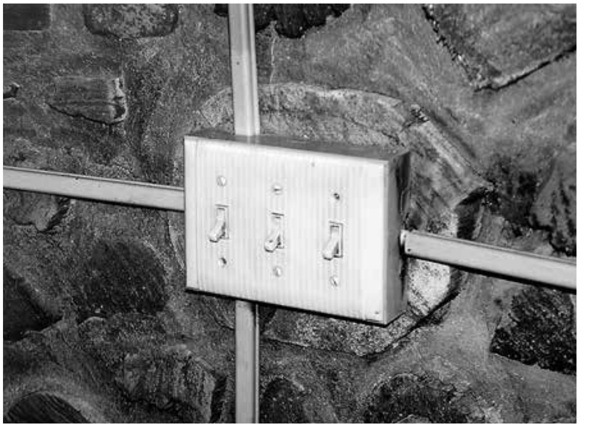
Thought should also be given to any future needs for outdoor power away from the building, and conduits should be run underground to the point or points where they may be used when needed. Conduits may also be run to outlet and switch locations in the insulation cavity of the cordwood wall. Install elbows to place electrical boxes flush with the finished interior wall.

Wiring for wall outlet circuits may be laid in the insulation cavity during wall construction. Flexible wall conduits are recommended for this (see Figure 9.2). At least one cordwood builder, however (Ed McAllen of Galesville, Wisconsin) used direct burial Romex™ conductors in the center of his 16-inch-thick cordwood walls and met with code approval because the Romex was always more than 4 inches from either surface of the wall. He brought the conductors into the back of his electrical boxes, which were set flush into large log-ends. During the winter prior to building, Ed prepared 20 or so 10-inch-diameter logs for this purpose, by cutting and chiseling correctly sized rectangular openings into the logs to receive the boxes. He routed a pathway from the box opening to the center of the log to carry the Romex from the insulation cavity into the back of the electrical box.



9.2. Electrical boxes can be supplied by flexible conduit running within the insulation cavity. Credit: CoCoCo.

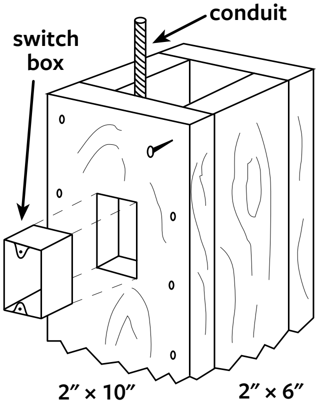
Cliff Shockey employs a similar detail with his double-wall technique. After building his outer cordwood wall and installing the hardboard, insulation, and vapor barrier in the middle third of the wall, Cliff runs his rough wiring for interior duplex receptacles, switches and lights. During construction of the inner wall, special notched log-ends, similar to McAllen's, are placed where they are needed according to the electrical plan. The rough wiring is brought into the box, leaving 8 to 10 inches extra for making final connections later.



9.3. Surface-mounted Wiremold allows the electric to be installed after the walls are built.

There may be sections where it is not possible or desirable to hide the wire in the cordwood wall or under the floor. In those cases, wiring may be enclosed using Wiremold™ or electrical metal tubing (EMT) conduit on the interior cordwood wall surface or along posts, beams, and window or door frames. Exposed conduit or Wiremold is code approved and has several advantages for the cordwood masonry builder: Using this method, cordwood masonry production is not further slowed by taking time to weave conduit or Romex through the insulated cavity. Electrical can be installed after the cordwood walls are built and the roof installed. Also, the electrical circuits are readily accessible to facilitate changes, repairs or additions.

There are some disadvantages to surface-mounted wiring. The Wiremold or EMT adds extra cost to the electrical component. New skills must be learned to make a nice job of surface-mounted wiring. And some people may not like to see surface-mounted conduit, although it is becoming more common all the time, particularly in commercial buildings. Wiremold (and other available systems) comes in a variety of colors and EMT conduit can be painted to match or contrast. By careful planning and intersection with interior partitions (where conventional wiring practices may be used), it is possible to minimize the amount of surface-mounted wiring quite a bit, although code does require a duplex receptacle every 12 feet around the perimeter of all rooms.



9.4. Box post made from 2-by-6-inch and 2-by-10-inch lumber. Use screws or coated nails and wood glue.

Feeds may be run from the distribution panel to points around the building by using the space left between the inner and outer wooden plates, often made from 2-by-6-inch planking, at the top of the cordwood wall, if your construction method happens to incorporate that detail. Wiring to lighting fixtures can be run along the top side of girders, if exposed post and beam construction is used in the home. If you build up your own box posts for a post and beam frame using, for example, 2-by-6 and 2-by-10 (see Figure 9.4), then wiring can also be run inside the box post cavity.

Other builders have run a baseboard around the base of cordwood walls, incorporating conduit or Romex conductor behind the baseboard and surface-mounted boxes on the baseboard surface. If the first course of similarly dimensioned logs is cut an inch or two shorter than normal—14 inches instead of 16 inches, for example—the baseboard need not protrude into the room.

If the builder desires to have backup power in the form of a generator, then this feature may be part of the original electrical plan, or it may be added at any time in the future. The homeowner can choose backup for only those circuits that are deemed necessary.

With powerful computers in many homes, thought should be given to determine any future locations for computers and related equipment, such as phone jacks. The

Electrical in Cordwood: Some Additional Comments

by Mike Abel, Licensed Electrician

In my round cordwood home, I used a combination of several of the methods Paul mentions but relied most heavily on flexible metallic conduit (also known as "flex"), with individual, appropriately sized stranded conductors of type THHN insulation. From my rigid conduit stub-up in the slab at the exterior wall cavity, I changed to flex with the appropriate fitting and moved on to my wall outlets and switches. The flex snakes satisfactorily through the insulation cavity, and then, using a flex connector, terminates at the end of a shortened log-end (see Figure 9.2). While building the wall, I determined the length of the flex needed, cut it with a hacksaw, and then used a fish-tape to pull a pulling string, to be used later to pull in the wire. It is important to put the string in before embedding the flex in the wall, as it is essentially impossible to send a fish-tape through the flex later. Use a multistrand poly pulling string, similar to baling twine—it is quite strong—and a wire-pulling lubricant, such as Ideal's Yellow 77, to lube the wires. The flex method is far superior to direct burial or NM (Romex) in the cordwood walls, as greater flexibility is gained at the time of the installation, as well as later when electrical changes may be desired.

For switch and outlet boxes, I used 4-inch-square metal boxes, which provide more room for wire pulling and for the making up of connections. These can be purchased in standard 1½-inch depth or deeper and can be extended in depth with extension rings. Also, this type of box allows a normal duplex receptacle location to become a double-duplex location. All of my outlets are double-duplex—an additional receptacle only costs about 50 cents—advisable because of the impossibility of getting into the walls later. For the same reason, I put those double-duplexes every 7 feet (2 meters) around the perimeter.

Flex needs to be grounded, as the NEC code book will tell you. Grounding is important. Prior to pouring the slab or foundation, an 8-foot by ½-inch grounding rod should be sunk into the ground near the service panel location. In addition, most utilities will be using a grounded neutral system, and the neutral should be grounded at the transformer. Any readers who find this all rather technical should consult their utility company, the NEC code book, or a licensed electrician.

In the slab rough-in for my round cordwood house, I included two stub-outs to all four compass points for future uses. Already, I have used one to provide power to my woodshed 30 feet away, as well as to provide an interior three-way switch for the woodshed light.

wiring requirements for technological devices are changing and uncertain. For this reason, both RG-6 coaxial cable and Category 5 phone/data wire should be run from the utility room to any location which might receive a computer, phone, fax machine or television. Consideration should be given to any speaker locations, and in-wall wire should be run from the stereo to these locations. These can be mounted by one of the methods suggested earlier and terminated with readily available wall plates. Burglar and smoke alarms should be considered at the design stage, with wiring run at the appropriate time during construction.

Just as much consideration should be given to home power systems wiring, such as solar, wind and small hydro systems. In fact, the National Electrical Code now addresses many of the issues involved with independent power. You may or may not have to pass an electrical inspection in the case of homemade power, but it is a good idea to have it inspected anyway. The inspector may spot something that might save your building or your life.

No matter which wiring method you choose, make a good wiring circuit diagram to work from. This is your roadmap, and if you sub the work out to a licensed electrical contractor, he or she will insist upon it and check it for codeworthiness.

The author wishes to acknowledge contributions to this paper from Cliff Shockey and Rob Roy; cordwood owner-builder Ed McAllen of Galesville, Wisconsin; and especially to licensed electrician and cordwood builder Mike Abel of Wetherby, Missouri.

Wiring Mushwood

For over 40 years our main residences, Log End and then Earthwood, have been off the grid—wind and solar systems and battery storage—while for 25 years, our summer camp, Mushwood, has been plugged into commercial power. Why? The heavily wooded lake lot is a poor wind and solar site, the power lines came right by and we know how to consume very little electricity, keeping our monthly bills low.

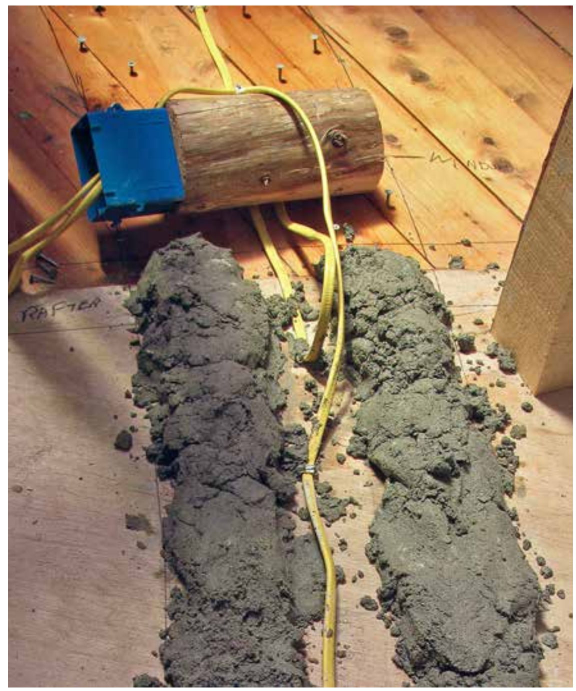
Many years ago, I took a course in wiring at the local college and did my own electrical circuit diagrams for the original Mushwood building (as Paul so rightly suggests in the main text). Then we had the wiring done by a licensed electrician.

In 2010, we decided to renew the shingles on Mushwood's mushroom cap, the geodesic dome. But when we started to tear the old shingles off, we were totally surprised that the plywood was deteriorated, actually soft. The cause was the lack of a vapor barrier and moisture condensing on the plywood with no place to go. We decided to rebuild the second story with a round cordwood space, working under the umbrella of the dome, just as we had done with the first story 20 years earlier.

I took the opportunity to photograph how we integrated electric into the cordwood walls. Figures 9.5 to 9.10 are a picture essay. You can see the inner surface of the dome in some of the pictures, and the original plywood-covered floor we built upon. We simply rewired the same circuits we had used in the dome that already lead back to the circuit breaker box.

We installed our Romex cable—two #12 conductors plus ground—right in the middle of the sawdust insulated space. As the walls were 12 inches thick, it was easy to keep the Romex at least 4 inches back from the inside of the inner surface, satisfying code. The Romex enters the 4-inch-deep boxes through the back.

9.5. Before laying the first course, we installed electrical boxes to the ends of 4-inch diameter by 8-inch long log-ends, and held them off the floor with 16-inch tall pieces of wood, so that the duplex receptacles (DRs) would be at the conventional height off the floor. These log-ends were later built into the cordwood wall. The Romex follows the insulated space between the inner and outer mortar joints. The little roofing nails sticking out of the plywood help lock the mortar to the floor. The wood is also treated with sealer and bonding agent prior to laying down the 4-inch-wide mortar joint.



9.6. The mortar has been laid for the first cordwood course, with the Romex cable running through the insulation space. The special log with the DR box attached is just lying there, waiting to be integrated into the masonry.

9.7. The wall is built up to and around the electrical box. Notice that plenty of cable is left sticking out of the box to make the connections to the electrical equipment easy for the installer.

9.8. We installed electrical boxes directly to the side of the 12-inch-wide door frame. The Romex coming up from the circuit breaker box on the first floor follows the insulated space, and is stapled between two 1-inch by 1-inch key pieces on the door frame. The M-I-M stick shows where the mortar, insulation and mortar will go.

9.9. A view of the other side of the door frame shows the key pieces more clearly, as well as the first course of cordwood masonry.

9.10. A double-wide box fastened to a door frame (left side of image) will provide switches for an overhead light, as well as the LED light inside the crystal skull's hollow log (right side), as described in Chapter 8.

CHAPTER 10

Lime Putty Mortar

by Rob Roy and Bruce Kilgore

A Short History

Lime mortar has come back in vogue with the modern natural building movement, but it has been around a long time, at least since Minoan Crete about 3,000 years ago. Romans, building on the work of the Greeks, greatly improved lime mortar. The writer and engineer Vitruvius famously said of lime mortar, "After slaking it, mix your mortar, if using pit sand, in the proportion of three parts of sand to one of lime."

Independently, the Mayans made similar lime-based mortar products and stucco. Archaeologist Tom Sever says of the Mayans, "They had to burn twenty trees to heat the limestone for making just one square meter of the lime plaster they used to build their tremendous temples, reservoirs, and monuments." This deforestation for lime production may have contributed to the collapse of Mayan civilization.

In the late 18th century, Englishman John Smeaton laid the groundwork for modern hydraulic cements, leading to bricklayer Joseph Aspdin's famous Portland cement which he patented on October 21, 1824. In 1872, David O. Saylor made the first cement in the United States, in eastern Pennsylvania. It was not until about 1900 that Portland cement became as commonly used as lime mortars.

Lime Putty Mortar Versus Portland-based Mortar

Lime mortar is most easily and most economically made by mixing lime putty with sand, as described below. But what are the pros and cons of using lime putty mortar (LPM)?

Pros

- LPM requires only Type S hydrated lime, sand and water.
- It is very light in color, a plus with light-absorbing cordwood masonry walls.

- Mortar pointing can often be done the next day, if necessary.
- Lime mortar has a long track record: Romans used this mix 2,000 years ago and it has shown impressive durability.
- It is more environmentally friendly than cement mortar, having much less embodied energy in the manufacturing process (see sidebar).
- LPM is pleasing to work with; it is very cohesive and plastic.
- Good quality control can be maintained by careful volume or weight measure.
- Calcification can close up small gaps and cracks in LPM over time.
- Lime-based products, such as mortar and plaster, offer superior breathability to cement-based products.
- If a clean work area is maintained, dropped mortar can be recovered and used, minimizing waste. You can do this somewhat with Portland-based mortar, too, if you use it right away.

Cons

- Type S hydrated lime may be hard to come by in different parts of the country.
- Lime varies greatly in price.
- The lime putty should be made a minimum of three days in advance, although the authors recommend five days. For a large project, like a house, it is good to make five or six large batches at a time.
- LPM is subject to frost damage for a longer period of time than other mortars. Special care must be taken using LPM if temperatures of 30 degrees Fahrenheit or less are likely within a two-week period after laying up the wall. A lot of protection is afforded by draping both a blanket and a piece of plastic over the wall when low temperatures are anticipated. Take the covers off when temps climb back to 36 degrees or more. This method of frost protection works, too, with cement mortars, but you need only be concerned for two days, not weeks.
- Full strength—or nearly full strength—may take a month to achieve. Portland cement is hard and strong in days, not weeks. We don't see this as a huge drawback unless you want to build a large load-bearing cordwood wall fast.
- Bruce, with a thousand batches of experience with LPM behind him, notes that lime mortar has "a more narrow range of forgiveness" than Portland-based mortar. He emphasizes the need to pay attention to detail.

10.1. Cordwood masonry with lime putty mortar, made by Nancy Dow.

Making Lime Putty and Lime Putty Mortar

Over the years, we have seen that success with LPM is a matter of minimizing variables. Careful quality control has produced good results, whereas there have been failures where variables are not kept within best practices.

Get the Right Stuff

The first and most important variable is to use the right lime, which is dry hydrated Type S lime, which comes in nominal 50-pound bags. Rob goes further and likes to see a reference to building or masonry use on the bag. One time, organizers of a building colloquium secured a Type S agricultural lime; we had no choice but to try it. It made what appeared to be good mortar: it was plastic and supported the cordwood wall. But it never set up and was weak and crumbly after a week or two, instead of strong and hard. Also, be wary of lime which is more than six months old or has been improperly stored. A broken bag should not be used, according to restoration contractor Blair Bates. Bruce is a stickler for getting his lime as fresh as possible. While trying to perfect LPM, he discovered that bags of lime can vary by five pounds or more. "That was the *aha* moment," he says. He began to weigh everything—lime bags, lime putty, sand, even water—which led to diminished variables and high quality LPM.

Accuracy in Measure

Accuracy is important, whether you use Bruce's weight method or Rob's volumetric method. For making lime putty, Bruce weighs three bags of lime in pounds. Then he measures out a weight of water which is three-quarters the weight of the lime. If three bags weigh 160 pounds, for example, he mixes in 120 pounds of water to make the lime putty. To this water, he mixes in a cup of inexpensive dishwashing liquid. Why? See the sidebar. He starts with about a third of the water in the bottom of a plastic vessel made from half of a 55-gallon plastic drum. He adds a bag of lime and lets it sink in, then homogenizes it with a paddle mixer attached to a strong (one-half horsepower) electric drill. Then he adds

Environmental Issues

Tomas Lipps, editor of *Stonexus Magazine*, notes: "The manufacture of cement and lime accounts for ten percent of the entire world's contemporary carbon emissions. It must be said, however, that making hydraulic lime and quicklime requires less heat and produces less carbon dioxide. And, to their credit, lime mortars reabsorb carbon from the atmosphere as they set and harden, through the process called carbonation, thus ameliorating harm to the environment." *Stonenexus Magazine* Number VIII.

10.2. Bruce carefully measures water and Type S hydrated lime into a vessel made from half of a 55-gallon plastic drum.

10.3. Mixing the lime putty with a paddle drill.

another third of the measured water, being careful to pour the water onto a mason's trowel "floating" on the first third so as not to upset the stuff below. Then he adds another bag of lime and repeats the procedure, and then once more. After all the layers are added, he homogenizes the entire mix one more time with the paddle drill. The lime putty is allowed to hydrate five days.

If all this sounds fussy or fastidious…it's not. There have been failures with LPM. Bruce emphasizes getting the procedure right from the word go.

Rob's method is based on water volume. He does not weigh the bags, but is also careful to obtain fresh lime of the right kind in unbroken 50-pound bags. Rob distributes 2.25 gallons of water in each of two plastic 5-gallon pails, and then splits a 50-pound bag of lime between the two pails. He lets the lime percolate into the water, then mixes it with the same type of paddle mixer that Bruce uses. It can be mixed with a broom handle or similar stick, but this is tedious, takes a long time and we think we get a better mix with the paddle and drill.

With either method, cover the top of the container with plastic. The lime putty is ready to use after five days, but will only get better with age. Bruce has used it after weeks, even months, with excellent results. Rob relates an anecdote he heard that, in olden times, a keg of lime putty was a good and valuable addition to a bride's wedding dowry, along with a cow, goat, etc.

Again, with either method: wear a respiration mask when dumping the bags of lime. The dust is nasty and caustic. See also the Safety sidebar.

Wetter Water

Dishwashing liquid added to the mixing water serves as a surfactant, effectively making water wetter. The positive result is a very even water distribution though the entire barrel. As a bonus, the mixing process is both faster and less fatiguing. (Rob wonders if a little dish soap might benefit Portland mortar, too. *Hmmm, worth a test.*)

Sand—A Critical Variable

Both authors use the same fine masonry sand used with Portland-based cordwood mortar. Theoretically, a coarser sand should work, but using coarse sand at a Colorado workshop resulted in a less cohesive (plastic) mortar to work with, and, ultimately, the mortar became crumbly, which may have had more to do with the extreme drying conditions in the clear dry air at 8,200 feet. Roy's son, Rohan, conducted another workshop in similar conditions, with similar results: weak, crumbly mortar.

Of great importance is that the sand be kept dry. If it is too wet, it will not be possible to make a stiff enough mix to use with cordwood masonry. So, get dry sand—and *keep it dry*—by keeping it well covered. You can add water to a mix, if needed, but you can't take it out if the mortar is too wet before any water is added. Both authors rarely have had to add water to the mix, although we have both done so with very dry sand. You cannot add dry lime to the mix in order to stiffen it up. All lime used must hydrate a minimum of three days.

Mixing the Lime Putty Mortar

Bruce, a stickler for detail and consistency, measures each wheelbarrow load (batch) by weight: 75 pounds of sand and 28 pounds of lime putty, already prepared as described above. He mixes the ingredients first with a hoe until the mix is a consistent color throughout. Then he kneads the mortar with his gloved hands against one end of the barrel, much as pizza dough is kneaded. He kneads the mortar towards one end of the wheelbarrow, then the other. If it passes the stiffness tests (see below), it is finished.

Rob works with volume, not weight, beginning with a level 5-gallon pail of sand and a level 2-gallon container of lime putty. He places about half the sand in a wheelbarrow, adds all of the lime putty and mixes it thoroughly with a garden hoe until it has the consistency and appearance of marshmallow fluff. To this he adds the remaining sand and works it over until the mix has a consistent texture. Influenced by Bruce's success, Rob has also adopted the kneading technique, which drives the lime into the sand voids much more effectively than simply turning and chopping with a hoe.

10.4. Weighing mortar materials.

10.5. Bruce kneads the mortar.

Organizing the Mixing Area

Bruce takes great care to organize his mixing area for efficiency and consistency of mixing. He uses six lime putty drums, each one being a half of a 55-gallon plastic drum, ripped along its waist with a circular saw. He labels each batch with its date of mixture, so that he is always using lime putty at least three days old, and preferably five or more. (Once, when two-day-old lime putty was accidentally used in the mix, cracks formed in the masonry a few days later.) Plastic covers the half-barrels and the entire site is under cover.

Kilgore's sand is dry and under cover and he brings a quantity of it to the mixing area as needed. He has scales for weighing water, sand and lime putty and uses them with every batch. Paying careful attention to detail has yielded consistent workable mortar, without cracking, except, as noted, with two-day-old putty.

Testing and Consistency

Both authors test the mortar for consistency. A snowball-sized ball of mortar caught from a three-foot-high toss should neither shatter nor collapse in a soft "sploot," like a fresh cow pie. It should be cohesive and plastic, and rather stiffer than brick or block mortar. It should support itself along the steep side of the wheelbarrow

10.6. Bruce Kilgore's "production line" mixing area.

without slumping. Mortar which is too wet is sticky and difficult to work with and is more prone to shrinkage cracking, as all that water is transpired out during drying. Mortar which is too dry is harder to place as it is less plastic. More will spill onto the ground.

If the LPM is too dry, a little water can be added and the batch mixed again. If the mix is too wet, a little dry sand may be added, but not dry lime. By Rob's volumetric measure, up to a gallon of extra sand can be added and still be within the 3-to-1 formula recommended by Mr. Vitruvius 2,000 years ago, although both authors have come to prefer LPM with a sand-to-lime putty ratio closer to 2.5 to 1.

Using Lime Putty Mortar with Cordwood Masonry

Work in the shade, whenever possible. It is worth creating shade by stretching a tarp out from the roofed timber frame. The advantages of building cordwood masonry under the umbrella protection of a roofed timber frame are well known: it makes the building inspector happy, and the masonry work takes place out of the rain and direct sun.

In normal drying conditions, we rough-point the wall as we build, leaving about a quarter-inch of the

Safety with Mortar

With any mortar, but particularly if it's lime-based, take care not to inhale the dry powder. Use a good mask or respirator when handling and pouring bags of lime. Goggles are advised, too, as any cementitious product is nasty on the eyes. Always wear cloth-lined rubber gloves when handling lime, lime putty or in the mixing or laying of LPM. Lime is alkaline. A good antidote to lime burns is a mixture of water with vinegar added so that it is about five percent of the volume. The acidic vinegar helps to neutralize lime's strong alkaline nature.

10.7. Jaki Roy and Nancy Dow work with LPM on Bruce and Nancy's Ravenwood home in Saranac, New York, described in Chapter 19.

log-ends "proud" of the mortar background. Normally, final or "finished" pointing is done by the end of the workday, although one couple of our acquaintance was very happy with the husband building the cordwood wall one day and his wife coming along the next morning and pointing it. Rob and Jaki, have also done finished pointing the next day, but, more often, do it the same day. We have seen certain exposed conditions where pointing was difficult or not possible the next day. LPM might take two weeks or more to get fully hard and strong, but we have not been limited as to how high a wall we can build in a day.

Bruce's wife, Nancy, did all the building and pointing at Ravenwood, while Bruce and an assistant rushed to keep her supplied with log-ends and mortar. Rob mixes the mortar and lays up the wood with his wife, Jaki, who does most of the pointing. All agree that the pointing process with LPM is much faster and easier than pointing cement-based mortars. It is more plastic and smoother.

Pay Attention to Detail

Lime putty mortar is not for everyone. Success with LPM—and there have been failures—depends upon minimizing variables, as described above. If you are not a detail person, use the more forgiving Portland recipe in Chapter 3.

We cannot emphasize strongly enough the advantage of doing a test project with LPM before purchasing large amounts of lime and embarking on a 1,500-square-foot house. The test project can be a little garden shed, or a back panel of the house which might be hidden in some way. At the least, try several batches in a test frame and wait a couple of weeks to see how they perform. If successful, keep up the same methodology. If unsuccessful, try something different. Experiment further with the LPM...or switch to Portland. If your main reason for choosing LPM is environmental, and you have a ready source of clay, you might consider cobwood, covered in the next chapter, or paper-enhanced mortar, described in the chapter after that.

CHAPTER 11

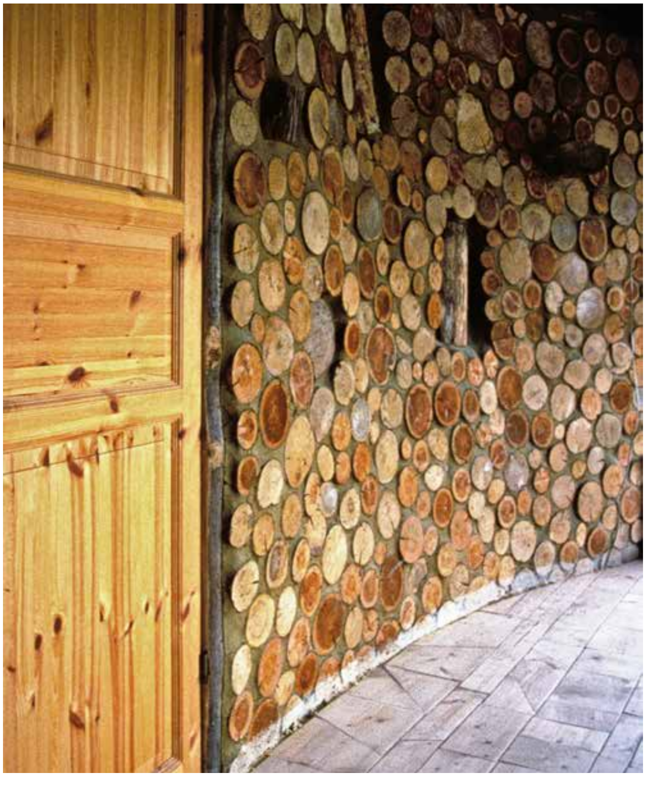
Cobwood Revisited

Just as fuel consumption should be an important consideration in deciding on a vehicle purchase, the embodied energy of building materials (the amount of energy required to manufacture those materials) should be factored in at the design stage of home building. Pertaining to cordwood masonry, for example, it takes 500,000 BTUs of energy to make a bag of Portland cement—equivalent to four gallons of gasoline. And there are other environmental considerations, such as air quality impact and the fact that limestone quarries lay waste to a lot of land. Is there a natural material that can substitute for the mortar in a cordwood wall? There is, and it's called cob.

In Old English, cob means a lump or rounded mass. In construction, it has come to refer to building with earth, usually one cob at a time—each one the size of a small loaf. At least one-third of the world's people live in earthen homes of one kind or another (cob, adobe, rammed earth, etc.) and have been doing so since the beginning of human history.

Tony Wrench, who wrote Chapter 19: A Cordwood and Cob Roundhouse in Wales in the first edition of *Cordwood Building*, said there: "The clay, which we used in place of cement mortar, was all taken from site. A JCB (backhoe) dug a circle into the bank, and the subsoil turned out to be clay with a bit of sand. We just mixed this with rainwater and a couple of handfuls of straw per wheelbarrow load and wound up with a very good cob material, as has been used for construction in Britain for over 1,000 years. We used a bit of bracken in the cob, as well, but not much. There has been some shrinkage around the log-ends. Gaps of up to a half-inch have appeared, especially around the south side, but these are easy to fill with a little additional cob."

11.1. Tony's Roundhouse, circa 1999, nestled nicely into the Welsh countryside.



11.2. Detail of Steen Moller's cobwood wall in Denmark. Credit: Catherine Wanek.

Blessed with clay-laden soils, Tony basically used the earth at his feet for his mortar. Jaki and I visited Tony's Roundhouse in 1999. As infilling, the system was obviously sound, although we thought the surface texture could have been improved with pointing, something he and his followers have been doing very nicely ever since. Tony has been teaching his cobwood roundhouse methods in Europe for a number of years and has a new 278-page color-illustrated book on the subject, *A Simple Roundhouse Manual* (see Bibliography). Search "that roundhouse" on the Internet, and you will find a number of websites and videos about Tony and his work.

Ianto Evans and Linda Smiley have taken cob to a higher standard, although they are still careful to follow traditional cob building techniques where these have passed the test of time. At their Cob Cottage Company in Coquille, Oregon (cobcottage.com), they teach the use of "Oregon Cob," with ingredients falling within certain proven parameters to assure maximum strength. More on this later.

Cordwood masonry is time consuming, but so is making a wall of solid cob. Combining the techniques can cut the labor-intensive cob-mixing process down to, say, 30 to 40 percent of that used in a solid cob wall, a compelling attraction. But can it be done? Well obviously, yes it can, as Tony and many others have proven.

Cobwood at Earthwood

Jaki and I had just finished hosting a major, four-day Megalithics (stone circle) Workshop at Earthwood, and our energies were still high when Linda and Ianto arrived, fresh from a cob workshop they had conducted in Ontario. We all had an interest in trying cobwood construction and figured that the four of us ought to be able to work it out, if anyone could.

The garage had been recently completed with standard cordwood mortar throughout. The frame was 8-by-8 inch timbers, establishing an 8-inch-thick cordwood wall. The log-ends were mostly spruce, three years cut and dried, with a few pieces of white cedar, poplar and basswood, also very dry. The wall panels were all protected by two feet of overhang. Jaki and I decided to remove a translucent 4-foot by 7-foot sheet of fiberglass greenhouse covering from one of the panels and replace it with cobwood. We figured we could get by with a little less light in the building, in the interests of science.

Our first problem was that we had not a speck of clay on top of the hill where we live, and Ianto can literally smell the stuff out. I called a contractor friend and learned that he'd done an excavation a half-hour away, and that he didn't think the owners would mind if we took a little of the messy, greasy stuff. We took my pickup truck over to the site and loaded on enough sticky, gray clay to make cob for the test panel. When we got back to Earthwood, Ianto began soaking the clay clumps in 5-gallon buckets, to hydrate (or soften) it so that it would be ready for use the next day.

Another missing ingredient was good straw. We had some rotting straw, but Ianto said that wouldn't do, so we ended up using some dry, fairly coarse hay instead of straw. (Straw is preferable, though, because its high cellulose content prevents it from breaking down easily.) Fortunately, we did have plenty of sand on site—both coarse and fine.

The cob experts could tell by feel that the clay we'd found was quite pure, so they recommended a mix that would be about 20 percent clay and 80 percent sand by volume. Some builders may be fortunate in having earth on hand with a favorable combination of clay and sand. Generally, an earth with clay content of from 10 to 30 percent will yield pretty good cob.

But how can you tell?

Cobbers recommend the shake test. First, pulverize a sample of your soil and put some of it in a clear quart Mason jar, filling say one-third of the jar. Then add water so that the jar is almost full. An added teaspoon of salt is said to help any clay to settle out. Put the lid on and shake the heck out of the mix. Then, set it down and watch the earth materials settle out. Within three seconds, the pebbles and the coarse sand will settle to the bottom. Silt or very fine sand may take ten minutes to settle out. If there is no clay in the soil, the water will be fairly clear at this point. In this case, clay would need to be imported to mix with your soil for cob-making. If clay is present, it'll be suspended in the water after 10 or 15 minutes. It may take hours to days for the clay to settle out, but once the water is clear, you can determine the percentages of sand and silt. You will also know if there is clay, but Ianto tells me that the shake test will not give you a very precise percentage of clay unless the water is somehow removed—a very difficult process.

Shovelfuls of our sand and hydrated clay were piled in the middle of a 6-by-8 foot blue polyvinyl tarp lying on the middle of the garage floor. Best to put the sand down first, as the clay tends to stick to the tarp. The ingredients were added at the rate of four parts sand to one part of our fairly pure hydrated clay. After a manageable amount was assembled in the middle of the tarp—about a 5-gallon pail full—Linda taught us to turn the ingredients by lifting the edges of the tarp, always folding the goods into the center. This goes better with two people, one on each side of the tarp.

Turn the goods until the clay clumps are broken up and the mix has taken on a fairly consistent coloration.

After turning, the mix is danced on by the cobbers. Jaki and Linda each wore rubber wading shoes, although many cobbers with toughened feet perform this operation barefooted. Sharp particles, however, can cut tender feet, so be warned. Know your material and your feet. Personally, I prefer the protection of the rubber wading shoes. The purpose of this dance is to drive the tiny clay platelets into the voids between the sand grains. Sand gives the cob its hardness and nonshrink characteristics, while the clay acts as the cement that bonds the material together and gives it strength. The clay can be thought of as natural cement when used in this way.

11.3. The cobber's dance. These young experienced helpers made our cob for us at our cobwood wall demo at the 2015 Natural Building Colloquium, Kingston, New Mexico.

Water can be added to give the cob a good plastic consistency and texture. Then straw (in our test, coarse hay) can be shaken into the mix from the flakes of bales and pressed in with your feet. More straw and water can be added as needed, and you will find it handy to turn the mix over now and again by lifting the corners of the tarp. How much straw? After a while, the cob will feel like a tough cohesive mixture, as opposed to squishy mud.

We started out making cob in pretty much the same way as Ianto and Linda would prepare it for a solid cob wall. We had to start somewhere.

Then it was time to experiment with the cobwood technique. Jaki and I laid out the cob on the 8-inch-wide wooden base of the panel as if it were mortar. We found it difficult to work with because of the long fibers of hay. We experimented with the M-I-M method (except that we were using cob instead of mortar) but also tested a solid cob joint transversely through the wall. We showed Ianto and Linda how we set the log-ends and found that it was much the same as with mortar—except the cob was stiffer than ordinary cordwood mud. The tough part was pressing the long-fibered cob into the spaces between log-ends. It worked well to use long sausage-like cobs with a cross-section similar to the mortar for which we were substituting.

11.4. Linda Smiley (left) and Jaki Roy lay up cob in preparation for log-ends. Note that rubber gloves are not necessary for playing with "mud pies." The panel at right is cordwood with mortar.

On the next batch, we tried shorter hay fibers, made by running our rotary lawn mower over a flake (thin horizontal section) of the hay bale. In no time, we had fibers about two to three inches long. This cob was easier to mix and much easier to lay between the log-ends.

We had a lot of fun sharing and combining our respective disciplines, and, after two day's work, we had learned quite a bit. Even in the first hours of the test, we were all optimistic that it was going to be a success. Ianto and Linda were happy with the way their cob was performing, and our log-ends didn't seem to mind being laid up with cob instead of mortar. In fact, the wall took on the appearance of a more or less ordinary cordwood wall, except that the "mortar" was brown rather than gray. The only negative was that we could only build about halfway up the 4-foot high panel. The cob began to slump under additional load. Stiffer cob—on a thicker wall—would be better, as we found in New Mexico in 2015 (see below). But the small, relatively delicate mortar joints of our 8-inch-thick garage panel could not be built with stiffer cob.

Linda showed us how to make a finer cob for plastering or pointing. This mix made use of some finer sand that we had on hand, a higher percentage of sand, finely chopped hay and more water. This plaster-grade cob was easier to point, and the hay strands were easier to hide than when we pointed the regular, somewhat coarser cob. It seemed to work well to recess the cob just slightly more than you want for the finished product, and then, on the same day, apply the finish cob mixture for better pointing. The fine cob, pressed into the cob base under the pressure of the pointing knife, adheres seamlessly.

11.5. Our cobwood panel in the garage, well protected by overhang, still looks good after 15 years.

We have left the panel in place for visitors to see. It is beautiful, with a lovely constellation of brightly colored bottle-ends as a design feature, as well as two large white cedar log-ends. The cob has taken on a light brown color, making the mortar in the adjacent panel look very gray indeed. The cob is quite hard, although it can be scratched—barely—with a fingernail.

The panel is fifteen years old as I write. It still looks great. There is no deterioration or flaking of materials. And it has a very warm appearance.

I had heard that cob could be refinished by spraying it with water and reworking it with a pointing tool, so in 2015 I conducted a test on our cobwood panel. I sprayed a rough section—there were a couple of hairline cracks, as well—with water and worked it over with my favorite pointing knife. Instantly, I had a smooth, fresh-looking surface.

In fairness, the panel is small—4-feet by 6-feet 6-inches—and surrounded by a heavy post and beam frame, so the bearing strength of the cobwood panel is not an issue. In Tony's Roundhouse, the cobwood walls were not called upon to be load bearing. Cobwood can be an attractive means of infilling a post and beam frame while making use of all natural materials—and that's pretty good. Ianto tells me that he sees no problem with cobwood as load bearing, providing that good house-quality cob is used. Ianto, of course, has infinitely more cob experience than me. But I would add this caveat: *not in a seismic zone*.

Should there be an insulated space between inner and outer cob joints? My gut feeling is that in cold climates the insulated space should be retained. Ianto Evans agrees. Another real plus with the cobwood wall, over solid cob, is that much less

Cobwood in Korea

At the 2015 Continental Cordwood Conference, Richard Flatau of Cordwood Construction LLC presented a paper that he had researched mostly from the Internet, but with some help from a friend in Korea. Richard told us about "soil houses," traditional peasant homes that dot the South Korean countryside. These homes are made completely of soil, but often builders use cordwood rounds in the walls for structural stability.

11.6. A typical Korean soil house with large log-ends as structural and decorative members.

cob needs to be mixed. With solid cob joints in a cobwood wall, about 40 percent as much cob needs to be mixed as with an all-cob wall. With the insulation in there, the amount of cob needed would be more like 25 percent. I am convinced that the wooden portion of the wall has a higher R-value than does solid cob of the same thickness.

Our Latest Cobwood Wall Building

Jaki and I were invited to present on cordwood masonry at the 2015 Natural Building Colloquium in Kingston, New Mexico. We were asked to use cob instead of mortar. As we were keen to do further experimentation and there were young cobbers willing to assist us, we were happy to oblige. Linda and Ianto were there, too, so it was like old home week.

The project was to extend an exterior wall for the Black Range Lodge along Kingston's Main Street. The walls would be 18 inches wide and about 2 feet high. Although such a wall does not need insulation, we decided to demonstrate how this could be done for a home. We made a M-I-M stick demarcated into 6-inch sections for mortar, insulation and mortar. The mortar, of course, was really cob, so I suppose we should have made a C-I-C stick.

11.7. Cobber Jaki having fun getting her hands in the mud. Credit: Rob West.

11.8. Our cobwood wall demo in New Mexico, completed.

There was little available sawdust for the insulation, but the cob people had a wonderful machine on site which chopped straw into one-inch pieces, perfect to insulate the gap between the two cob joints—and also perfect as the reinforcing binder in the cob itself. With experienced volunteer help (see Figure 11.3) we didn't even have to make the cob. Our assistants had us check the consistency of their mix, so that we had the right "slump" or stiffness to lay up the wall. The mix was about 25 percent clay and 75 percent sand, with the straw for extra tensile strength, like the glass fibers put into reinforced concrete. With all-cob construction—no cordwood—the straw is used at much longer lengths. The beauty of the short lengths is that pointing the surface is very much easier.

In the days prior to our workshop/demo, Jaki and I had cut a lot of log-ends to length at a little sawmill across the road, and made a couple of dozen lovely 18-inch bottle-ends, which Catherine Wanek of the Black Range Lodge really wanted in the wall.

We started on a earthbag foundation, which, itself, was supported by an existing—*shudder*—concrete foundation. (Our natural building friends frown on cement mortar, but seem to turn a blind eye to a concrete foundation!)

The earthbags were not wide enough to support the width of the cobwood wall, so we first packed a lot of cob up against both sides of the bags to get the required 18-inch width. This also served to hide the edges of the sandbags.

After that, everything seemed to go smoothly. Friday's demo was just for attendees, but Saturday's was open to the public, and interested people came from quite a distance. We would place our two 6-inch-wide by—roughly—1.5-inch-thick cob joints, install our straw insulation and then start placing log-ends in the usual way, careful to get the wall into the random rubble style by choosing pieces of varying diameters. Lots of people got their hands into the work and we managed to finish the section with a solid cob top just a few minutes after Saturday's dinner bell went off. I was ready to quit before then, but was shamed on to finish by friends Steve Chappell (Fox Maple School of Traditional Building) and Kelly Hart (greenhome building.com). Thanks, guys!

That night, the last of the colloquium, I gathered attendees as they exited the nearby classroom after a talent show. I gave them a light show at the wall, by having them stand on the outside of the wall while I played on the bottle-ends with two strong flashlights. Everyone oohed and aahed!

11.9. Cobwood detail.

But did we learn anything new? I think so. The chopped straw machine is great and would enable a cobwood builder to produce any amount of cheap insulation if they had straw on hand, which they would have to make the cob. The chopped straw, it seemed, would be a very effective insulation, and it was easy to install in the wide space in the middle of the wall. Finally, we were impressed with the mass and power of the wall. I think such a wall could be load bearing in a non-seismic area, but the builders would still have the downside of working out in the open. Care would need to be exercised to protect the wall-building from rain. We only built up about 18 inches in a day, but I am confident that we could have built twice that high with no slumping of the cob, which we had experienced years earlier on our relatively delicate garage wall.

To Summarize

1. Cobwood is appropriate for builders with access to good clay. We once experienced a failure at a workshop where our hosts provided what they thought was good clay. Indeed, the cob/mortar we made seemed to perform very well in the building process. But it never set up. In fact, it turned crumbly in time. Fortunately, we had also taught regular mortar at the same workshop, so not all was lost. Be sure of your clay. If in doubt, do a test panel and observe it after two weeks.
2. If you've got access to good clay, cob is kinder to the planet than cement-based mortar.
3. Thick cobwood walls of 16 inches or better *might* support a considerable load in non-seismic areas. This seems to be the case in South Korea (see sidebar), where cob and cordwood has been combined in round houses, but without an insulated space.

Top left: Bruce Kilgore and Nancy Dow in front of Ravenwood.

Top right: Bruce and Nancy's Ravenwood home, Saranac, New York.

Left: Nancy Dow's fine cordwood work, done with lime putty mortar.

Bottom left: Kitchen area at Ravenwood.

Bottom right: Living room at Ravenwood.

Above: Tom Huber's Cedar Eden, described in Chapter 13.

Left: Hexadecagon in Tasmania. (Peter Robey photo.)

Bottom left: Cordwood earth shelter by Geoff and Louisa Huggins, Winchester, Virginia. (Geoff Huggins photo.)

Below: Alan Stankevitz's home in La Crescent, Minnesota, features paper-enhanced mortar and spray-in foam insulation.

Top left: Hexadecagon in Hawaii. (Ben Oliveros photo.)

Above: Kim and Mike's Mermaid Cottage in Del Norte, Colorado.

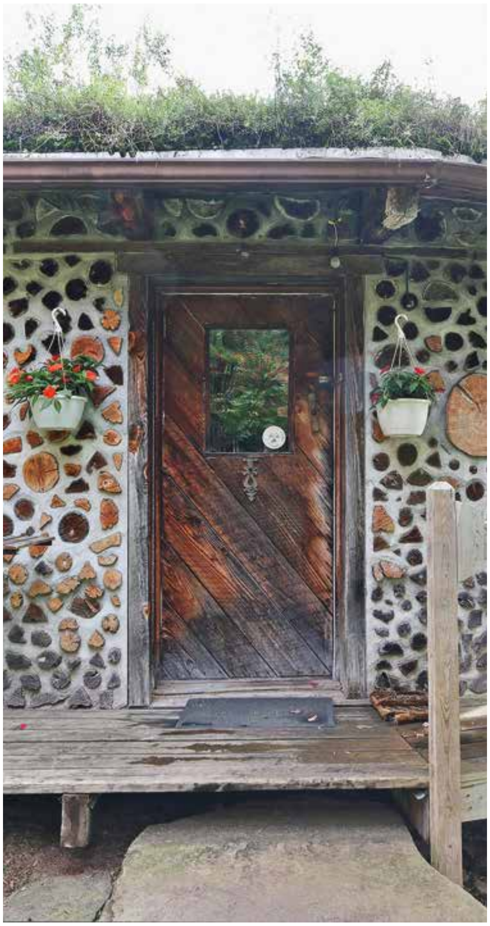
Left: "The Cordstead," by Sandy and Angelika Clidaras in Quebec. (Photo supplied by Sandy Clidaras.)

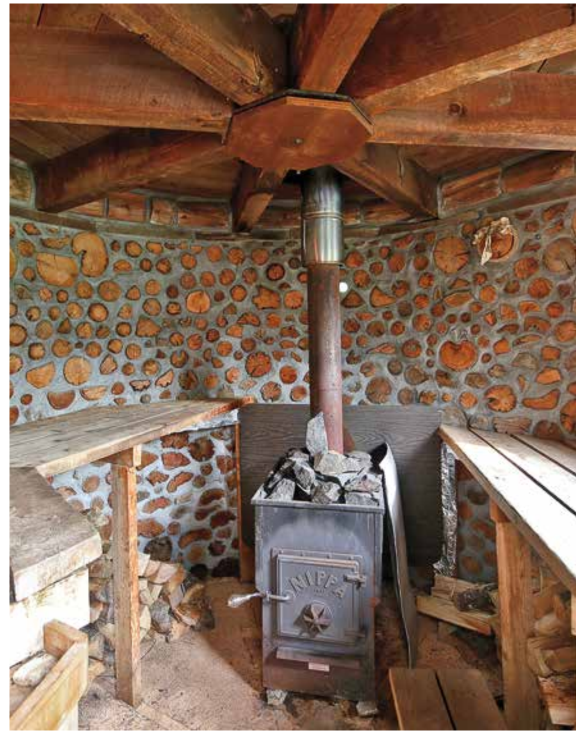
Below: Stackwall-cornered addition in Peru, New York, by Bruce and JoAnne Kennedy.

Top, right: Earthwood and author's home, West Chazy, New York.

Below: Second story entrance to Earthwood.

Below right: Earthwood outbuildings.





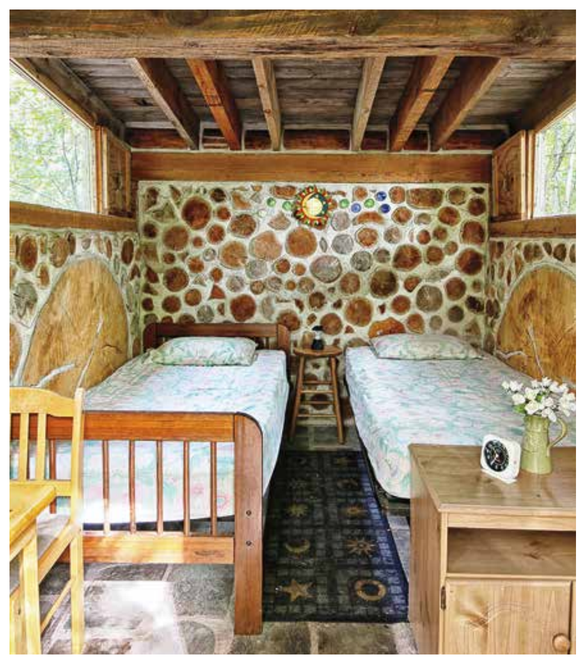
Top left: Earthwood interior.

Above: Earthwood sauna, West Chazy, New York.

Left: Sun room at Earthwood.

Bottom left: Stoneview guest house, Earthwood.

Bottom right: La Casita guest house, Earthwood.



Above: Pedro's house, Isla Mancarrón, Nicaragua.

Bottom right: Hostal Sueno Feliz, Isla Mancarrón, Nicaragua.

Left: Two fish and a parrot at Pedro's house, Nicaragua.

Top left: A map of Chateaugay Lakes Outlet, two fish, and the East log-end are part of the design features at the author's Mushwood Cottage, northern New York.

Above: Mushroom design on hollow log-end, Mushwood Cottage.

Left: Five little mushrooms at Mushwood.

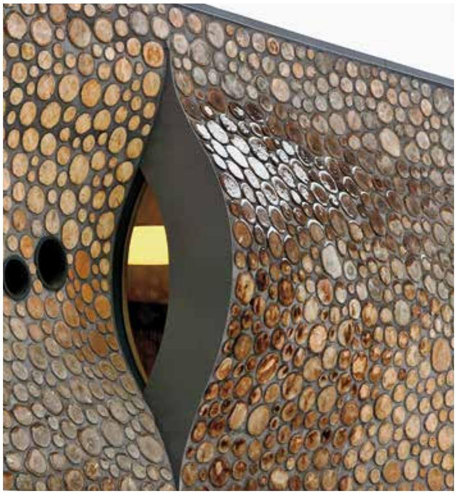
Bottom left: Darin Roy's shower, Driftwood, West Chazy, New York.

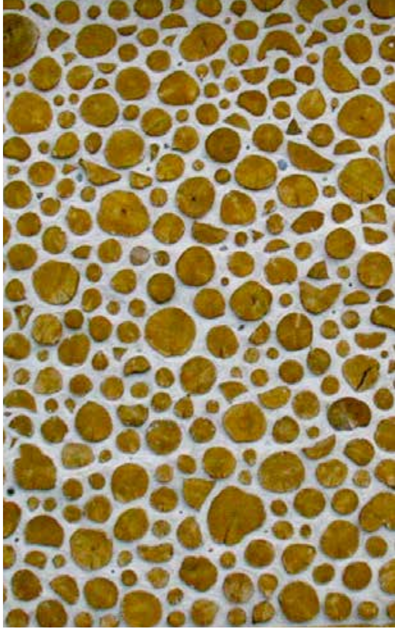
Bottom center: Bottle-end design at Mushwood.

Bottom right: Easter Island *moai* at Earthwood.

Above, left: The Arcus Center for Social Justice Leadership, Kalamazoo, Michigan. (Photo by Steve Hall, © Hedrich Blessing)

Right, below: The "warped wall" at the Arcus Center, Kalmazoo, Michigan. (Photo by Steve Hall, © Hedrich Blessing)





CHAPTER 12

Paper-enhanced Mortar

by Jim Juczak, Alan Stankevitz, Tom Huber and Rob Roy

Introducing my fellow authors. Jim and Alan are both former students, and both built large Earthwood-type houses under the umbrella protection of nominally round timber frames. Jim's Woodhenge near Watertown, New York, has 18 sides while Alan's home in south-eastern Minnesota, has 16 sides. Alan runs the fine daycreek.com website on cordwood masonry. Friend Tom began doing cordwood in Michigan during the 90s and brought it east when he took a position near us at Paul Smith's College in northern New York. Tom has done a number of beautiful cordwood buildings and has written papers for the past four Continental Cordwood Conferences. This chapter is revised and updated from Chapters 14 and 15 of the first edition, with new material from Tom Huber, who is also the solo author of the next chapter.

Papercrete, or Paper-enhanced Mortar (PEM) *by Jim Juczak*

The traditional cordwood masonry pattern is mortar, insulation and mortar layers: I had vivid memories of Rob's M-I-M pattern stick that he uses as a teaching aid. I was frustrated with the slowness of M-I-M type masonry and wanted to try to develop a mortar that more closely matched the insulation value of the log-ends themselves. I figured that a single homogeneous material laid up right through the wall would simplify construction. How could I get the insulation characteristics that would make this a viable option in our cold northern New York climate?

The new mortar is made of paper sludge—80 percent by volume—that I get free from a local paper mill. They throw away 40 cubic yards of fiber-reinforced paper sludge every day! The other 20 percent of our "papercrete" is Type N masonry cement.

Incidentally, I agree that Alan's term, "paper-enhanced mortar" or "PEM," is more accurate, and will use it hereinafter.

We mixed our PEM in 5-gallon buckets with a heavy-duty spackle blade on a half-inch drill, 100 gallons or so at a time. The PEM is both the structural support for the cordwood logs and the insulation at the same time.

Laying the 16-inch pine log-ends was a simple matter of dumping either a giant handful or even the entire bucketful of PEM and spreading the material across the foundation or the previous course of log-ends with rubber-gloved hands. We pointed the spaces between log-ends with gloved fingers first, then used a bent butter knife, and finally a stiff sponge to finish it off. The sponge absorbs quite a bit of the excess moisture from the papercrete and gives a slight stippling texture, which looks pretty good.

The next layer of log-ends are wiggled into place on the mortar bed, leaving about an inch of space between pieces to facilitate pointing. The process is repeated—one bucket of mud after another—course after course. We found that a crew of five could lay up about 500 gallons of mortar on a good day, with two of those five mixing the PEM. This works out to about 150 square feet of wall.

Typically, we would lay cordwood and mortar until just after lunch and spend the rest of the day pointing and tidying things up. One caution should be observed with PEM: don't lay cordwood masonry more than about two feet in height in a single day. The PEM is quite jello-like, and the wall will start to lean in various directions if you try to build too high, too fast.

The paper-based mortar takes at least a day to set up and weeks to fully dry but

12.1. Our 16-inch-thick walls have a solid papercrete mortar joint. The log-ends are pine. Credit: Jim Juczak.

has a hard finish similar to rigid foam insulation or hard papier-mâché. In the years that I've been working with the stuff, there have been no cracks in the mortar, no settling of cordwood masonry within its panel and minimal shrinkage gaps between the log-ends and the mortar.

We've been 15 years at Woodhenge now, and the home performs brilliantly in our North Country winters. I estimate the insulation value of our PEM at about R-4 per inch, or around R-60 for the 15-inch mortar joints. As half of our wall surface is wood and half mortar, the overall insulation is probably about R-38. To cut down on air infiltration, all we've had to do is stuff some of the larger primary checks with foam and cover that with clear siliconized caulk.

My Paper-enhanced Mortar *by Alan Stankevitz*

I started my first wall following in the footsteps of Jim Juczak. Unfortunately, I am not close to a paper mill to get any free paper sludge. (Can you tell I'm jealous?) So, instead, I was able to work out a deal with the county's recycling center for 75-pound bales of shredded newspaper. The first bales also contained office paper waste, which was hard to slurry. But after some "case of beer" negotiations, the guys at the recycling center were happy to supply me with "pure" newspaper.

My first mix was a combination of two parts newspaper to one part Type N masonry cement. No sand. I slurried paper by soaking the bales of shredded paper for 24 hours in a 55-gallon drum. I'd tried this mix on a test wall with success, so it

12.2. There are 16 panels on each of the two stories at the Stankevitz home. Credit: Alan Stankevitz.

seemed okay to use on the house. The mix was very wet and hard to point; it had a slight cottage cheese texture to it. After I completed the first 8-foot-square panel of our home, I left it to dry for a couple of weeks...then a couple more weeks...and then a couple *more* weeks. While drying, the mortar color changed from dark gray to light gray, then to light green, and finally to a pleasing white. After six weeks, the PEM was pretty much dry, but it was a slow process. The mortar had no cracks in it, but I noticed a widening gap between the frame and the cordwood masonry. There were no gaps around individual log-ends, but the entire cordwood wall appeared to be shrinking.

Because of the shrinkage, I decided to try a more traditional cordwood mix, using sand with the slurried paper and masonry cement. All subsequent walls were built using the following formula (by volume): 2 parts drained slurried paper, 2 parts fine sand, 1 part Type N masonry cement.

I love this mix. It has a very nice putty-like feel to it, dries in a couple of weeks and looks great. Like Jim Juczak, I have been brush-finishing the mortar with a small foam painting brush, and when it dries you cannot detect any curing lines between batches.

The only thing I have to add for this new edition is that I have been able to cut down the time to make the slurry by using a mortar mixer. I found I could slurry directly in the mixer. Not only does it make slurrying faster, it helps clean out the mixer. It sure beats using a high-torque drill, paddle and a large bucket.

Pros and Cons

Here are some pros and cons that I have observed with PEM:

Pros:

- What a great way to use recycled newspaper! There's so much waste in the world—why not use it in an Earth-friendly way?
- Paper is free. If you can't get it at a recycling center, just ask your friends, family and neighbors to save it for you.
- PEM has great workability. It is sticky and firm and is easy to work into nooks and crannies. It also adheres very well to the wood and is a pleasure to point.
- The latest mix retards the set enough to eliminate most, if not all, mortar cracks but does not take forever to dry. All panels since the first have turned out fine.
- I don't really know the R-value of the PEM, but with its 40 percent paper content, I would assume that it's higher than more standard mortars. In any case, I have foam insulation between my inner and outer walls, as per Chapters 6 and 7.
- The PEM is visually appealing. You'd never know there is paper in the wall, and the mortar is a uniform, light gray color.

- PEM has passed a 15-year test of time at our home without deterioration of any kind.

Cons:

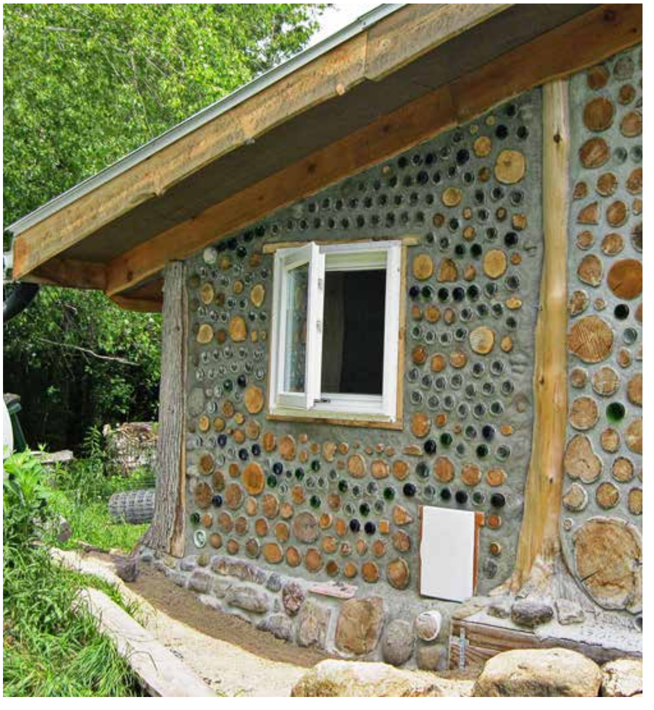
- Having to slurry the paper adds another step to the process. (If you are as lucky as Jim Juczak, and have a friendly paper mill nearby, this extra step is eliminated.)
- I'm not sure how high up on a wall you could go in one day without the masonry compressing on itself a bit. If two people are laying, it might be wise to work on separate walls.

Cellulose-enhanced Mortar

by Tom Huber

I have taken to coining a phrase that relates to this type of mortar: *The wetter, the whiter; the better, the brighter.*

For well over a decade now, I have been using a paper-enhanced mortar (PEM) or, more specifically, *cellulose*-enhanced mortar (CEM) by incorporating purchased cellulose in my mortar mixes. My first two field tests contained shredded office paper and shredded newsprint respectively, but now I buy GreenFiber cellulose in compressed 2.2 cubic foot bales. (Editor's note: In March of 2016, Home Depot was selling the bales at $12.15.) While the cellulose mix costs more, I continue to use it for its lower labor and superior performance. As with the PEM mixes of Jim and Alan, the cellulose is fully soaked in water, so takes longer to dry than regular mortar. As with the PEMs I tested, the CEM does not shrink. The longer CEM takes to dry, the whiter it becomes, provided that the weather stays warm. Given the long drying time one should not use CEM—or PEM—when there is frost danger. Freezing will lead to weakened and spalling walls.



12.3. Tom's west wall, made with CEM. Left of cedar tree is fresh, right is seasoned. Credit: Tom Huber.

Along with increasing the insulative value of the wall, the other main reason for utilizing cellulose-based mortar is to increase the adhesive strength of the bond with the wooden log-ends. Since only a friction bond exists between mortar and wood (versus a chemical bond as with stone and brick masonry units), increasing this bond will go a long way in preventing separation (or shrinkage) between wood and mortar. This is also the primary reason that I add hydrated lime to the mix. It, too, increases adhesion and dramatically increases the whiteness of the mortar. So after several years of experimentation, this is the recipe of my current (2015) mortar mix:

5 gallons moistened cellulose / 2 gallons Type S masonry cement
2.5 gallons mortar sand / 2 gallons hydrated lime

At Cedar Eden (see Chapter 13) I collect rainwater off the metal roof of the cabin, and then fill plastic barrels with cellulose and water and let it soak several days before using. This creates a super pulpiness with the cellulose which makes the mix very buttery in consistency when combined with the fine sand and lime, rendering it very easy to point. Also because it is quite wet, ample time exists for doing the fine tuck pointing given its later set. When ready to make up a wheelbarrow batch, I first drain off and squeeze out most of the water using a small screen placed over one of the barrels and fill a 5-gallon pail with the moistened cellulose. I then dry mix the sand, cement and lime (from measured pails), and then knead in the 5 gallons of cellulose by hand. It is important that the same proportions be used for every wheelbarrow load, in order to have a uniform mortar color when it dries. I've also used this mix as a finish coat for an earth oven project. So far, it is performing beautifully in this application (weather resistant and a tight, insulative external layer), which further reduces fuel use for the oven while being extra resilient in weathering the long Adirondack winters.

The Biggest Negative to This Recipe—It Stinks!

By far the greatest drawback to this mix is that it literally smells from an ammonia type off-gassing that occurs between the fire retardant in the cellulose and the chemical composition of the hydrated lime. Common fire retardants added to cellulose insulation include borax, boric acid and ammonium sulfate. After I first smelled ammonia in a PEM mix, I Google-searched and found similar reports among papercrete users. The presence of ammonia produces little risk when mortar mixing in an open-air environment, but a protective ventilator mask should be used in tight interior spaces.

Once the mortar sets, it no longer smells unpleasant in any way. A light sanding of the cedar log-ends releases the cedary smell again while removing the watermark stains that develop from absorbing the moisture in the mix. You can use a grinder or hand sander to remove the watermarks or take a grinder pad by hand to the log-ends, which works quite well and doesn't require any electrical power (and is much more enjoyable—no noise!).

Paper-enhanced Mortar Observations

by Rob Roy

In early 2016, I rechecked with Jim, Alan and Tom, and updated the information accordingly. Based on interviews with all three authors, visits to their homes and their commentaries above, I'd add the following observations.

1. The primary difference between their mixes is the sand content, which varied from none (Jim) to little (Tom) to a fair amount (Alan). Sand, obviously, makes the mortar harder and stronger, but denser. Sand increases thermal mass. The non-sand or low-sand mixes dry slower.
2. Judging from snowball samples that Tom kept, we agree that CEM's insulation value is probably somewhere around halfway between regular mortar and Styrofoam. Similar samples from Jim, with no sand, are obviously even higher in insulation, which justifies his solid mortar joint. Jim's estimate is R-4 per inch, but this is untested. Even R-3 would yield R-45 for his mortar portion. The exceptional thermal performance of Jim's house through 15 North Country winters settles the point.
3. Does PEM save time? Depends. With Jim's ready-mixed paper pulp and 45-second mixing time with a high-speed paddle drill, yes, mixing PEM is faster than mixing regular cordwood mortar. But both Alan and Tom report longer mixing times—Alan because of the extra time preparing the paper slurry, Tom because he finishes a batch by hand-mixing it like cob, an extra operation. Time spent on any mortar is also a function of availability of materials.
4. Paper-enhanced mortar makes use of a waste material and shows promise as an insulative mortar that can be used in cordwood panels within a post and beam frame. Without testing, we cannot say with certainty that PEM is suitable where the cordwood masonry is load-bearing. Due to PEM's slower curing time, do a test panel a full month before you want to start the actual project, calculate for yourself any increase in cost and time and then decide if PEM is right for you.

CHAPTER 13

Cedar Eden: Design Considerations

by Tom Huber

The Pattern that Connects

Gregory Bateson coined the phrase "the pattern that connects" back in the 1970s to describe an aesthetic whose core principle is one of unity. It signaled a paradigm shift away from reductionism to a holistic, synergistic worldview where the whole is greater than the sum of its parts. Everything in nature is connected, which includes the mind and actions of humans. In this chapter, I'll elaborate on this principle as it pertains to the natural building method of cordwood masonry at Cedar Eden, a hobbit-scale farm in Potsdam, New York. There are many reasons why humans build structures using cordwood masonry. Perhaps the greatest of these is the psychic drive to create beauty as a type of harmonious interaction with the natural world.

Cordwood masonry, quite simply, is the pattern that connects at Cedar Eden. The property comprises 69 acres, with about 40 acres forested primarily in northern white cedar (*Thuja occidentalis*). This species is also referred to as the American arborvitae or tree of life due to the medicinal properties of the sap, bark and twigs. For those of us in the cordwood community, white cedar is one of the most desirable choices due to its natural decay resistance, high insulative value, fast drying and low shrinkage properties. It is also a beautiful wood to work with, given its wonderful cedary smell and ease of removing the bark when cut in early spring and throughout the growing season. Personal confession: I have a love affair with cedar!

Given my strong motivation to continue building with stone and cordwood (as I had previously in Michigan), the prodigious piles of stone and the considerable cedar forest strongly suggested the rightness of purchasing land north of the Adirondack Park in St. Lawrence County. The rich soils, open sky with meadow views, wind power potential and ample rainfall also promised a good fit for homestead living. These are all critical elements in the larger whole when I refer to "The Land" or "Cedar Eden." To the degree that I understand and stay true to these life-enhancing, complex, interrelated patterns one could say that my habitation on The Land is successful. To the degree that I live in a way that only supports the human side of the great interplay of life, it could be said that such building projects are unsuccessful or miss the mark.

Place-based Design Considerations for Cold Climates

A building that works must first be guided by the locality where it is built. When building in cold climates, such as the Adirondacks in northern New York, a successful building project benefits by facing the structure true south for solar gain (for light and heat), ideally with earth-berming to the north and good protection from the wind. Also, smaller, compact structures are the easiest to heat and keep cool, especially when they are well insulated and have plenty of interior thermal mass, which makes cordwood masonry an ideal and durable natural building method. Redundancy in heat sources (passive solar, wood stove, masonry stove, etc.) is especially helpful for consistent thermal performance during harsh winter conditions.

The Hobbit Way of Homesteading

In 2005, when my wife, Holly, and I left our homestead in Michigan to move to the Adirondack Mountains of New York, the only thing that was clear was my new job at Paul Smith's College. However, after getting settled the first year, the search for land began again, leading to the discovery of Cedar Eden, a little over an hour away from where we'd purchased an older passive solar home near the college. Once we closed on the land, we transitioned from tent camping to purchasing a used camper (first year) to building a tractor shed (second year) to converting it to a small cabin (third and fourth years) followed by an addition to the north (fifth year) and the bedroom addition to the east (sixth year), and, in 2015, a simple solar porch to the south (seventh year). We also had an Amish-made shed transported to the property and added a lean-to addition to its north side. Since most of the work was completed on weekends, it was important to apply an incremental, step-by-step approach—what I call "the Hobbit Way." This allows one to get a foothold on the land (controlled front) from which to expand each season and passing year. Looking back, I probably should have had the Amish shed positioned

13.1. Foundation and timber frame for the east addition. Credit: Tom Huber.

on the land before building the cabin for multiple purposes: tool storage, compost toilet, solar shower. The cabin's metal roof was strategically planned for a water catchment system from the beginning to supply plenty of water for masonry work, watering gardens and trees, etc. In 2014, we had a well drilled and outfitted with a Bison hand pump. Small solar panels are used for a couple of lights for the camper and the cabin.

13.2. The cabin is easily heated with a Jotul stove. Credit: Tom Huber.

A Cabin with Four Doors

From the outset, the plan was to build a passive solar cabin with four doors to allow for four different additions: a bathroom/storage area to the north, a bedroom to the east, a solar space/greenhouse to the south and the main living addition to the west. This west addition, to be completed last, will include an upstairs loft, master bedroom and bath, kitchen with masonry heater and wood cook stove. The south-facing roof of this main living addition will also serve as an active solar power plant for the homestead. In front of the structure, an edible pond garden with cordwood sauna and earth oven is also being created in small stages. All along the way the design is kept open to change so that both a childlike wonder and high functionality can be incorporated. I no longer claim to know the overall best way to design and build hobbit projects. Instead I take it one season at a time.

Every step of the way, a conservative approach is taken for off-grid, mortgage-free living. For example, the main cabin can be easily heated first with the small Jotul wood stove. Once the thermal mass of the walls are charged, a door can be opened to direct heat to the other additions. This is helpful when coming over to Cedar Eden in the middle of winter when it's –10 degrees Fahrenheit.

The site was carefully selected so that the cabin would be nestled in a cedar grove facing south for passive solar gain while providing protection from the strong western wind. Attention to drainage patterns resulted in digging a trench and installing a drain tile for directing water flow around the buildings given the northwest slope of the land. The rich, fertile topsoil from the trench digging was placed around the perimeter of the pond for the permaculture garden.

By employing the add-on strategy, each new addition brings a sense of completion to that particular stage of living, whether it be as a camp, refuge, retreat, small farm or fully functional homestead. The small-scale additions themselves can also be constructed to be even more efficient by incorporating shelving (Figure 13.2) and cabinets into the walls themselves. We installed a large compartment for storing clothes in the bottom section of the south wall of the bedroom addition by insulating the outer wall with foam and screw-attaching 5-inch log-ends abutted to the plywood-foam panel. Mortar was then fitted around the shorter log-ends with the whole section tied in to the rest of the wall on the sides with longer 16-inch log- and bottle-ends.

The overall goal of these methods is to have each stage completed by the end of a particular building season, in order to keep a sense of accomplishment moving the process forward. A long-term option also exists as a multi-generational habitation on the land. Whether or not this actually happens depends on many variables often beyond the control of the first family.

Intentional Patterns—The Nature of Order; Building as Sacred Practice

Christopher Alexander's work on pattern language applies well to cordwood construction. Alexander discusses his thinking in detail and depth in his four-volume series, *The Nature of Order*, in which he distills 15 integrated design properties that lead to the creation of buildings that have living structure, centered wholes and tranquility. The properties inform patterns which resemble ancient and primitive forms from the deepest archetypes (folk architecture). The intentional properties provide an essence of life-giving qualities that he originally referred to as a "timeless way of building." All of these qualities provide a greater personal feeling for the structure. Alexander believes we feel happy in the presence of deep wholeness. This is perhaps why cordwood buildings work so well, and vinyl-sided manufactured houses do not.

If I understand correctly, Alexander believes that great works contain a special quality of relatedness of ourselves to the universe—another form of Bateson's "pattern that connects." The task of building was understood by the master builders as a spiritual exercise; a direct attempt to come face-to-face with the Luminous Ground (also known as the Void or Emptiness) of the universe. Although the Luminous Ground is nameless and without form, it can be expressed in intensely personal ways from the deep eternal self. It is this numinous experience which we feel at certain sacred places (forests, meadows alive with wildflowers) which Alexander refers to as a "quality without a name" that informs a timeless way of building.

At Cedar Eden, we have continued to incorporate one of Alexander's most important patterns—"Light on Two Sides of Every Room"—through the use of full-light doors, south-facing windows and tubular skylights. We used clear poly-

13.3. The east addition is completed, with a sheltered area for taking refreshment breaks. Credit: Tom Huber.

carbonate roofing material for adding on a solar/moon porch to the south side of the bedroom addition and main cabin. This promotes passive solar gain, but also creates greater functional and aesthetic space. In addition, it helps protect the walls from weather, directs moisture away from the building and provides multi-use function for the south edge. The generous "solar-collector" windows, in addition to allowing for passive solar gain and natural daylighting, also provide a way to bring the outside world inside for living more in tune with the beauty of the place. Essentially, multiple benefits are provided by one single element, which relate to a primary pattern.

The protected transitional spaces give a place to work outside in all but the harshest weather conditions and provide outer passageways for accessing areas outside the cabin. Here is where wide overhangs, awnings and porch spaces expand the durability and functionality of the living structures for low-cost investments of time and materials. Adopting insulated stonework as a base for cordwood walls also lifts and protects the log-ends for longevity. Buildings "live long and prosper" by keeping their feet dry. Inside too, "hobbit-scale" passageways can be created when the residents are on the shorter side of average height.

Retreat from the World

So how many functions can be provided by a building with cordwood walls? Especially walls made with "Things from Your Life" (Alexander's Pattern #253)—unique bottle-ends, stones, quotes written in mortar, shelf mushrooms and other special

13.4. Two sides of a cordwood wall: “stoned on mushrooms” and a “blessed virgin.” Credit: Tom Huber.

objects? What if these walls were used to provide safety, privacy and comfort as well as resonance with one’s personal narrative during an experiential form of psycho-spiritual therapy known as Holotropic Breathwork? In my last holotropic session in the cabin at Cedar Eden, I finally worked through a certain emotional funk I’d been feeling since late fall and the onset of winter. Also during the session I was internally bombarded with a creative brainstorm of ideas related to organizing an annual Adirondack Fungi Fest at the college every October. One thing I found curious, is that at the beginning of the session I was feeling a bit apprehensive without having a “sitter” for my session. I looked out the full-light door to the west of the cabin and saw a deer browsing a few cedar trees. The deer saw me, but still stayed near the cabin. It’s the first time I’ve had a deer for a sitter! For more information about this method, Google “Stan Grof Holotropic Breathwork.” Stan has more experience assisting folks with holotropic states of consciousness than anyone else on the planet.

A deep sense of psychological well-being is often felt at Cedar Eden through a type of alchemical synthesis between the numinosity of the inner self and the natural beauty of the place. It is this sublime feeling which epitomizes my life affair with Cedar Eden and compels me to engage in the sacred craft of natural building.

13.5. Cordwood cabin with additions at Cedar Eden (Potsdam, New York). Credit: Tom Huber.

CHAPTER 14

Cordwood-to-mortar Ratio: An Analysis

Consistency in Cordwood Build Quality

Look at ten different cordwood projects by ten different builders and you will probably see ten different textures, build qualities and wood-to-mortar ratios. Some builders like their log-ends strongly revealed from the mortar matrix, others much less so. Some will spend 20 percent of the construction time on pointing; others very little, maybe just a rough "rubber-glove" pointing. Some will keep a constant thickness of mortar joints; others, not.

When we teach cordwood masonry, Jaki and I impart a certain build quality to our students that we feel satisfies the important considerations of appearance, longevity, energy efficiency and reparability (should mortar or log shrinkage occur). We do not intend to imply that ours is the "right" quality or texture.

Because we teach a consistent texture and building style, a panel of cordwood done by a dozen new students will look, at the end of the day, as if it was built by a single mason. We point out errors (such as two log-ends touching each other, huge mortar joints, lack of pointing relief) and ask the students to correct their work. We teach a fairly high standard, but it gives the students something to aspire to on their own projects. If they choose a different standard that they are pleased with, that's fine too, as long as it is consistent. An excellent trick for keeping the wall's appearance consistent is to deplete the various sizes, shapes and species of log-ends at a steady rate. The masons building the Arcus Project (Chapter 16) sorted all their cylindrical white cedar log-ends by size, and depleted the dry-stacked ranks of wood at a steady rate by always having a consistent mix of sizes delivered to the scaffold. Then it became the mason's job to mortar the log-ends into the wall, also at a steady rate.

The original Earthwood house, our office and our sauna were built primarily from old cedar split rails, quite effective and certainly nonshrink, but they are

14.1. La Casita guest house at Earthwood. The 52-inch-diameter Balm of Gilead log-ends make up half the area of these panels. The other 60-plus log-ends—and all the mortar between them—make up the other half.

almost impossible to find now. For the past quarter century, we have returned to our roots at Log End homestead, building with a mixture of white cedar rounds varying from 2 inches to 12 inches in diameter. (The largest log-ends we have ever used are six nearly round pieces of Balm of Gilead, a cottonwood. Amazingly, the fast-growing tree was just 75 years old! No, we didn't cut it down; it was a short piece we found at a sawmill, too large in diameter for the saw.)

14.2. This panel is 60 percent wood and 40 percent mortar.

Varying Wood-to-mortar Ratios

Curious about what percentage of our cordwood masonry wall was wood, I accurately measured a fairly typical rectilinear panel in one our bedrooms. It was 24.5 inches by 38.5 inches or 943.25 square inches. Then I measured every log-end, counting the fishbowl and the bottle-ends as log-ends, too. The total surface area of all the masonry units came to 566 square inches, almost exactly 60 percent of the total panel area.

When Jaki and I trained the Arcus Project masons at a two-day workshop in Kalamazoo, Michigan, we

14.3. Each log-end in the 5-foot by 10-foot training panel for the Arcus Project was measured accurately. By area, the panel is 60 percent wood and 40 percent mortar. The round hollow area is rigid foam behind a special light window being tested, and counted as a large log-end.

built a 5-foot by 10-foot practice panel. These professional stone and block masons picked up cordwood masonry very quickly and took instruction very well from us nonprofessional masons. At the end of the workshop, I calculated the area of each and every log-end in the panel, totaled it all up and figured out the wood percentage. It was 60 percent wood and 40 percent mortar!

At our first homestead, back in the 70s, all the cordwood work was done as panels within a strong timber frame. The mortar portion of the wall was only about 20 percent by area. At Earthwood, in 1980, we began to use cordwood masonry in load-bearing curved wall structures, and beefed up the mortar accordingly to our current 60/40 wood/mortar ratio, which we now use within a timber frame, as well, for better thermal performance, as discussed in Chapter 3.

Jaki and I recently visited Sandy and Angelika Clidaras at their beautiful Cordstead in the Laurentians, just north of Montreal. (And you can, too, as their place is available as a vacation rental. Go to: thecordstead.blogspot.com.) It struck me that their wood-to-mortar percentage was radically different than at Earthwood. There was a convenient panel to measure in their antechamber, so we measured its width and height, and the sectional area of every single log-end. This panel, seen in Figure 14.4, was 30 percent wood and 70 percent mortar, exactly twice as much mortar per

14.4. Thirty percent wood, 70 percent mortar by area.

square foot of wall as the work we commonly do. I was not entirely surprised. Sandy thought that maybe the panel was slightly atypical because it was narrow, but we agreed that even in the vast round areas of cordwood masonry, the wood was not much over a third of the total wall area.

The question is: So what?

Impact of Wood-to-mortar Ratio

Sandy's house may well be the best-insulated single-wall cordwood home ever built. He injected closed cell expanded foam between the inner and outer mortar joints of his 18-inch-thick walls, and was very careful to avoid any air gaps. (See Chapter 7.) In short, like *any* properly insulated cordwood wall, the superior thermal performance is in the mortared portion of the wall, not the wooden part. This is true at Earthwood, too, where I estimate about R-16 for the wooden portion of the wall (16-inch white cedar log-ends), but R-22 for the mortared portion, with its 6-inch-plus sawdust-and-lime insulation. (Remember that engineers assign a value of R-2 for the transfer of heat from one side of a mortar joint to the other. Heat has to enter the joint, pass through it, and exit the other side. Two such joints, then, are worth R-4.) On average, our walls have an R-18.4 insulation value. In Sandy's case, he has about R-18 in the wooden (cedar) part of the wall, but closer to R-30 in the mortared portion (with its foam core insulation). Because the walls are 70 percent mortar by area, this works out to an average value of R-26.4, 43.5 percent better than at Earthwood, although his walls are only two inches (12.5 percent) thicker.

In addition, with his high 70 percent mortar ratio, Sandy has 75 percent *more thermal mass* on the inside of the foam insulation barrier than if his mortar portion was 40 percent of the wall's area, like ours. The math: (.70 – .40) / .40 = .75. This thermal mass acts like a giant capacitor inside the house, discouraging rapid fluctuations in the interior temperature. Similarly, in a hot climate, the outer mortar matrix helps keep the house cool.

So, in short, Jack Henstridge was right so many years ago when he said that the log-end's main purpose in a cordwood wall is to tie the inner mortar joint to the outer mortar joint. But energy efficiency is a function of the mortar joint: how it is made, and what percentage of the wall it constitutes.

CHAPTER 15

Cordwood Cutoff Table for a Chainsaw

by Rob Roy and Bruce Kilgore

A cutoff saw is not only the fastest, safest and most precise method for cutting log-ends for cordwood, but it also enables owner-builders to cut heavy timbers at perfect right angles, or almost any desired regular angle. Further, it makes it easy to cut firewood at regular lengths for the woodstove. In fact, it allows the cutting of wooden pieces up to 24 inches with great precision.

Rob wishes he'd had one of these cutting benches 30 years ago. (He still doesn't have one; he borrows Bruce's!)

Precision log-end length makes for good build quality in cordwood masonry, but the ease, speed and safety aspects of the cutoff saw are equally important. A single person can get a lot of log-ends cut in jig time, whereas two people working together can reduce a pile of long logs to the desired length almost twice as fast. The cutting mechanism—the chainsaw—always passes through a straight fixed plane, unable to hit anything which could cause kickback of the saw. Hands are kept safely away from the saw itself. The counterweight features make for almost effortless operation. Equal wear on both sides of the chain means longer use time between sharpening. And the bench and fastening mechanisms ease the sharpening process itself.

Early prototypes of the tool originated in New Brunswick over 40 years ago, traceable to cordwood pioneer Jack Henstridge and some of his friends. *Mother Earth News* featured an article about the tool way back in its May-June 1982 issue. Since then, Bruce has taken the design through four evolutionary phases. All of his changes have continued to refine the saw's performance and ease of operation. Improvements include the ability to service and fuel the saw without removing it from

(*Authors' note:* This chapter revises an article that we did for *BackHome Magazine* #126 [September–October 2013], and is used with permission.)

15.1. A lot of log-ends can be cut fast and accurately with this cut-off table and saw.

the bench, solid anti-vibration operation and ease of moving the fairly large and bulky tool by a single person.

Fabrication Skills Needed

Many rural denizens have welding skills or know someone who does. Bruce learned welding in order to fabricate special heavy timber fasteners for his cordwood house and by making the cutoff saw. The alternative is to go to a professional welder with the parts and the plan and pay to have it welded. Then, you can fasten the wooden deck and fence yourself. While it may be possible to bolt the angle iron frame together, the authors fear that these bolts will loosen up during use. Plus, welding is the best way to fasten the mounting plate to the pivot mechanism.

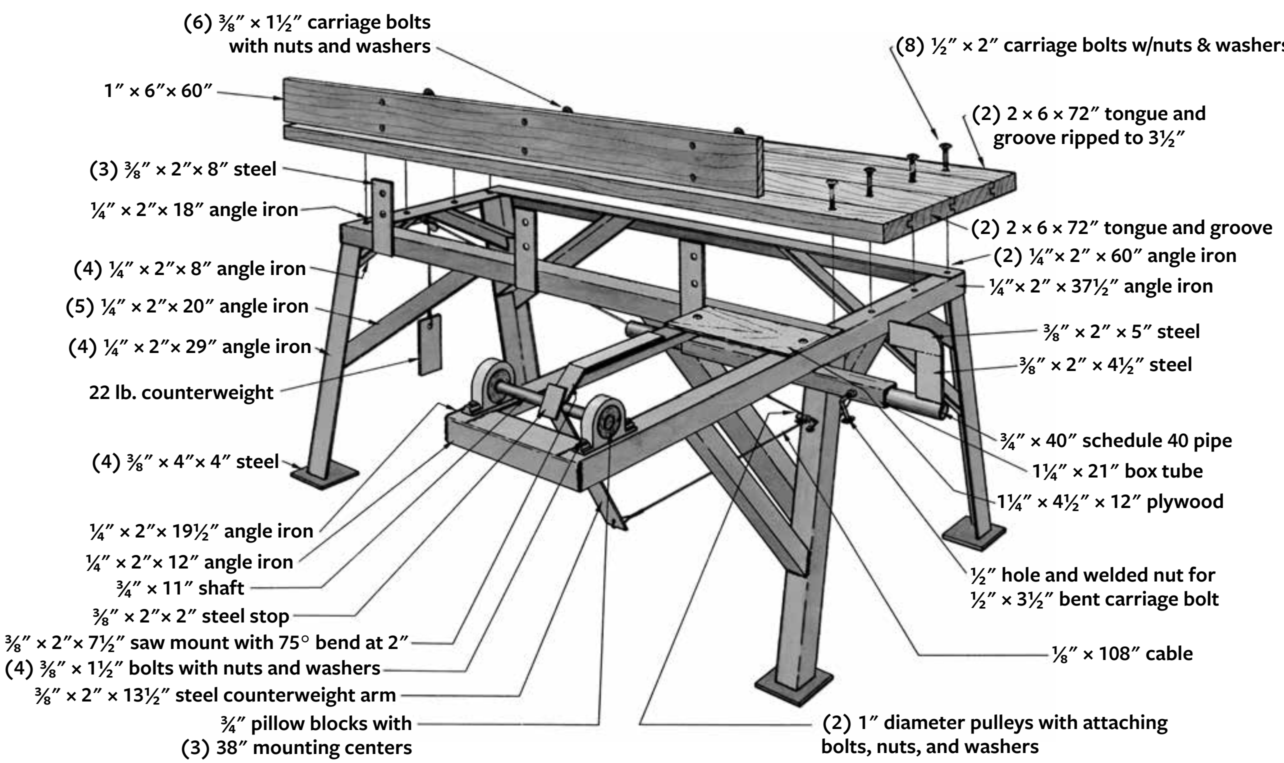
You Will Also Need...

A chainsaw, first and foremost. This is the tool you are going to design your cordwood cutoff saw bench around. In his early versions, Bruce chose small inexpensive chainsaws. Besides their low cost, he was after a saw with a small, narrow cutting kerf, so that the logs would show less evidence of the saw cut on their ends. Furthermore, these less expensive saws didn't have anti-vibration features, making them somewhat easier to join to the mounting plate described below.

In recent years, Bruce has had a change of heart. He now prefers—and advises—a more powerful and longer-lasting chainsaw like his Stihl MS290. It cuts faster, starts more easily and will last longer than the budget saws. "You can feel the difference," he says. "The extra power, in combination with a new or well-sharpened chain, gives good clean cuts, with a lot less work and hassle. The only slight downside is that there is a little more work in fastening the saw to its mounting and the pillow blocks, in order to lessen the play in the anti-vibration feature of most high-end saws."

The Frame

For the basic frame, Bruce has successfully made the cutoff saw with $\frac{3}{16}$-inch by 2-inch angle iron, but now prefers $\frac{1}{4}$-inch by 2-inch angle iron. "This has increased the weight of the finished product by almost 50 percent," Bruce says, "but the extra inertia and sturdiness is well worth it, especially with a more powerful chainsaw."



15.2. Cordwood cutoff table. Credit: *Mother Earth News*. May/June 1982. p. 110.

You will also need some ¼-inch by 2-inch flat stock steel for various other parts, as indicated in the plan (Figure 15.2).

Whatever chainsaw you choose, the trickiest part of the whole cutoff saw construction is marrying the saw to the mounting plate and the pivot mechanism. Each saw is a little different, which is why you need to have it on hand to custom-fit homemade parts to it. Bruce's 16-inch Stihl MS290 joined nicely to a hinged mounting plate made up of two pieces of 8-inch by 10-inch by ¼-inch plate steel. Two steel door hinges are welded to the plate, as seen as in Figure 15.3.

15.3. The two quarter-inch steel mounting plates are connected with two door hinges, welded to the plates. In the open position this provides access to gas and bar oil fillers.

15.4. The hinged two-piece steel mounting plate is seen in the closed (operating) position. The two pillow blocks are joined by a three-quarter-inch solid steel bar, free to turn easily between them. The hinged mounting plates are joined to the bar by first welding a 6-inch piece of the 2-inch flat stock to the bar. Then a short (2-inch) piece of the flat stock is welded vertically, as seen. Finally, to stiffen this assembly, another piece of the flat stock is also welded vertically to the underside of the mounting plate, but at a 105-degree angle to the previously welded vertical piece.

Pillow blocks—simply ball bearings mounted in a sturdy flat-bottomed housing—are an essential part of the design, as they guide the saw firmly and precisely through its up-and-down cutting path. Although some backyard builders have chosen heavy strap hinges for this hinging mechanism, the more precise pillow blocks direct the vertical swing of the saw consistently with very little play. Bruce used Dayton brand three-quarter-inch mounted ball bearings available from Grainger's Catalog (part number 4x725). The cost for a pair was $46 in 2016.

Don't get too stressed out about most of the details given here. You can and must modify as you see fit, and, of course, to match the chainsaw you've chosen. The key is the chainsaw mounting. The method shown and just described worked well for the Stihl MS290, but might need tweaking for a different saw. Since every make of chainsaw is different, you will need to find a creative way to defeat the anti-vibration system in your saw, using U-bolts and other fasteners. The only critical angle is the 105 degrees created to hold the saw above the hor-

15.5. The hinges seen in Figure 15.3 allow the saw to be turned 90 degrees, enabling it to be filled with gas and chain oil without having to remove it from the bench.

15.6. Bruce is able to set his cutoff table's fences so accurately…

izontal plane of the bench. This angle, measured between the upper and lower stop points of the bar, maximizes the working swing area of the saw. Bruce played around with this a few times, only to come back to the original angle which Jack and the boys probably arrived at by trial and error.

We recommend building the table a full 8 feet long, which makes squaring off long timbers much easier. In one of Bruce's earlier versions, Rob discovered that we could cut timbers at 90 degrees by carefully shimming the wooden fence. But now, having taken greater care during the construction of his latest version, Bruce has made a cutoff table which allows the saw to cut perfect right angles through heavy timbers, such as 8-inch by 8-inch beams.

In using the cutoff table, Bruce soon discovered that more counter-weighting is needed as the saws get larger. He found that dividing the weight worked well, mounting most to the lower control arm, and then hanging the rest on the pulley system. By this method, swinging the saw through the vertical plane is almost effortless. If you put all of the weight on the lower control arm—or the pulley system—the result is that you feel all of the saw's weight at the top and bottom of the swing and muscles fatigue more readily.

In early versions, Bruce installed wooden skids at the bottom of the legs, which worked well for dragging the unit around the job site. You can see

15.7. . . . that a heavy timber can be cut perfectly square.

15.8. A long (12-inch to 14-inch) piece of 2-inch flat stock, called the lower control arm, extends downward from the ¾-inch pivot bar. Another three-quarter-inch bar is welded out from the flat stock. Weights are held in place by set screws on two "shaft collars" (*inset*) made by Dayton, available for about $2 each from Grainger's Catalog. (Grainger's part number 2x570.) Only one of these shaft collars is seen in the picture. Note that an eye-bolt holds one end of the pulley cord to the lower control arm.

15.9. Large wheels and detachable handles make it easy to move the heavy assembly and roll it up a pair of planks onto a pick-up truck. Note the pulley mechanism beneath the bench, which holds the counterweight plates. The saw can be mounted to the right or left end of the table.

them in Figure 15.1. However, he now mounts wheels to the saw end of the table, as in Figure 15.9. This makes it much easier to move by one person. If you go this route, large pneumatic tires, like those for a wheelbarrow, work best.

PART 3

Case Studies from Around the World

CHAPTER 16

The Arcus Center for Social Justice Leadership

by Studio Gang Architects

The Arcus Center for Social Justice Leadership at Kalamazoo College in Michigan is a new, purpose-built structure dedicated to developing emerging leaders and sustaining existing leaders in human rights and social justice. This paper addresses the challenges and achievements of using cordwood masonry (*wood masonry* is the term we use most) to construct it. The use of wood masonry for the Arcus Center is a key part of the building's design, and resonates with the center's social justice mission. In using this method at an institutional scale, we were presented with interesting logistical and technical challenges. However, by merging traditional cordwood masonry practices with contemporary design and building technologies, we were able to explore new and different ways to incorporate the benefits of this traditional method.

Why Wood Masonry?

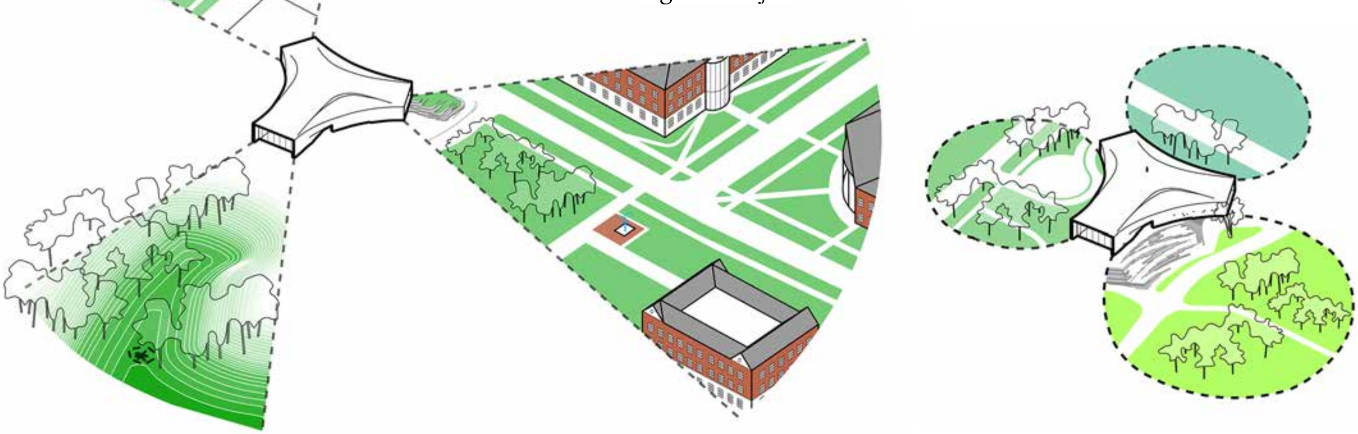
The process of building with wood masonry and the values it represents directly informed the Arcus Center's design and construction. Remaining true to the communal history and spirit of this tradition, every stage of the project—the decision to use wood masonry, procurement of the material and its methods of construction and detailing—was approached as a collaboration between the College (our client),

(*Author's note:* Claire Halpin and Wei-Ju Lai of Studio Gang Architects, Chicago, presented a version of this chapter at the Continental Cordwood Conference in July of 2015. Their paper was subtitled "Merging a Traditional Building Method with Commercial Construction Technology." I was brought in as a consultant in the early design stages, and, prior to construction, Jaki and I trained the expert brick and stone masons in the special considerations for cordwood masonry. We believe this is the largest example of cordwood masonry in the world, and one of the most beautiful.)

16.1. The Arcus Center for Social Justice Leadership, Kalamazoo, Michigan. Photo by Steve Hall, © Hedrich Blessing.

builders and architects. From the building's overall form, to the construction sequence, to the wall composition and other specific components of the masonry, the design of the building sought to expand the potential of this traditional "hand" method, merging it with newer technologies.

The building's form was directly informed by its use, context and material. The purpose of the Arcus Center is to bring together students, faculty, visiting scholars, social justice leaders and members of the public to engage in conversation and activities aimed at creating a more just world.



16.2. *Left*, the building's tri-axial organization addresses three adjacent contexts with transparent façades. *Right*, the gently arced walls of the building's exterior embrace three distinct outdoor areas that serve the programs of the Center. © Studio Gang Architects

It provides a safe, welcoming space in which to have sometimes difficult discussions surrounding issues of injustice, share personal stories and to organize action.

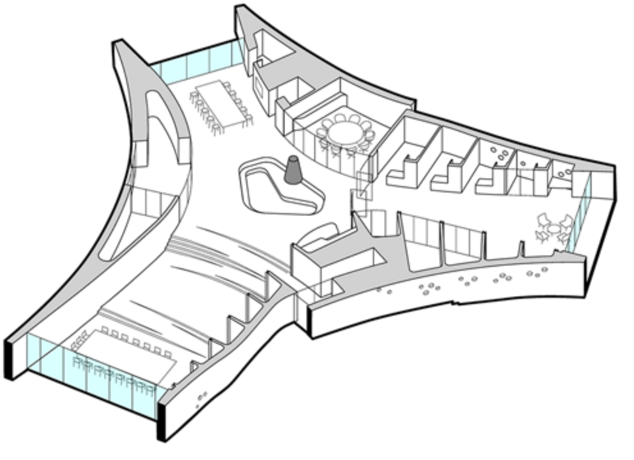
Located at the apex of the Kalamazoo College campus, on a hilltop site that incorporates a major incline, the Arcus Center engages each of its distinct contexts—the campus, a residential community and an old-growth grove—through transparent glass facades. The arcing masonry walls simultaneously embrace three distinct landscape conditions.

The wings of the plan intersect at an informal meeting space: a crossroads for convening. The presence of a hearth and kitchen for sharing food at the center of the building creates the potential for frequent informal meetings and casual, chance encounters. Smaller meeting rooms and individual workspaces are nestled into the area bordering the main assembly spaces. The building's visually open, day-lit interior, made possible by the large glass facades and clerestory, is designed to support conversation and community by allowing for different configurations and ways of gathering that begin to break down psychological and cultural barriers between people and facilitate understanding.

The building's tri-axial organization developed from the desire to have the architecture engage with each context, as well as a study of the shapes that form naturally when people gather in large groups. While we envisioned using glass for its transparency, we also wanted the design to resonate with the vernacular of the local architecture and relate to the Georgian brick language of the campus. Yet, while Kalamazoo College has a strong history of social justice leadership that dates back to its founding, much of its campus is comprised of buildings whose style evokes colonial- and plantation-era attitudes.

Looking to identify more socially conscious and environmentally sustainable alternatives, we explored local building traditions. Cordwood masonry appealed to us as a sustainable, more democratic, socially and environmentally friendly method of construction. As a collaborative building process that allows people with a wide range of abilities and strengths to participate in construction, cordwood masonry embodies the values the Arcus Center was founded on.

Its aesthetic also appealed to us: the individuality of each log, with its unique shape, size, color and growth pattern, could be seen as reflecting the diverse population the Center serves.



16.3. The wings of the plan intersect at an informal meeting space: a crossroads for convening. © Studio Gang Architects

We were pleased to discover that wood masonry sequesters more carbon than is released in building it, responding to today's need to reduce carbon pollution—one of many environmental issues embraced by social justice movements. Further solidifying our decision to use this method, we discovered cordwood structures in Michigan dating back more than a hundred years, and we learned that Kalamazoo is located within the growth range of northern white cedar, one of the best species of wood for this use.

Learning from the Experts

Once we resolved to use wood for the façade and began seriously looking into the technique of cordwood masonry, we sought out the experts. To learn more about the process and how we might go about scaling it up for commercial construction, we turned to Rob and Jaki Roy of the Earthwood Building School. Rob and Jaki and the collective knowledge of the continental cordwood community have been essential to the design, execution and successful application of this technique within a commercial setting.

With the broad base of knowledge that the Roys offered, we could turn our focus to the design challenge of combining this traditional, hand-built method with commercial construction technologies, codes and regulations. We were also challenged by some initial skepticism from the client, as well as contractors and engineers who were unfamiliar with alternative building methods. Here, too, the Roys were instrumental in securing confidence in the project, hosting a workshop in northern Michigan for a group of Studio Gang architects, as well as representatives from the client, contractor and Kalamazoo community. Imparting their wisdom and good will, the Roys instilled in the entire team the confidence and enthusiasm necessary to forge ahead. They also introduced us to technological advances innovated within the cordwood community. With this sturdy foundation, we sought to build on these innovations and explore opportunities to use digital tools to play with the surface geometry.

16.4. The individuality of each log, with its unique shape, size, color and growth pattern, could be seen as reflecting the diverse population the Center serves. Credit: Studio Gang Architects.

Playing by the Rules

While the social justice mission and site topography led to the tri-axial organization of the building, we further defined the scheme by establishing rules for the integration of the hand-crafted wood masonry and contemporary steel construction.

The first of these rules relates to the way the building engages each of its three contexts with a transparent façade. The arcing walls that connect these façades, and simultaneously embrace three distinct landscape conditions, are hand-built with wood masonry. The masonry walls are set atop a continuous steel sill, rather than a wood frame, and terminated at each end by a clean steel edge. The steel structure allows for long, unbroken areas of wood masonry walls.

Each wall incorporates an opening, for entry or light, and is treated in a specific way to manipulate its surface geometry. Typically, to create an opening, the geometry of each arcing wall is sliced and then "pushed" or "pulled" as is appropriate to shape the opening. The concave curvature of the walls compresses the masonry, which we learned was an added benefit when it comes to preventing cracking of the mortar.

Each wing of the building and each arced wall is similar but modified to its particular use and context. One wing meets the site at grade, a second descends along with the grade toward the grove adjacent to the site and a third cantilevers out toward the college campus. Due to the site's natural change in elevation (approximately 12 feet) and the emphasis on universal accessibility, this cantilevered end of the building projects out above the ground level, allowing the floor inside the building to remain level and for circulation to occur underneath. The cantilever had several interesting aspects to its construction. Thornton Tomasetti, the structural engineer of record on the project, recommended that the wood masonry begin at the farthest end of the cantilever, symmetrically on each side, in order to load its most extreme end first and equally. This would ensure that any deflection—while unlikely—would be greatest at this initial loading

16.5. White cedar logs arriving at contractor's yard. Photo courtesy Miller-Davis Company. Credit: Studio Gang Architects.

16.6. Logs cut to size, set in covered racks and sorted by log diameter. Credit: Studio Gang Architects.

16.7. Logs pre-sorted with random size mix into bins at the job site, ready to be used. Credit: Studio Gang Architects.

and lessen as the masonry work progressed back, preventing cracking. The same principle was also applied to the masonry sequencing at lintels above openings: masonry was begun at the center of the lintel and then outward toward either end.

Continuing in the vein of the traditional cordwood method, we used locally sourced northern white cedar. Wood was purchased more than a year before construction began. It was sorted, cut to length and allowed to dry under protected racks. Prior to the masonry work, it was then redistributed into bins with a representative "random" mix and brought to the jobsite.

Thermal and Structural Constraints

Throughout the project, we researched and considered numerous types of wood masonry wall construction: through-wall masonry with a sawdust insulation cavity (as taught at Earthwood Building School workshops), the double-wall technique that has been described in previous papers and in *Cordwood Building: The State of the Art*, and others. We studied the length of the logs, the composition of the mortar, created mockups, modeled different combinations and tested wall assemblies for their thermal performance in the energy model our engineering team developed.

The possibility of using through-wall masonry exposed on the interior was given much consideration during the design process but ultimately was not used for several reasons, including the following: the current energy code, which requires a minimum continuous layer of insulation that would not have been achievable with sawdust insulation to the accepted standards of the governing code authority. Also, the design of the mechanical system depended on an airtight building enclosure for positive pressurization, which would have been challenging to provide with through-wall masonry due to the potential of air gaps at the log surfaces. Structurally, the cantilevers and façade geometries could not have been achieved with through-wall masonry alone; to satisfy the structural code requirements for a commercial building, a steel structure and metal stud wall were used in concert with the masonry. Daylighting requirements also contributed to the decision not to use through-wall masonry, as light-colored walls were necessary to reflect ambient daylight back into the spaces. The final design is what we determined was the most appropriate com-

16.8. Typical exterior wood masonry walls are 11 inches thick, with a solid mortar joint. The other layers that make up the wall assembly are described in the text. Credit: Studio Gang Architects.

bination for this project. It is in some ways based on a traditional masonry cavity wall that is common in other types of construction, except instead of stone or brick, white cedar logs are used.

The typical wall section is shown below: it consists of 11-inch wood masonry on the exterior, a 1½-inch cavity, a continuous 1½-inch layer of rigid foam insulation with a layer that also serves as a vapor barrier, a stud wall with spray foam insulation that also serves as an air barrier to the system and then the interior finish (which varies throughout the building). This exterior wall assembly provides a total insulation value of approximately R-30.

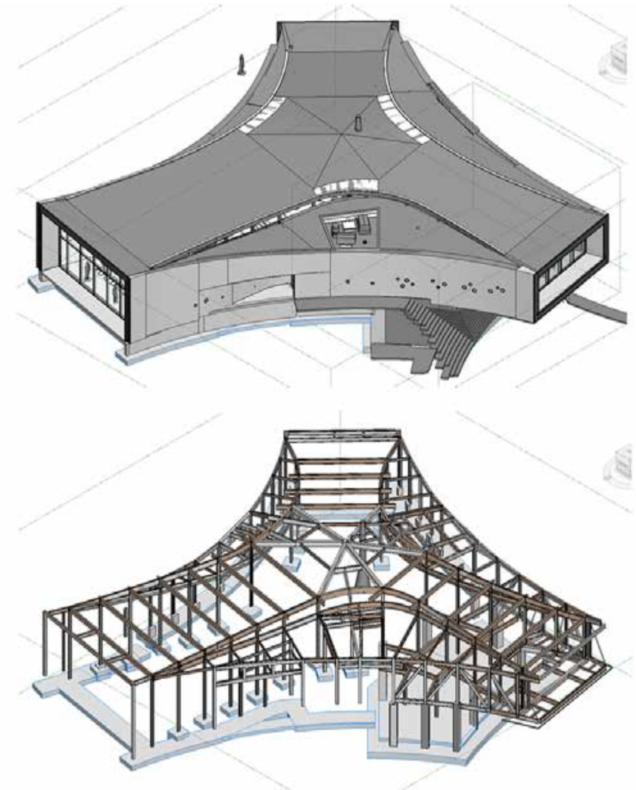
The wood masonry wall is continuous along each façade, broken only when the wall is terminated by the steel frames at each end. This is made possible by the masonry ties that connect the wood masonry intermittently to the backup stud wall.

Behind the masonry, the one and a half-inch air space allows any moisture penetrating the wood layer to drain and weep out of the system. Behind the airspace, the insulation, made up of sheets of rigid foam, creates a continuous unbroken insulation layer around the building. This satisfies one of the energy code requirements that stipulates a minimum level of continuous insulation (in traditional stud walls, the effectiveness of insulation placed only between studs is reduced by the thermal bridging that occurs at stud locations). The insulation/sheathing layer is a product that includes a reflective film layer on its face that also acts as the weatherproof and vapor barrier in this system. Contrary to traditional wall assemblies in cold-weather areas where vapor barriers are often located on the warm/interior side of the insulation, the dew-point analysis for this air-tight system places the vapor barrier on the sheathing layer.

The sheathing is attached to the stud wall that makes up the exterior wall of the building. Spray foam insulation in between the studs adds more insulation and forms a sealed air barrier that makes the entire wall assembly extremely energy efficient.

The wall composition also aided sequencing during construction. By first erecting the steel frame, followed by the stud wall, and then insulated sheathing, interior work was able to occur while the masonry work progressed at its own pace on the outside. This is based on strategies we learned from other cordwood builders who, as common practice, construct the frame of the building and roof first, to allow the methodical masonry work to continue under its shelter.

In the Arcus Center building, there is no roof overhang (as is often suggested by cordwood builders in order to protect the wood façade from exposure to rain). The building's roof slopes inward, away from the perimeter. Rainwater is collected via drains on the roof surface, so there is no overflow of water over the roof edge.



16.9. *Lower left*, the steel frame is erected first. *Upper left*, the roof and inner layers of the outer wall are then completed, allowing construction work to continue inside the building while masonry is ongoing. © Studio Gang Architects. *Right*, the 11-inch wood masonry walls are built next and are capped at the top by a metal coping. Drainage of rainwater is achieved via interior roof drains, allowing the exterior to be free of downspouts and protecting the façade from roof runoff. Credit: Studio Gang Architects.

The amount of rainwater the façade is exposed to during a storm is no more at the top of the wall than at the base (which would be unprotected regardless of whether or not an overhang were provided).

Pushing the Limits with Digital Tools

As described above, the continuous masonry walls were an important part of the design. However, in some locations inside the building there was a need for natural light, beyond what was provided by the glass façades and clerestory. In order to allow light and views through the wall without introducing new “slices” or geometries, porthole windows were integrated into the wall. The design for these windows was directly inspired by the bottle-end techniques frequently used in cordwood construction; however, due to the energy requirements of the building, it was important in this case that the windows be thermally broken and contain insulated glass, which would not have been the case with bottle ends. Also, with a total wall thickness of nearly two feet, it would have been difficult to source bottles of an adequate length for the wall assembly. Forty-six windows were prefabricated in three different sizes (8-inch, 11-inch and 14-inch diameter) and integrated into the façade. Parameters were given for their heights and general locations, but otherwise we allowed for their flexible placement so that the window installers and masons could collaborate during construction. The method used was to locate pipe sleeves on the wall during masonry construction, integrating the location into the pattern of log-ends. Later, inner sleeves containing the insulated glass were set into the wall.

16.10. The wood masonry exterior is built around 46 prefabricated insulated window units of varying sizes, integrated into the log pattern. See also Figures 16.1 and 16.9 (*right*). Credit: Studio Gang Architects.

There are a few exceptions to the typical 11-inch composition of the wall described above: these include the three "frame" ends of the building where through-wall masonry was used. These locations are exterior-to-exterior and did not have the same thermal and structural requirements as the rest of the building. We took advantage of these locations to use the logs all the way through the wall, expressing the materiality of the logs as much as possible, with thicknesses varying from two feet to approximately six feet. The logs were laid perpendicular to the tangent of the curve on the exterior wall. At the interior face of the through-wall masonry, at the frames, the log-ends were cut at an angle, with the resulting wall appearing elongated or elliptical in elevation.

16.11. The three entrances are framed by wood masonry through walls, beginning two feet wide at the steel-framed ends and increasing in depth up to six feet further in; possibly the longest log-ends ever used in a cordwood wall. Photo by Steve Hall, © Hedrich Blessing.

One of the most unique "slices" in the building's wood masonry façade is the warped wall. The geometry of this wall—concave on one side, convex on the other—forms an eye-shaped window opening perpendicular to the wall. To create this slice, we modeled the wall in 3-D, then sliced the geometry at even intervals to create 2-D shapes that served as the

16.12. Specially fabricated metal studs shaped the "warped" wall. Credit: Studio Gang Architects.

Memo: Wood Log Size Mix

Wood sizes shall vary from the smallest available diameter (approximately 2 inches) to the largest size that is practical to cut using the methods discussed and approved by owner, contractor, and architect (approximately 12 inches in diameter). The quantities of each diameter shall be proportioned as listed below to allow for a random distribution within the masonry construction:

Where X = diameter of log:
2″ ≤ X < 4″: 20–30%; 4″ ≤ X < 6″: 25–35%; 6″ ≤ X < 8″: 25–35%; 8″ ≤ X <10″: 10–15%; 10″ ≤ X <12″: 2–4%

basis for custom metal studs. The subcontractor used a digital file of the 2-D shapes to cut the stud profiles. Each stud was slightly different, with the curved profile straightening incrementally.

Placed precisely along the wall, the studs created the armature for the "warped" shape. With the addition of the sheathing insulation layer, it became a smooth surface upon which the wood masonry wall was then built. The logs were likewise cut at an angle to form the smooth surface of the wall.

Mixing It Up

The size mix that was developed for the masonry was based on measuring from an existing Michigan cordwood masonry wall with an appropriately even distribution of log sizes. The sizes were intended to be distributed randomly throughout the wall—a process that was streamlined during construction by preparing bins of logs with an even distribution of diameters, so the masons had the correct "random" mix readily available to them. The sidebar is an excerpt from a memo describing the specification of the logs.

16.13. The warped wall in its completed state. Credit: Studio Gang Architects.

The goal of this distribution is to allow for some flexibility in sizes while ensuring an even distribution of random sizes of logs and to avoid having many identical sized logs repeated. The higher percentage of smaller logs is intended to maintain a higher log-to-mortar ratio, and allow for more flexibility in log placement during construction of the masonry wall.

In addition to the above specifications, a set of "rules" was outlined in the drawings, stipulating that the logs were to be randomly and evenly distributed by size, with a maximum gap at tangent points of the logs of one inch; that primary checks must be within 45 degrees of bottom center; and that only full logs were to be used (no

16.14. The masons maintained a good balance of log sizes throughout, while keeping a constant minimum width of mortar joint. Credit: Studio Gang Architects.

splits). Beyond these stipulations, the masons working on the project placed the logs according to their judgment and collaborated with carpenters to cut custom logs at an angle where needed at through-wall locations and warped wall, as well as with other trades such as window installers to integrate the porthole windows into the mix.

Not the End

Although we were presented with numerous challenges in scaling this method for a commercial building, we believe we achieved numerous successes and learned many lessons that can be passed along to the cordwood community and to the architecture and construction professions at large. Perhaps these lessons will inflect future cordwood innovations. While the wood masonry tradition has been advanced, for the most part, by those searching for sensible, cost-effective and energy-efficient building techniques for their homes, we suggest that the environmental and cost benefits of this technology could be leveraged at a larger scale in future public and institutional buildings like the Arcus Center. How can this be accomplished?

To promote the increased use of wood masonry for mechanically conditioned buildings, the techniques developed and lessons learned at the Arcus Center could be formalized into standard details, material and installation specifications and assembly diagrams for reference and adaptation. In addition, the method used for calculating carbon sequestration and assessing the environmental benefits of this material versus alternatives could result in its recognition by regulatory agencies and environmental responsibility advocates like the United States Green Building Association (USGBC), resulting in further benefit to building owners using wood masonry.

For us, the Arcus Center represents a new hybrid typology blending a social, educational, cultural and civic program type. We are proud that it also represents a new hybrid method of construction, blending this traditional hand method with commercial technology, and we hope that the Arcus Center can inspire further use of this energy-saving, renewable, collaborative method in large-scale construction projects.

Studio Gang Architects studiogang.com
Jeanne Gang, Todd Zima, Margaret Cavenagh, Claire Halpin, John Castro, Ana Flor Ortiz, Wei-Ju Lai, Lindsey Moyer, Rolf Temesvari, John Wolters.
Engineers: Thornton Tomasetti (structural); Viridis Design Group (landscape architect/civil), Diekema Hamann Engineering (MEP, fire protection).

CHAPTER 17

My Cordwood Construction Evolution

by Geoff Huggins

Over a span of time of nearly three decades I've built four cordwood structures. I immediately fell in love with the technique, back when I discovered Rob's 1980 book, *Cordwood Masonry Houses*. At the time, my wife Louisa and I lived in the Washington, DC, area, both of us deeply embedded in technical careers, but plotting to break free of the city's fast-track scene. We bought a piece of land in Virginia's northern Shenandoah Valley and began the transition to a simpler lifestyle.

Our first dwelling was a small cabin, half cordwood. Next we built our home: underground and cordwood. These were followed, in the last ten years, with a cordwood privy and a meditation hut.

All of these structures were built using similar construction techniques. We made early decisions about our approach and pretty much stuck with them through the construction of all four buildings: (1) using post and beam and infilling with cordwood, (2) using a similar mortar mix to that developed by Rob, (3) oil treating the log-ends used for infill and (4) using meticulous (sometimes obsessive) pointing techniques for the mortar. These techniques are what we call our "cordwood constants."

As each building was begun we also added some new techniques, embellishments that spoke to us to try out. They were: (1) insulating the mortar, (2) trying out various artistic and whimsical methods and (3) experimenting with different types of wood. These techniques are what we call our "cordwood embellishments." Both kinds of techniques are expanded upon below.

Cordwood Constants...and Why

We began our cordwood adventure by conducting lots of research, soaking up everything we could find and enrolling in an Earthwood workshop back in 1983. This got us off the ground with good practices, as well as with a little practical experience under our belts. We decided to go post and beam, as this approach quickly assembles the skeleton of the building, gets a roof on for protection from the elements and gives us leisure time to infill the walls.

Our chosen home site was a young Virginia pine thicket, with tree trunks from 3 to 8 inches in diameter. Cutting those pines to make way for each of the dwellings gave us all the wood we'd need. Virginia pine is denser than white pine and is excellent for cordwood infill: it neither absorbs moisture nor shrinks as much as other kinds of pine. When cut to length, the log-ends cured well within a year. Cutting the trees also gave us all the mortar sawdust we needed, created as chainsaw waste. We used Rob's Portland recipe described in Chapter 3.

We decided to implement a log treatment technique that would minimize swelling when the logs were set in moist mortar, and thus reduce later shrinkage. I had picked up the idea from somewhere during my research, but it took a little while for us to overcome the "yuck" factor: the cured logs get dipped into a half-and-half blend of used engine oil mixed with a thinner like kerosene. The thinned oil soaks well into the wood, rendering it decently oil-logged, so it's much less likely to soak up water when placed in the mortar. The used engine oil also tints the logs a nice brown hue, which does not fade to gray in the sun. What we found is that, in two to three months' time, the volatile compounds in the oil-kerosene treatment had evaporated, leaving behind a rubber-like substance that had penetrated well into the wood. Moreover, it was odorless, and did not rub off on our hands. Goodbye to the yuck factor.

Finally, we were meticulous, if not rather zealous in our pointing technique. Basically, we used the log laying and pointing techniques that we learned at Earthwood, and which Rob describes in Chapter 3. *Pointing is very important*. A cordwood building will last many years, but it should also satisfy one's aesthetic and artistic inclinations. That is the essence of cordwood construction in my mind, how it stands out from other building techniques: it's both durable and appealing. The amount of time invested in pointing the mortar is, I believe, time well spent, since for many years thereafter I will be looking at the end product of my labors. If it looks sloppy, that carelessness will regretfully poke at me again and again. If, however, I took the extra time to fine tune the details during construction, the pleasing appearance will enduringly satisfy.

I found that a crucial aid to getting me through the laborious pointing process was attendance at a nearby Buddhist meditation center, where I learned to be present with what was unfolding in one's life at the moment, judging events to be neither exciting nor boring: they just are. I found that I could become absorbed in incredibly monotonous activities without feeling the need to hurry on to some kind of conclusion.

So those are the highlights of the cordwood construction techniques that we found worked for us in all four buildings. They constituted our cordwood constants.

17.1. Our first cabin. Credit: Geoff Huggins.

Cordwood Embellishments...and Why

As we tackled each building, we had an urge to experiment, to try new techniques that spoke to us—or we saw others using—and we decided to give some of them a shot.

The first building we raised—the small 12-foot by 15-foot cabin in Figure 17.1—was intended to be a shelter for weekend trips to the land, while we planned the house. We soon ended up living in it for over two years, as we slowly built the house (all that zealous mortar pointing). The cabin has no insulation—either as a mortar sandwich or in the upper wood structure or roof—though a wood stove was installed. During those two years of residence, cold winter nights saw icicles form on the ceiling overhead, as they dripped onto our bed. Now the cabin is a workshop. The timber-framed cabin was built with 5-inch-square oak timbers, using mortise-and-tenon connections. The walls were infilled with small, round Virginia pine logs, but we did only modest pointing of the mortar on this first building. (An early lesson we learned: smooth, round logs may later easily be pulled from the cured wall. We soon began hammering roofing nails part way into the logs, to anchor them in the mortar.) The little log-ends were only 5 inches long, to match the 5-inch posts. Since we did not plan to insulate this small cabin, we went with the thin walls; for a small building, it gave us maximum floor area: 170 square feet. It is a rugged and roughly-built little structure.

The rectangular main house is both underground (2½ walls below grade) and cordwood (1½ walls above grade). We cut 8-inch log-ends for the walls. This is a very thin wall, by most cordwood standards, but we live in a rather mild climate, compared to most cordwood builders. We chose the thinner walls because it was easier to frame the windows and doors with an 8-inch wall; besides, about two-thirds of the walls (and the whole roof) are underground, which provides that part of the house with excellent heat retention. For a little over a 1,000-square foot house, we burn less than six face cords of 16-inch wood each winter, about two full cords.

17.2. Our house is cordwood above ground. Credit: Geoff Huggins.

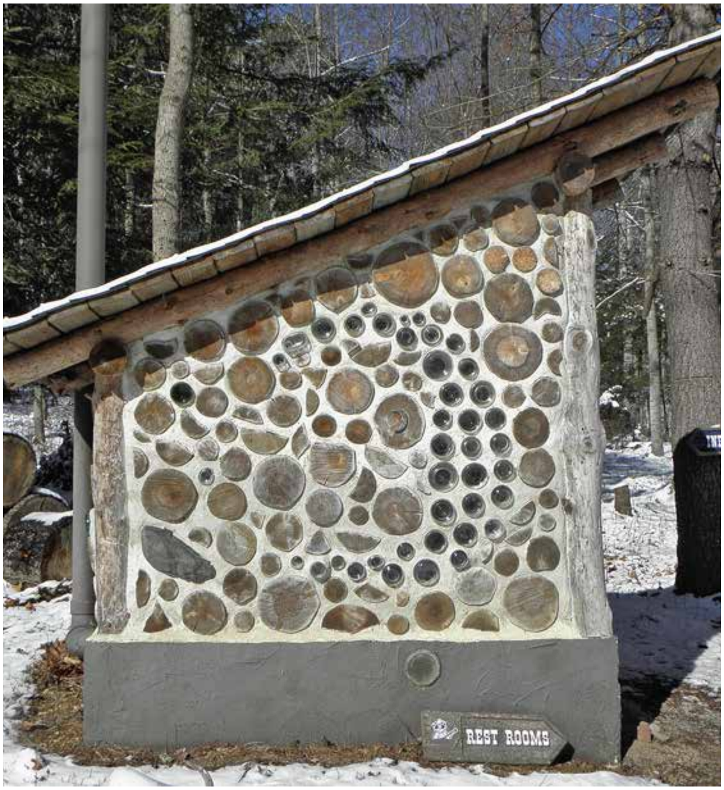
17.3. The earth-sheltered part has a living roof. Credit: Geoff Huggins.

Ten-inch walls were an alternative to the 8-inch cordwood walls we actually built, but when I analyzed and compared the heat loss, I found that while the R-value of the thinner wall suffers by 26 percent, there is only a 9 percent change in heat loss. Why? Because, in either case, half of the heat loss goes out the windows—and our windows are not that large (Figures 17.2 and 17.3). The house's cordwood walls were built with both split and round Virginia pine logs, with very few decorative embellishments. Instead, we got a little creative with the windows, doors and interior design, as seen in Figures 17.4 and 17.5. We again used post-and-beam construction, buying rough-sawn timbers from a local sawmill, and using tree trunks from the land as weight-bearing posts. The house was completed 30 years ago.

We didn't get carried away with attempting decorative ideas until we built our cordwood privy. This, like the cabin, uses 5-inch logs, with no insulation. Why insulate when you don't install a door? (We live isolated in the woods, and we enjoy watching Mother Nature from the throne.) It is a composting privy, with a large capacity human-soil holding space, which we empty every four years or so; placing the beautiful compost around our fruit trees.

17.4. Stained glass windows atop walls. Credit: Geoff Huggins.

17.5. Homemade door. Credit: Geoff Huggins.



17.6. Composting privy. Credit: Geoff Huggins.

The three walls of the privy were decorated with bottles and glasses. On one wall a large crescent moon (the universal privy symbol) dominates. On another wall we built in an aquarium window, a blue glass thermometer and a small statue of Ho Tai (whose tummy we religiously rub on every visit). On the back wall of the privy we set stones and other masonry mementoes we'd collected on our travels around the US and overseas. (I love the small chunk of roof tile from an ancient Italian building.) If there's one room that should go a little over the top in ornamentation, it ought to be the utilitarian privy!

The most recent cordwood structure is my spiritual abode: an octagonal meditation hut. It is my *kuti*; which is a Buddhist word for a tiny dwelling place or meditation hut. It was the most fun to build and is the most eccentric. I wanted to try building a circular cordwood structure, but was drawn once again to go post and beam. For such a small building (floor space is 90 square feet), the wall curvature would simply have been too tight. So I compromised and designed an eight-sided kuti.

17.7. Interior: privy moon. Credit: Geoff Huggins.

17.8. Back wall with Ho Tai, lower right. Credit: Geoff Huggins.

17.9. Winter kuti (back view). Credit: Geoff Huggins.

Since the kuti was the first optional structure we built (the others were necessary for either living or relieving), we could take our time in planning and acquiring materials. That allowed me to track down some good deals, keeping costs to a minimum. All windows and the door were donated, all the cordwood again came from the land, and other materials were scavenged in other ways. The total construction cost was about $500, with over half that just for roof shingles and sheathing. (I wish we had a local source of reeds for a thatched roof.)

Two new techniques were introduced for the kuti: the use of slab-wood for window and door framing and about eight different kinds of wood for infilling the walls. By this time I felt confident enough in our used-engine-oil treatment to minimize shrinkage and reduce the gaps when the mortar had cured. I also wanted to introduce some beautiful hardwood logs like oak, apple, redbud and locust, although about two-thirds of the logs were still Virginia pine. I wanted lots of windows in the kuti, to give me a feeling of meditating outdoors. A large skylight bathes the interior in sunlight.

The slab wood came from a nearby lumber mill at a ridiculously low price: all the wood I could load on my pickup for $5. I had wanted to try slab wood for framing

17.10. Summer kuti (side view). Credit: Geoff Huggins.

17.11. Slab-wood window frames. Credit: Geoff Huggins.

17.12. Kuti skylight. Credit: Geoff Huggins.

windows and doors and this was my chance to play with that concept. I also did the interior ceiling in slab wood.

The kuti's cordwood walls are the thickest I've yet built: 12 inches. The windows are all single pane, so the structure loses heat rapidly, but the little woodstove can keep the interior nice and cozy, with a building that small.

Some things change in life, some stay constant. Things evolve and things get settled into. Maybe these four buildings are all the cordwood structures I will build, with no need to evolve any further. Who needs more than one house or privy? However, I have come to love watching birds, and just maybe they might stimulate me to try yet one more dwelling: a cordwood nesting box. Maybe I should start saving my kitchen matches for the tiny logs.

CHAPTER 18

Adirondack Cordwood Cabin

by Rarilee Conway (with James Conway)

In June 2013 my 21-year-old son, James, and I participated in Earthwood's Cordwood Workweek. Our intent was to spend quality time together learning a life skill. That summer/fall I put my new skills to practice building a 10-foot by 12-foot sleeping cabin on my property. The purpose of this project was to show my husband that I could do it myself and to end up with additional interesting space for guests.

By "coincidence" I stumbled upon scrap log-ends from a local lumber mill at a very reasonable price. It was worth it to me because I did not have to cut, peel and wait for logs to dry. The log-ends were uniform in size and shape: milled-three-sides pine ends and pieces left over from log cabin construction. I could cut them to 8-inch lengths using my band saw, giving very regular and smooth end cuts. The sleeping cabin successfully achieved the intended purpose and we were on track to build a small cabin in 2014, once James graduated from college.

Our Adirondack Cordwood Cabin (a.k.a. Stoneview) was designed and built utilizing Rob Roy's book of the same name: *Stoneview: How to Build an Eco-friendly Little Guesthouse* (New Society Publishers, 2008.) Luckily, our town code enforcement officer was knowledgeable and comfortable with this alternative construction project. The goals of this project were to provide James a way to pay off his college loan, give me an excuse to quit my job and establish rental income property for our family. We broke ground in June 2014 and the two of us worked approximately 40 hours per week for six months doing almost everything ourselves.

I maintained detailed cost information throughout the project. (See the sidebar below.) It is interesting to note that apples-to-apples costs just about doubled from what it was in 2004 when Rob built the first Stoneview. Our project included significant modifications and additions from Rob's plan: commercial electric service, adding an 8-foot by 8-foot bathroom with tiled shower and SunMar compost toilet, on-demand gas hot water heater, a full kitchen, a back door and a Lopi gas stove for

18.1. Our Adirondack Cordwood Cabin is a 22-foot-diameter octagon. Credit: Rarilee Conway.

18.2. Log-ends from Haselton Lumber. Credit: Rarilee Conway.

heat. It was important to me to put in a composting toilet as part of the whole eco-friendly approach to building, but we were still required to install an engineered grey water system.

All of our corner posts and the center post were harvested from our property. We used the method of larger log posts visible from the outside with smaller diameter posts fastened to them to be visible from the inside, as per page 15 of *Stoneview*. The consistent brick-like nature of the log-ends enabled us to maintain very straight, level and uniform mortar joints. We chose to use a lime putty mortar due to its ease of use, brightness and longer set time. Enkadrain (a drainage matting) and W.R. Grace Bituthene waterproofing membrane were used to construct the lightweight living roof, as per Chapter 5 of Rob's book.

18.3. Ten-foot by twelve-foot sleeping cabin. Credit: Rarilee Conway.

We used 200 bottles to make 100 bottle logs, many of which I created using stained glass pieces epoxied onto the inside bottom of the bottles. This makes a kaleidoscope-looking bottle end: very interesting and you can make your own color designs.

If I Was to Do It Again…

In hindsight I would make the following changes:

- Build the octagon with 10-foot-wide sidewalls instead of 8-foot, providing almost 200 square feet of additional living space and allowing for the bathroom addition to be 10 feet by 10 feet. This would likely allow for a washer/dryer unit and possibly a closet as well.
- Utilize the on-demand gas hot water heater as an in-floor heat source.
- Use wider log-ends to enhance thermal capacity and add two inches more foam to the roof for better insulation.
- Wire for audio speakers in the walls.

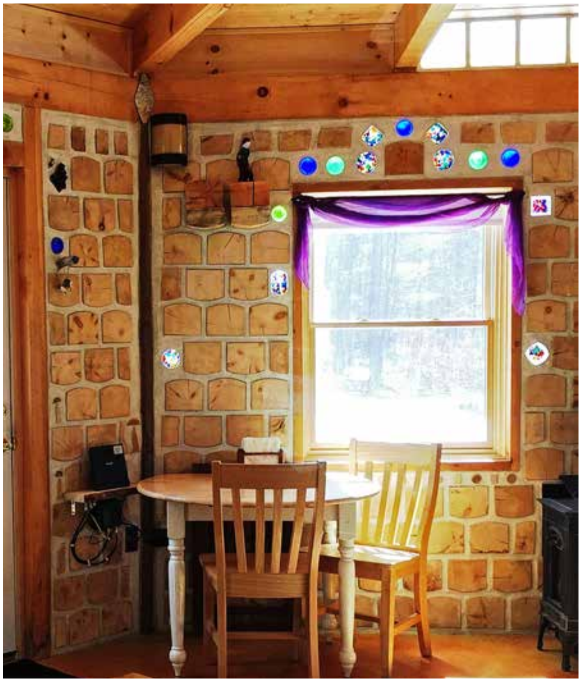
The entire experience from the workshop in 2013 through our recent completion and now successful vacation rental was so worth it. I got to spend six months with my son, lost ten pounds, and learned a great deal. Our cabin is

2014 Adirondack Cordwood Cost Detail

sand, stone	$1,722.60
backhoe	800.00
hand tamper	54.00
rebar	75.80
Styrofoam	600.24
plumbing materials	940.68
concrete	915.06
girts	1,709.70
rafters	825.00
V-joint T & G	2,186.09
windows	1,614.17
doors	400.00
sheetrock	61.31
studs	186.05
masonry sand	125.00
Portland cement	112.00
lime	331.00
flashing	47.39
Bituthene membrane	567.53
hardware and misc.	600.00
P.T. retaining timbers	191.26
floor stain, paint, caulk	300.00
electrical material	450.00
lighting	568.79
hot water unit	991.61
fuel	50.00
cordwood	350.00
driveway	1,200.00
shed	488.13
seepage pit	1,000.00
compost toilet	1,808.99
Lopi gas stove	2,349.00
fridge	400.00
range	470.00
shower	298.12
Enkadrain	484.00
fencing	448.50
gas hookup	991.70
electrical hookup	1,500.00
utilities	285.49
electrical inspector	265.00
building permit	147.70
screws	300.00
tree removal	570.00
counter tops	419.71
water shut off valve	200.00
engineer	350.00
Total cost*	**$30,751.62**

* Does not include labor, land or furnishings.

18.4. The timber frame. Credit: Rarilee Conway.



18.5. Inside Adirondack Cordwood Cabin. Credit: Rarilee Conway.

so comfortable to be in—it has good energy! It is available for short-term rental on Airbnb, and is very close to Whiteface Mountain in Wilmington, New York.

Author's Note: Rob here. Many "Stoneviews" have been built around the world, from Idaho to Corsica in France. In December of 2014, Jaki and I visited this one built by Rarilee and James, just an hour from Earthwood, and it is easily the most beautiful we've seen. The use of the regular log-ends is anything but boring, because of all the wonderful special features that Rarilee and James incorporated into the walls: stained glass "bottle logs" (bottle-ends), hearts, mushrooms and more. You can see a couple of dozen color pictures at airbnb.com/rooms/4872916.

18.6. Stained glass bottle log. Credit: Rarilee Conway.

CHAPTER 19

Ravenwood: A Labor of Love in Northern New York

by Bruce Kilgore (with Nancy Dow)

Our Cordwood Odyssey

Nancy and I became a couple in the fall of 1994. I was a firefighter in Burlington, Vermont, and Nancy was a school teacher in northern New York. Five years later, when we realized that this thing we had might last after all, we set out on what was supposed to be a simple adventure. We would go shopping for a new camper. However, we made a series of leaps from why a camper...to why not a camp...to why a camp, when we could build a home where we would actually *want* to spend time.

Then fate stepped in. I was browsing a magazine rack and noticed an issue of *Mother Earth News* featuring a couple building a cordwood sauna. I did something I never do and read the byline: Rob and Jaki Roy, Earthwood Building School, West Chazy, New York. Hey! I know where that is; I had driven by their sign dozens of times. The next day I was knocking at their door. I was familiar with the idea of cordwood masonry from past articles, but this was the first time I got to see it for myself. I found myself following Rob around, looking at the house and various outbuildings saying, "This is so cool!" Rob talked about building mortgage-free and I was hooked.

My next challenge was to convince Nancy and her two kids from a previous marriage, ages 10 and 15 at the time, that this was the way to go. I brought them to Earthwood for the fall Solar Homes tour. Their responses were not exactly over-the-top. Rob arranged for us to visit several other cordwood homes—still lukewarm, at best. Over the coming weeks, we began looking at conventional home construction, building loans and 30-year mortgages. Nancy and I quickly agreed a 30-year mortgage was out of the question. I continued to pitch cordwood and managed to convince Nancy to take Rob and Jaki's cordwood class in the spring of 2000. We had a great time and met some fascinating folks. Some became good friends. Most of all, Nancy enjoyed the work. That summer we began seriously looking for land, still unsure of the house we would build. While searching for a lot listed in the local paper, we happened upon a broken-down sign on what looked like a promising home site. A call to the realtor revealed it to be an expired listing, but she thought it might still be available. Digging deeper, I discovered that the adjoining property was also for sale. The first time Nancy and I walked in those overgrown fields, we felt like we had come home. We made offers on both parcels and soon closed on our very own slice of heaven, forty-three acres we call Ravenwood, located just inside New York's Adirondack Park, with a charming view of the Green Mountains of Vermont. Over the next three years, we established a 600-foot driveway, put in a well and constructed a "bender" for temporary storage. A bender is like a Quonset hut, the top half of a horizontal cylinder. Ours, made with bent boughs and plastic, can be seen in Figure 10.6. At the same time, we began an application to convince the Adirondack Park Agency to grant their first-ever permit to erect a 100-foot high, one-kilowatt wind turbine.

A Five-year Plan

By this time, Nancy and I had formulated a five-year plan to build a house without a mortgage. We still had not agreed to build a cordwood house, but I was determined to build something. I built a cordwood cut-off saw (see Chapter 15) and started to gather, cut and stack northern white cedar. In 2003, Nancy came to terms with my stubbornness and we agreed to build a small, round cordwood cabin to practice our skills.

I had never built anything round, let alone timber framed and cordwood. With the freedom of total ignorance, I dove in the deep end. I chose a building site that seemed level enough, and after four large dump truck loads of fill, it was. This led to our first new challenge: building a stone retaining wall to keep the fill in place. Two weeks later, the result was a pedestal for our cabin to sit on. Next, the slab; how hard could that be? If you know what you are doing, it's easy. I over-thought the process, but managed a respectable form and even placed radiant floor tubing, something else to explore in the future. I was so proud of this little milestone that I convinced Nancy to camp on the new slab.

Moving on to timber framing, I consulted with Rob Roy on the frame design. He provided a simple, sound building plan. I totally ignored it (this continues to be my pattern). It's amazing that he calls me his friend! Working mostly alone, it took me the rest of that building season to finish the frame. We managed to put the tongue-and-groove roof deck on before the snow. This is where I made my next big mistake. I believed tarps would be sufficient water-proofing for the winter. Wrong. Watermark stains now decorate the ceiling.

Trying to make the most of this 315-square-foot space, I began playing with ideas like cordwood infilling between posts, cordwood outside the post, and finally settled on wrapping around the post. This is how cordwood "wraparounds" came into being, which Rob describes in Chapter 4. During the summer of 2004, we hosted several workshops and a weekend work party, but it still took a full building season to complete the walls. It was worth every minute. During this time, Nancy and I learned how to work together. I was essentially her mortar-maker, wraparound cutter, bottle-maker, staging-builder and all-around problem-solver. Nancy could express her creativity and she developed a good eye for choosing and

19.1. Our 22-foot-diameter cottage. Credit: Bruce Kilgore.

placing log-ends. Her knack for pointing speaks for itself, but it was after Jaki Roy's compliments that Nancy beamed with pride. It was also at this point that Nancy agreed to build a cordwood house!

With our first cordwood structure finished, the biggest lesson learned from our cabin experience was that we needed secure storage space where we could keep tools and material, rather than wasting time hauling them back and forth from where we were living, 20 minutes away. Around this time, Rob's *Timber Framing for the Rest of Us* (New Society Publishers, 2004) was published. In 2005, plans were drawn, advice was given and compromises were made to build a 40-foot by 14-foot storage building based on Rob's "six-poster" sauna design, but repeated four times, for a total of 15 posts. When the slab was finished, we hosted Rob's timber framing classes. Unlike the cabin, the class had the building framed and the roof decked in three afternoons. Okay, Rob *does* know more than me. We hosted a few more cordwood workshops, but this time Nancy slipped into teacher mode, sharing tips and techniques she had developed. She had come a long way. We finished the storage building well enough to meet our needs. The rest could wait; we had a house to build.

The Trisol Design

It was much more difficult than I thought to come up with a design. Cordwood, yes. Timber frame, yes. Earth roof, yes. Off-grid solar and wind, yes. Round, *no*. Nancy and I looked at various floor plans, but nothing seemed to work. I knew we wanted to build a highly energy efficient house. We also wanted it to be passive solar and earth sheltered. To maximize solar gain, we would need a long south wall; to minimize exposure, we would need a short north wall or no north wall at all. We met with Leandre Poisson of New Hampshire and toured one of his Trisol homes. We liked the idea enough to purchase his basic plans. I set about trying to marry Leandre's design to a two-story timber frame that could carry an earthen roof. My goal was to build as much of the house as we could ourselves, with some unskilled hired labor. Cutting and heating with our own wood is cheap, but a lot of work. Therefore, we chose to build double-wall cordwood, primarily for energy efficiency. By using 8-inch logs outside, 1-inch lath, 8 inches of insulation, 1-inch lath, and 8-inch logs inside, we created the 26 inch walls described in Chapter 7. Finally, we decided to use lime putty mortar after experimenting with it on our storage building. We liked its lighter color, longer pointing time, breathability and lower embodied energy. (See Chapter 10: Lime Putty Mortar.) The final design is unique, to say the least. I like to say it's the only one like it on the block.

19.2. Our triangular Trisol foundation in place. Credit: Bruce Kilgore.

Breaking Ground

We broke ground in the summer of 2006. The construction of the footing and slab was very straightforward. The only significant difference was that we put two inches of insulation under the slab for the radiant floor tubing, instead of the one inch we'd used at the cabin. Under each post and the future masonry stove, we prepared a much thicker slab. Our foundation is built of dry-stacked, surface-bonded 10- and 12-inch concrete blocks, making this double width to 22 inches. This was done to support the outside cordwood wall. On the inside of the walls, we used white surface bonding cement as a base surface for painting. We then filled sections of the block at 10-foot spacing to form pilasters. To finish, we filled the tops of the walls with concrete. Before backfilling, we applied waterproofing, drainage and 4 inches of extruded polystyrene insulation. We also continued to collect cedar.

I spent the next winter fabricating the metal hangers we would use to connect our timber frame. If all went well, the timber frame would go together like an erector set.

19.3. A very heavy timber frame was designed to support the living roof. Credit: Bruce Kilgore.

19.4. I spent a winter fabricating the metal hangers we would use to connect our timber frame. Credit: Bruce Kilgore.

Racing to Get the Roof On

We hosted another of Earthwood's timber framing classes in 2007. Once again, we had a wonderful time and our lower level was nearly complete. With some hired help, the deck was on in a few days. The race was on: we had to get the rest of the frame up and the roof watertight by the end of summer. Because of the shape of our house and the 2:12 pitch of the roof, nearly every post has a compound miter cut on top. Once cut to proper length, we stood and braced each post in position. To raise our beams into place, we utilized a friend's boom truck. The systems of hangers worked almost perfectly and, in less than one week, the frame was done. We moved quickly to get the roof deck and Bituthene 4000 waterproofing membrane in place. Despite one of the wettest summers ever, the roof was shedding water.

Cordwooding Commences

As mentioned in Chapters 6 and 7, we chose a double-wall cordwood system. In preparation for cordwooding the outside wall, the frame was covered with 1-inch by 4-inch wooden lath spaced 4 inches apart, horizontally. This lath would provide attachment points. Just as wall ties are used for brick veneer walls, our cordwood is toe-screwed, when possible, to the lath. Tarps were attached to cover the house for the winter. Throughout this season, we also hosted Rob's cordwood classes to keep going with the storage building. And we continued to stockpile cedar.

In 2008 we hosted a spring timber framing class to frame and deck the front porch. Finishing the main roof was the next major project. Within one week, on top of last year's waterproofing, we had layered 8 inches of Styrofoam insulation,

19.5. View from inside showing the outer wall built up to the horizontal wooden lath. Credit: Bruce Kilgore.

more waterproofing, Ameridrain drainage matting and 788 bales of hay to provide R-40 insulation.

Finally, we could begin cordwooding the outside wall. Rob has already described our basic technique in Chapter 7 to show how it marries up to our choice of spray foam insulation. Our lime putty mortar is described in detail in Chapter 10.

We had learned from our cabin and storage building how to organize ourselves, so cordwooding was now in full swing. Nancy would scrape log-ends, ready her work area, build the masonry, toe-screw logs, point and decorate. I would set staging and tarps, prepare for mixing, and help stock the work area.

We usually did 10 to 12 batches per day, depending on circumstances. (Fifteen was our best!) Starting with the west wall and turning south, our plan was to complete all outside walls, but 353 batches later, Nancy was back to teaching school and we ran out of enough after-work daylight to cordwood the north side. We had to stop.

By the summer of 2009, we had modified the house plans and decided to attach a breezeway and garage to the north side, so our first job was to fasten additional timber posts to the existing frame. It actually made it easier for Nancy to cordwood in sections, rather than one large wall. Another 183 batches of mortar, added to the previous summer, made the total batches for the outside walls 536. With the exterior complete, we moved inside.

My next focus was to prep for insulation. The 8-inch space defined by the frame would be filled with half-pound density, soy-based, open cell foam, as per Chapter 7. Our first choice would have been sawdust; however, locating sufficient amounts of this resource, along with lost time and additional labor, discouraged us. We also preferred the breathability of the open cell foam.

Before cordwooding could continue, lath and fabric had to be installed on the interior walls, then the rough plumbing and electrical wiring. For switches and outlet boxes, we first attached a short block to the lath to mount each box. Our electrical inspector was concerned about Romex wire's insulation contacting the mortar, so we chose BX wiring (shielded flexible conduit with conductors inside) and believe that the extra cost was offset by fast, simple installation, taking only two days. Our electrical inspection was painless.

Interior cordwooding was a dream. With no weather concerns, we pressed forward. The lower level of the south wall was completed in six days, averaging 12 batches each day. The upstairs south wall was finished in 13 days. Our hired help left for college and work progressed at an average of nine batches per day. Another building season was coming to a close and we still needed to install windows and doors, so we stopped cordwooding. We installed special-ordered glass specifically glazed for passive solar gain (Cardinal Glass: cardinalcorp.com).

Closed In!

Since the house was now winter-tight, we were able to continue work inside. We opened the floor and built temporary work stairs. We also installed the core of our masonry stove and covered the exterior with red brick. I built a rack and installed the rest of our off-the-grid solar array. In the spring, we erected our tilt-up wind turbine and Jim Juczak, another cordwood builder, made the final connections to our battery bank and inverter. We were making power!

Nancy finished the kitchen by the time school let out at the end of June, 2010. We mentally divided some walls into sections, areas that would be seen versus portions covered by cabinets and closets. Here we used our "ugly" logs and a more relaxed pointing technique. Nancy masterfully decorated the visible areas, creating special features such as single shelves and hollow log-ends. Many trinkets and gemstones from her parents adorn these walls. Nancy refers to it as her comfort wall. The remaining north wall, along with the west wall, was finished by the end of July. We used 408 batches inside, which, along with the exterior work, gives a grand

19.6. The completed kitchen. Not-so-nice log-ends are hidden behind cabinets. Credit: Bruce Kilgore.

total of 944 wheelbarrows of mortar to cordwood our 2,000-square-foot double-wall house. Wishing we had acted sooner, we decided this was our last opportunity to remedy the gray, weathered appearance of the interior posts and beams. After researching several options, we settled on spraying the timber with Olympic deck wash, rinsing with water and drying with rags. The lighter color is impressive, but—trust me—this is a job better done prior to timber framing.

Nancy made an executive decision: even though the house was not complete, we would move into the guest cabin by the end of August and continue work from the vantage point of being onsite, not 20 minutes away. *Time for the big push*. We hired a local contractor to install ceramic tile downstairs while Nancy and I put down hardwood flooring upstairs. We also installed the chimney and got the woodstove functioning. I worked with our electrician to install lights, outlets and switches. In keeping with the black timber fasteners, we painted the visible BX wire and nestled it along the beams for a uniform, unobtrusive look. With the house *still* not complete, we decided to stay with our cozy cabin lifestyle while I moved on to frame, drywall and paint the bedrooms and bathroom downstairs. And build doors. And kitchen cabinets. And. And.

Staying true to our plan to build mortgage-free was more challenging with the finish line in sight, but we made it. During the next building season, we framed in the porch and garage for 8-inch single-wall cordwood construction, hosted two weddings and prepared for our first grandchild! Oh, and I almost forgot: we moved in on June 21, 2011.

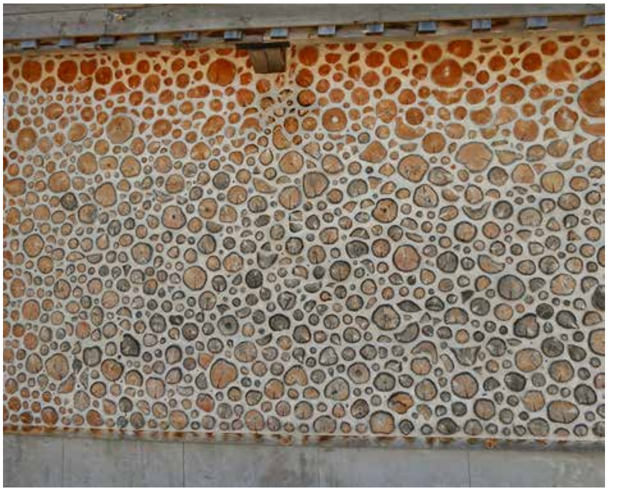
There is still much more work ahead. Ravenwood will continue to grow with the addition of a workshop, greenhouse, sauna with plunge pool, bee yard and maple sugar house. Now in retirement, we will never be bored.

What Worked…and Hard Lessons Learned

We are very pleased with our choice of double-wall construction, as it has minimized our heat loss through thermal bridging. We have created an inside wall that is a more efficient heat sink. Using an infrared thermometer, I observe an even temperature distribution along the interior walls. The lime putty mortar has performed perfectly. Any hairline or stress fractures occurred during building, reflecting our learning curve. A few hairline cracks occurred in the mortar early in the building learning process. We see no evidence of new fractures, even after at least two tremors. Our worst cracks are where we started on the front of the house. We offer this advice: start on the back!

Our design goal was to passively heat, as much as possible, through a northern New York winter. Original calculations, based on the amount of insulation and southern exposure, was to burn roughly two full cords of hardwood per year. The first three years: Yes! Last winter, a bitterly cold one, we exceeded that amount by an extra face cord, still very respectable.

To help regulate heat, we purchased insulated window shades. During the summer, we keep the shades closed until the sun is off the south wall, keeping the house cooler. We take advantage of sunny winter days by opening the shades, warming the house to a balmy 75 degrees. Once the sun is off the south wall, we lower the shades to trap the passive solar gain inside. Now that we are retired, we are home to better manage the shades or, when the day is gray or it is below zero, we may build an extra morning fire. Additionally, to help control and maintain humidity levels, we added a fresh air intake vent to the woodstove. This greatly improved the overall comfort level within the house. I am also beginning to look into a solar system for domestic hot water. And since we installed radiant tubing in our concrete slab, excess heat might be dumped there.



19.7. Even the very large cordwood walls did not suffer from mortar cracking. This is part of a section 23 feet long and 12 feet high. Credit: Bruce Kilgore.

We built with local white cedar that had seasoned for several years. Nancy stayed true to placing logs with checks facing down, generally between four and eight o'clock, giving walls a consistent look, even on the inside double wall. She

19.8. One of the several ravens that live in the cordwood walls. Credit: Bruce Kilgore.

19.9. Wood-burned log-end. Credit: Bruce Kilgore.

19.10. Ravenwood, complete...? Credit: Bruce Kilgore.

filled larger hollow-centered logs with mortar and gem stones. She left three logs hollow, so she could display unique objects. After the first heating season, we were shocked to find many logs continued to dry, creating new checks. Even after four years, we still hear the occasional crack.

19.11. Nancy has a creative bent. Credit: Bruce Kilgore.

Another mistake we feel we made during construction involves logs with checks. Don't fall into the "I'll deal with them later" trap. If you wish to build with rounds, we recommend you deal with checks as you go, whether you choose to fill them with insulation, mortar or both. Then, you only have to deal with the checks that show up after the house is finished. We learned that if you miss even one log, it can become a haven for bees or wasps.

Rob Roy's note: Ravenwood is one of the most beautiful cordwood homes I have seen, anywhere. Bruce and Nancy were excellent students, and both are very good at instructing new students when we hold workshops there, just a half hour from Earthwood. See the color section for some recent pictures of Ravenwood.

CHAPTER 20

Hexadecagons in Hawaii and Tasmania

with Peter Robey and Blythe Tait
(*and with help from Ben Oliveros*)

Two of our favorite cordwood workshops were held five years apart: with Ben and Mirtha Oliveros at their orchid farm on Hawaii's Big Island in 2005 and with Peter Robey and Blythe Tait near New Norfolk, Tasmania, Australia, in 2010. Coincidentally, both couples built almost identically sized temporary cabins out of cordwood masonry—square buildings 20 feet on a side—and lived in them while they built their main houses. Both homesteads are off the grid. Both built two-story cordwood hexadecagons, also the same size, as their permanent home. (A hexadecagon, to save a run to the dictionary, is a 16-sided polygon. Wikipedia has a good entry on the shape's geometry, including a nice animation of how to construct a hexadecagon with a compass and straightedge.)

But the mutual choice of hexadecagons is probably less than coincidence. Jaki and I always tell our students that if we were to build Earthwood again, we would make it 16-sided, so that the roof could go on before the cordwood commenced. Both couples liked the idea of the round house, but both lived in climates where protection from the elements is imperative. In fact, Mountain View, on Hawaii's wet side, suffers from about 200 inches of rain per year, and, being near Volcanoes National Park, is in a seismic zone. So a hexadecagon made sense.

Ben had come to a workshop at Earthwood before he and Mirtha moved to Hawaii. He had been doing orchid work in Georgia back then, and decided that the Big Island's climate would be perfect for taking his work to the next level, so they bought 20 acres near Mountain View. They already had their temporary shelter framed when we arrived for our 2005 workshop there, during which the cordwood masonry commenced.

We were surprised, one day, to receive a very large book order from Australia, still a record. It was from Peter and Blythe. They bought nearly every book and video

20.1. Ben and Mirtha's house in 2008, just before we started helping Ben with the second story cordwood.

Hexadecagons, Architecture and Cordwood

The Renaissance artist Raphael completed his painting *Marriage of the Virgin* in 1504 and it now hangs in Milan's Pinacoteca di Brera art gallery. The backdrop to the marriage is a perspective image of a beautiful stone building, a regular hexadecagon. Two hundred years earlier, the Moors incorporated hexadecagons amongst a myriad of other geometrical patterns at the Alhambra Palace in Granada, Spain. And the polygon's history no doubt goes back much earlier than that. It is the first of the regular polygons which I think of as having "honorary circle" status, yet it can be built with straight lumber.

Back in the 80s, Richard Kovach and Dawn Danielson built a 16-sided Earthwood near Carlsborg, Washington, a seismic zone, to satisfy their code enforcement officer. Later, Bunny and Bear Fraser built a two-story hexadecagon in Coe Hill, Ontario—a home featured in Chapter 6 of the original edition of *Cordwood Building*. They sold the home to another couple who now run it as an excellent Bed and Breakfast. (Jaki and I have stayed there. You can, too. Go to: gatheringbb.com.) Many others have built hexadecagons since, including Alan Stankevitz, whose story appears in Chapter 6 about double-wall cordwood and Chapter 7 about foam insulation.

we had. We kept up with the couple, and when we were looking for workshop hosts in Australia for the winter of 2010 (summer "Down Under") they were the perfect choice for hosts. The workshop's 16 students were mostly from Tasmania, with a few from mainland Oz. The workshop project was a small round sauna, because Peter and Blythe and their two young sons had already completed the cabin and were living in it. With just my book and video to go by, they built it in an astonishing 40 days... and did a fine job.

20.2. Peter and Blythe's 20-foot-square temporary shelter, Tasmania.

Builder Ben

Juggling fatherhood, his fledgling orchid business and building a 2,500-square-foot home was a Herculean task, but Ben pursued it with the quiet tenacity that we've come to know from him, and always supported by Mirtha, herself balancing motherhood with her work as a lawyer in nearby Hilo.

We didn't see Ben and Mirtha for three years after that first workshop, and, when we did, in 2008, a second son was already running around. In the meantime—in Ben's precious *spare* time—he had (1) framed his 40-foot diameter, two-story home; (2) installed the 16 huge rafters; (3) put on his Spanish-style concrete roof tiles with photovoltaic cells knitted in amongst the tiles; and (4) completed all the cordwood masonry on the 16 downstairs panels.

20.3. Ben and Mirtha's 20-foot-square temporary shelter, Hawaii.

Jaki and I were conducting another cordwood workshop at the La'akea Community in nearby Pahoa, where Ben and Mirtha joined us one night for supper. Oddly, we had traveled 4,500 miles to introduce the area's cordwood enthusiasts to one another! Our students were very impressed when we took them over to see Ben and Mirtha's work.

20.4. To do cordwood on plywood for the second floor, we first applied bonding agent and a wooden key piece.

At the supper, Ben had asked if he could hire us to do some work with him on his second story, where cordwood had not yet commenced. We were happy to oblige, and even camped in one of the nearly finished rooms downstairs, the first people to actually spend a night there, with a mountain view of Mauna Loa and Mauna Kea. Ben had begun his cordwood on a concrete slab downstairs, in the regular way, but wanted to know how to build on plywood upstairs. We'd recently had a similar situation on the new second story at Mushwood, where we urethaned the plywood and applied a bonding agent over that prior to cordwooding. At a building supply in Hilo, Ben found some gooey pink stuff which he thinks was Lanco bonding agent, used before plaster is applied to "any structurally sound surface."

20.5. Ben would carefully cut through the long logs where 5 or 6 small branches came together to make beautiful end-grain designs in his Cook pine. Credit: Ben Oliveros.

20.6. Ben cleaned up hollow log-ends, where a large bee's nest had been. Then he cut slots into the pieces with a chainsaw, about a third of the way in from the exterior side, and slid various colors of stained glass into the slots. Lovely light finds its way in. Credit: Ben Oliveros.

As Ben's land is very new, geologically, and he is in an active volcanic zone—fresh lava recently traveled within 15 miles of his property—Ben thought that a key piece on the bottom of each panel would be a good idea. I'd never done this, but agreed with Ben. As his walls were 12 inches thick, we installed regular store-bought 2-by-4s in the middle third of the wall, as seen in Figure 2.4. They are actually 1.5 inches thick, so our first mortar joint was about the same thickness, or a bit more.

We did two full panels in a couple of days—just 14 to go! Ben kept it up and the family moved into the lower story of their beautiful home later that year, while they completed the upper level.

The Wood

We tried several different Hawaiian woods at the first workshop in 2005, but Ben soon zeroed in on Cook pine (*Araucaria columnaris*), an introduced plantation tree in Hawaii, as the best choice for its stability, workability and appearance. Ben obtained his cordwood by clearing away a large windbreak on someone's property not far away. The species is strong, but light in weight. It was first identified by one of Captain James Cook's botanists in the South Pacific, and the famous explorer liked it for ship's masts and yardarms. Ben was able to see and actual-

20.7. Solar shingles integrate with brown concrete tiles on the Oliveros roof. Credit: Ben Oliveros.

20.8. Sixteen of the 32 heavy Douglas fir rafters are exposed in the center of the building, and support a large round skylight. Credit: Ben Oliveros.

ize wonderful star-shaped patterns where five or six small branches come together, as seen in Figure 20.5, and made use of hollow log-ends by putting colored glass in them, as per Figure 20.6. Ben also successfully used a small amount of *ohia*, a stable Hawaiian hardwood.

A major expense was the 32 long Douglas fir roof rafters, brought in from the Pacific Northwest. Nominally 4 inches by 16 inches, they actually measure about 3.5 inches by 15 inches, still extremely heavy. To install them, Ben hired a boom truck, which, he tells me, "was the smartest thing I ever did." Birdsmouths for each individual rafter were carefully measured and made on the ground, and the whole rafter installation took only two hours!

Ben and Mirtha—and now *three* kids—occupied the entire home by late 2012.

(*Author's note:* Peter's account, below, has been adapted from a paper he submitted to the 2015 Continental Cordwood Conference and an illustrated article he did for the fine *Australian Owner-Builder* magazine #193, February/March 2016, and used with permission.)

Australia's First Council-approved Cordwood Residence? *by Peter Robey*

My wife, Blythe, and I came across cordwood accidentally. We were in the dreaming-about-it stage of house-building, and trawling the Internet for inspiration, when we stumbled across a photo of a darling little house fit for hobbits: a cordwood house! A few more clicks led us to Rob and Jaki's website, cordwoodmasonry.com.

We had no prior experience with building. We were city folk, born and bred. Yet, over the next five years, we completely changed our lives and are now living in the country in a house we built with our own hands. Throughout the building process, we were always gobsmacked when something actually *worked*. For this reason, we call our place *The House that Worked Out*, and to the best of our knowledge it is the first council-approved cordwood home in Australia.

The house is based on Earthwood, with changes made to suit our climate, personal style and the Australian Building Code. It was completed to a livable state in two years and received final council approval within three years. In this time, we only used three contractors: Billy the concrete worker, to ensure we had a level foundation to start with; a plumber, because Australian Building Code requires this; and an electrician. Otherwise, we built the house entirely by ourselves (with sometimes questionable help from our then young sons)—everything from raising the frame to fitting the kitchen.

Framework

We chose a hexadecagon because it is so much easier to have a post-and-beam frame approved by council, but the frame was also an advantage in other ways: providing attachment points for the roof, helping us keep the alignment of the cordwood walls true and assuring that future projects—such as attaching a porch roof to the house—would be straightforward.

20.9. Peter and Blythe's 40-foot-diameter timber frame. Credit: Peter Robey.

The framework of *The House that Worked Out* is made up of 24 Australian hardwood posts, plus a monster 3-foot diameter central column weighing over three tons. Sixteen hardwood posts are arranged in an outer ring which encloses the cordwood walls, and a further eight posts of 12-inch-diameter round celery pine form an inner ring, mostly visible inside the house, giving a bit of a contemporary log cabin vibe.

The diameter of the house is 40 feet. We have an earth roof and installing this after the frame allowed us to commence building the walls regardless of weather conditions (although there were many cold winter mornings when we wished this was not the case).

It took three months to build the house frame. The earth roof was waterproofed and covered in five months.

Cordwood

After our "test-run" cordwood cabin, we seriously considered *not* building our main house out of cordwood. It is very time consuming. Plus, the cordwood logs shrink in the mortar over time and the gaps need to be refilled. We investigated other types of building, including strawbale (not great thermal mass), poured earth (not great insulation) and monolithic domes (great mass and insulation, but more specialized equipment required). In the end, we came back to cordwood; it's cheap, the combined mass and insulation of the walls provide an excellent internal climate and cordwooding is so easy that even no-clue-city-folk like us can do it. We have built other outbuildings with cordwood and will continue to do so.

We stopped counting after our 850th wheelbarrow of mortar. Many alternative builders extol the virtues of mixing mortar and mud by hand, but we preferred the noise of a cement mixer to the noise of our grumbling and groaning whilst mixing by hand. We trialed a lime mortar at our cabin before building this house, but were not happy with the results—lots of mortar cracking—so we settled on a cement-based mortar and are much happier with the results. The mix was 6 sand, 1 cement, 1 lime.

Native Australian wood is almost wholly hardwood—lots of eucalyptus—and not suitable for cordwooding, so we purchased 18-foot plantation pine logs, called radiata pine. Radiata (pronounced ray-dee-*ar*-ta) is used extensively in Australia as it is fast growing, needing only about ten years to harvest. We cut the logs into 12-inch lengths and split the log-ends. We had used rounds in prior cordwood projects and experienced large gaps in the mortar around the logs after drying, so this time we only used splits, with better results. We dried the cordwood ten months.

We used rice hulls for the insulation infill; they do not absorb moisture and provide good insulation.

20.10. The interior of the house is open to the upstairs. The cordwood masonry is covered with plaster rendering. Credit: Peter Robey.

20.11. The House that Worked Out. Credit: Peter Robey.

20.12. Winter in Tasmania. Credit: Peter Robey.

The cordwood process took a year, and, yes, it was cold mortaring in the Tassie winter. But every morning, Blythe would gear up and put in her daily quota of barrow loads. Well done, Blythe—I love you!

Rendering

One of the benefits of cordwood walls is that no extra finishing is required: no plasterboard, no plastering, no painting. Many people get very creative with their cordwooding, with colored glass bottles and interestingly shaped logs in the walls, even shells and pebbles. We love the look of cordwood externally but prefer a plainer brighter look inside, so we rendered the internal walls with a lime plaster. There is little information on the Internet about rendering cordwood walls, so it was a trial-and-error process. The walls dried to a nice coffee color, but we wanted the house to be lighter, so we covered the rendering with a homemade limewash.

Features

- **Access:** The house is set into a slope and has a 23-foot external bridge which allows level access to the second storey. This ensures we can access the whole house if we ever have difficulty with stairs, and we are very proud of it.

- **Passive solar design:** The living areas are in the northern aspect of the house, and the bulk of our double-glazed windows are to the north. We notice a massive difference in the warmth of our house compared to other homes which are not solar oriented. Keep in mind that we're in the Southern Hemisphere.
- **Open interior:** We created an atrium-like interior in the center of the building, giving an unimpeded view from the ground floor up to the exposed beams of the roof. The second level floor stops about halfway in with the hallways cantilevered over the ground floor. The atrium design means that we removed a lot of living space on the second level, but it gives a wonderful feeling of airiness and fills the house with light. We don't miss the living space we sacrificed for this special design feature; the house is still very roomy.
- **Stand alone power:** Like Ben and Mirtha—and Rob and Jaki—we are solar powered and completely off the grid.
- **Water:** We built our water catchment and tanks up a hill so that water is gravity-fed to the house.
- **Hot water:** We have solar hot water and a wet jacket in our woodstove, which supplies hot water in winter.

Working to Pay for Materials while Building

Owner-builders know the strains of budgeting and handling the finances. We had a list pinned to the tools area of the build site showing the next wave of expenses. As milestones were passed and ticked off, new items were added. We felt in a state of exhaustion towards the end: building, working, eating (*maybe* eating) and sleeping.

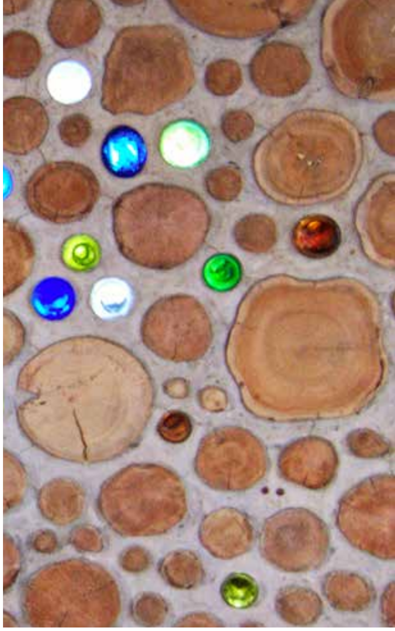
Living in the House that Worked Out

The thermal mass in the walls keeps us cool in summer and the house is easy to heat in winter. On sunny winter days, no extra heating is required, and we smugly observe smoke coming from chimneys of other houses in our valley. Every room is light and airy. There is a feeling of connectedness in a round house; we visit the peripheries, but we are never far from the main hub. We believe this contributes to our closeness as a family.

We tried to think of changes we would make if we could, but we truly couldn't think of any. It truly is The House that Worked Out.

CHAPTER 21

The Hermit's Hut



Geoff Huggins (Chapter 17) is not the only hermit to build a cordwood refuge. The latest addition to our little Cordwood Village at Earthwood Building School is our own Hermit's Hut, a very popular guesthouse at workshops. (If occupied by a single lady, would she be a "hermette?")

The building came about because we had scheduled a timber framing workshop in the springtime, and the hands-on project was to have been son Darin's 20-sided frame. Quite a few students were registered. But that springtime was one of the wettest on record and we were not able to get Darin's foundation done in time for the scheduled workshop. What to do?

I went to my woodshed to see what heavy timbers I had left over from various projects, including megalithic stone moving. The collection of beams, and their lengths, suggested a bare-bones timber frame with a footprint exactly 8 feet square. The major post timbers were 8 inches by 8 inches and the rafters 5 inches by 10 inches. Well, tiny houses are all the rage, but this one would have been *really* tiny. The 64-square-foot footprint was bad enough, but when you subtracted the 8-inch-thick cordwood walls, the interior dimensions were 6 feet 8 inches by 6 feet 8 inches, just over 44 square feet. The hermit might have to step outside to change his mind!

I drew an inch-to-the-foot scale drawing to work out the floor plan as well as the structural detail: how to make use of the odd assortment of parts in the shed. The 6-feet-8-inches interior dimension suggested a fine bed size for even a lengthy hermit. The building was small enough that we could pour the footings and floor monolithically, about 27 cubic feet of concrete, almost exactly a cubic yard. Helped by an intern who happened to stop by at just the right time (though not necessarily for him), we decided to mix two bags of Sakrete concrete dry mix at a time

21.1. The Hermit's Hut. How we "manifested" the door is shared below.

21.2. Jaki plants the lightweight living roof (three inches of topsoil) to sedum, dead nettle and other ground cover plants.

in a wheelbarrow. Just add water and mix. Sakrete comes in bags that are two-thirds of a cubic foot. The math: 27 cubic feet (a cubic yard) divided by 0.667 cubic feet per bag equals 40.5 bags of Sakrete. Our calculations were pretty good; we had one bag left over!

We sited the Hut at the end of the path going down through the middle of our little Cordwood Village, consisting of two two-person guesthouses, a bathroom/shower and a communal mess hall for cooking and eating. The Hut would be the fifth and final building, kind of overlooking the others thanks to a foot or so higher elevation.

Our eight timber-framing students installed the six posts, the three rafters, seven purlins over the rafters (mostly 4 inches by 6 inches), snowblocking, plywood, drip edge, waterproofing membrane and drainage matting—all in the three half-day sessions, the other three sessions being classroom work devoted to timber framing theory.

Three cordwood workshops saw the walls nearly completed. Jaki and I finished up the high bits ourselves, the very highest bit being the living roof, seen at left.

21.3. The resident glass hermit provides a night light within the small interior space.

While in Del Norte, Colorado, we visited Kim and Mike Cellura-Shields, of Mermaid Cottage and Peace of Art Café fame. Kim gave us a heavy glass head used for hat modeling, which we incorporated into a panel with a little LED light inside. It's now the hut's resident hermit.

Cultivating Coincidence

The building was finished, the earth roof was planted to sedum, dead nettle and other ground covers, and all that was missing was the door, which we manifested by "cultivating a coincidence."

We do Open House at Earthwood twice a year, spring and fall. Tom Huber, noted cordwood builder (see Chapters 12 and 13) came to our October opening with a small class of Paul Smith College students. I gathered the group around the Hut with its 36-inch-wide gap on the front side, the door's rough opening. There were about ten people in a semi-circle around me, including Tom, his students and two or three other visitors. I was fresh from writing (with Jaki) *The Coincidental Traveler* (Earthwood Publishing, 2014) and was full of the wonders of synchronicity. To the group, I enthused, "To build cheap, it is important to know how to cultivate coincidences, how to find good free—or *almost* free—building materials."

Ten blank faces.

I told them how I had manifested a free shower unit for the Stoneview guesthouse by letting my need be known to two young couples in our community who were both in the building phase of their lives. It turned out that both couples knew where I could get a free shower cabinet. The young visitors looked at me like I'd pulled a rabbit out of a hat.

"Now," I said to my captive audience, "you can see that we are in need of a door. Probability theory says that there is a good chance that at least one amongst you knows where I can get a door for this door opening."

Tom Huber immediately raised his hand. "I've got two I'm not using. Come on out to the college and take your pick."

Long story short: Jaki and I took Tom up on his offer and drove our pickup out to Paul Smith. Tom had two large, solid, heavy doors, about 9 feet high and each wide enough, left over from an Adirondack Great Camp building project. These doors were two of 200 that had been shipped over from England in a container. One (Figure 21.1) worked perfectly, although I had to cut nearly two feet off of it. Tom

21.4. The author extends himself by being the first hermit to spend a night in the hut.

and his wife, Holly, also took us out to eat at the excellent restaurant overlooking the lake on campus. So we got a door and a fine meal because I had extended myself by letting my need be known. The Bible says, "Ask and it shall be given to you." The obverse? "Don't ask and nobody gonna give you nothing!" Go, thee, and do likewise.

I hope this little story helps the reader to manifest good free building components for his or her own project. *Extend yourself*.

Siliconized Sealer

The ability to cultivate coincidences may be the most important insight of this chapter, but to finish on something a bit more technical (but also important), I want to share a situation that looked kind of bleak at the time, but came out very well indeed.

It was autumn of the Hermit's Hut's first year and an unusual rain pelted the north side of the building, seen in Figure 21.5. Some of the cedar cordwood had been recycled (or used over and over again in demos) and weren't what you would call top-of-the-line log-ends. Then they got wet, especially the first two or three courses. As this was a heavily wooded area, they were very slow in drying out again. I kept

21.5. The north and west sides of the Hermit's Hut, treated with siliconized sealer. The little building looks down over the avenue of the Cordwood Village at Earthwood.

my eyes on the wall every day and finally got lucky. We had just enough warm dry days to dry the log-ends out to the point where I could hit them with my 4500-rpm Makita circular sander, and, quick like a bunny, apply a coat of Cabot's Siliconized Sealer. I did about half-way up the north wall (with the window in Figure 21.5) and about as much of the west wall (no window.) And the heavy timber posts, as well.

Here are some sanding tips: (1) The easiest time to sand log-ends is when they are being held in place by the mortar. Besides giving the work a pleasing masonry appearance, recessed pointing keeps the mortar out of the way of the sanding disk. (2) If you wait a year or two to sand, you can clean up weathering. The silicone sealer does a very good job of keeping the log-ends looking good for a long time. With quaking aspen—called "popple" in New York's North Country—the blackened ends, caused by bacteria digesting wood sugars near the surface, can be eliminated and, as the sugars have now been digested, it doesn't come back.

Now, after five years, the north and west walls of the Hermit's Hut are among the most beautifully preserved at Earthwood. I have since used the same method to freshen up several other special exterior cordwood masonry panels, sections and special log-ends with great success, even 35-year-old weathered split cedar fence rail log-ends. Posts and girts, too, seem to enjoy a lasting benefit. The manufacturer, Cabot, says that the product lasts up to six times longer than petrochemical-based waterseal products, and I am inclined to believe that this is so. It is the best way I have found to thwart common weathering. But the sanding is important, with 50-weight or 80-weight grits both good choices for log-ends. The product goes very much further on a smooth surface.

21.6. Rob sands log-ends with his favorite power tool, a Makita 4500-rpm circular sander.

21.7. The right-hand log-end is half sanded, to show contrast. Sealer is applied with a brush.

CHAPTER 22

La Casa del Trunco

Cultivating a Coincidence in Nicaragua

In our book *The Coincidental Traveler* (Earthwood Publishing, 2014) Jaki and I devote the entire Chapter 3 to "Cultivating Coincidences." That work treats the subject with respect to travel, while the previous chapter, "The Hermit's Hut," tells how to create wonderful and beneficial coincidences simply by extending yourself: scoring bargains on materials when you build, for example, cordwood or otherwise.

Our recent trip to Nicaragua may have been the most "coincidental" we have taken yet. The back story: A few years ago, a couple from Vermont, a bit younger than ourselves (we guessed in their 60s) came to Earthwood because they wanted us to go down to the Islas Solentiname group of islands in the southeastern part of Nicaragua's huge Lake Nicaragua, and help them to build a cordwood home, perhaps with the local people in a workshop situation. They brought us a number of fine painted balsa wood carvings made by artisans on Isla Mancarrón, the largest of the 36 islands in the archipelago. We expressed a strong interest, spoke with them on the phone—once, I think—and then…*nada*. Years went by and we lost track of them, couldn't even remember their names. Sad.

But we often wondered if they had ever built that cordwood place on Isla Solentiname.

Fast forward to Sunday, March 29, 2015. Jaki and I are budget-traveling in Nicaragua for a month, using local transport. We're on a local bus from Juigalpa to the Lake Nicaragua port of San Carlos, from where boats make their way to Solentiname. We notice two cute little kids towards the back of the bus, a boy and girl, their complexions obviously a bit more European than most of the local children. We do not see an obvious parent on the very crowded bus. Once in San Carlos we walk to a popular café and notice the two children sitting at the next table, with their mother. We strike up a conversation—"We saw your kids on the bus…"—and this led us to learn that her name was Marga Luna, she was from Spain, spoke English and had a hotel in El Castillo, down the San Juan River toward the Caribbean, the very place we wanted to get to the next day. Marga invited us to go see her if we needed anything in El Castillo. Well, we liked her little family-run hotel, the Rio del Luna, so much—and she had one room available—that we checked in on Monday. We got to know Marga and her husband Manuel, a local, quite well during two days there, and darned if they don't know of Jim Walker and Carolyn Parker in Solentiname and their cordwood building, although they thought the couple had died. Further, they were able to put us in touch with a hotel on Isla San Fernando in the Solentiname Islands where we could get more information. Now we had to go to the islands, and did.

Solentiname's Cordwood Homestead

An English-speaking young lady at the hotel on San Fernando (the wrong island, we learned) told us to find her aunt, Esperanza, on neighboring Isla Mancarrón and the next day we did. From Esperanza, we learned that Jim had bequeathed the property to Pedro Mendez and his wife. We finally found our way down a dirt path to a lovely remote spot on a small peninsula near the village on Mancarrón where we spotted a young man. It was Pedro!

22.1. The third building at the Walker/Parker homestead, now belonging to Pedro.

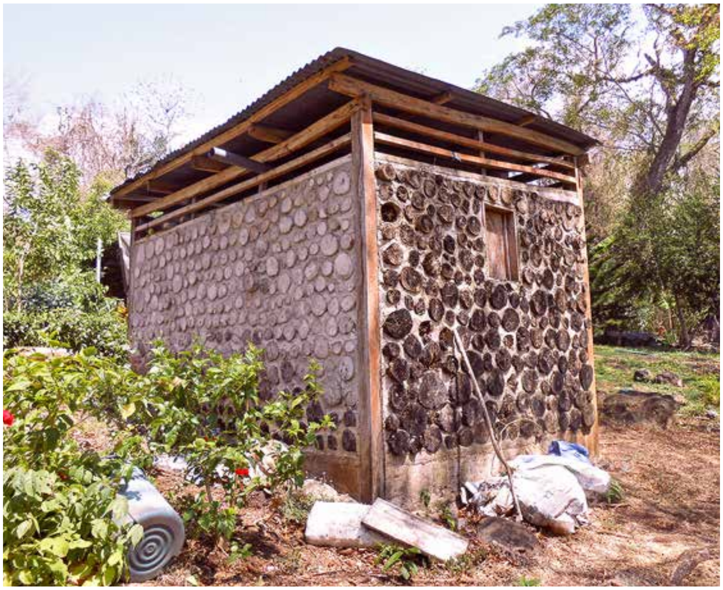
22.2. Pedro, with chainsaw, in front of his round cordwood home, "La Casa del Trunco."

Once we explained who we were, and that we had known Jim and Carolyn, Pedro was very welcoming, showed us around, answered our questions and allowed us to take pictures. In our poor Spanish, we picked up that Pedro had been a regular worker on the project, which consisted of an initial rectangular cordwood storage shed, followed by two round and separate cordwood houses, each around 22 feet in diameter, with maybe 40 feet between the buildings. The cordwood walls ranged in thickness from 5 inches for the shed to 8 inches for the two houses. Mortar was solid through the wall, as preserving internal heat is not an issue in the Nicaraguan lowlands.

The wood was, according to Pedro, *senisado* and *lagrel*, both hardwoods, but fairly stable nonetheless. (Unfortunately, I can find neither species on a Google search.) We saw no evidence of expansion cracking, although we did see two long vertical cracks on the second round house, which appeared to be stress cracks from excessive structural loading from above. There was some shrinkage of wood, though not as much as might occur with North American hardwoods, possibly as a result of the inherent stability of tropical hardwoods, a characteristic that had been impressed upon us by a wood turner in Hawaii.

There was some wood rot, particularly on the windward side of the shed, where driving rain occurred. Termites attacked these exposed walls, but nowhere else. There was also some deterioration to wood where the cordwood masonry was commenced too close to the ground and stayed damp for periods of time. Jim and Carolyn and Pedro developed a skill with log placement and even incorporated special features like two fish, one each side of the front door, made from consecutive log-ends. Pointing, as can be seen in the pictures, was not brilliant. None of the builders had received training in pointing. Nevertheless, the build quality seemed to improve with practice. The shed was pretty rough compared with the two houses.

After a 45-minute visit, we bid *adios* to Pedro and walked to yet another cordwood building that we had learned of through our enquiries, this one also a result of Jim and Carolyn's work.



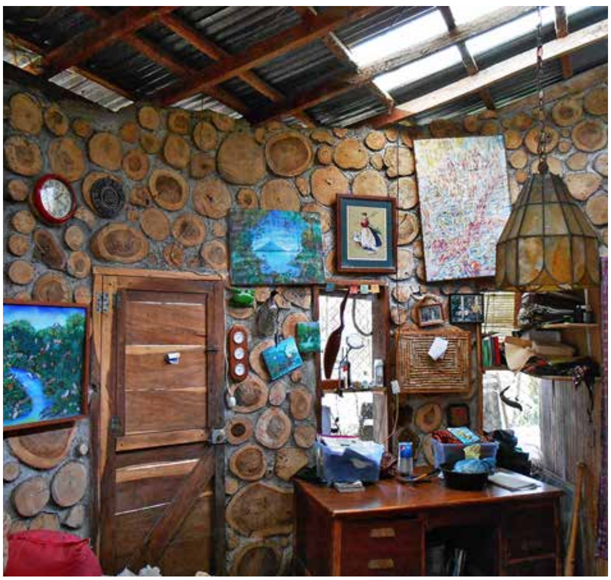
22.3. The shed, probably the first cordwood building in Nicaragua. Note deterioration of windward side. The adjacent side, with less driving rain and more overhang, is in good condition

La Casa del Trunco…

…is what Pedro called his house, literally "the house truncated" (or "cut down") but, in the vernacular, probably something more like "the house of truncated logs." Log-ends!

Is cordwood masonry appropriate in Central America? In the right places, where there is plenty of wood, I would say, yes, it is. It certainly makes a refreshing change from the predominant concrete and concrete block structures seen everywhere, city and country, which is so energy hoggish and contributes to climate change and rising sea levels. The manufacture of cement and lime accounts for ten percent of the entire world's carbon emissions.

If waste wood is used, cordwood makes sense. If forests are cut down to provide log-ends, then, no, it doesn't. Not in Nicaragua. Not anywhere.



22.4. Interior of first house.

22.5. Kitchen area of first house.

22.6. Two fish, from consecutive log-ends, swim each side of the main door, while Pedro's parrot looks on from above.

The Cordwood Dorm Room

Hostal Sueno Feliz (Happy Dreams) is owned and operated by Luis Sandoval and Esperanza Rosales—not the same Esperanza who directed us to Pedro's homestead. Luis told us that he learned the cordwood technique while working over at Jim's place, and that he'd built all of the several buildings at Hostal Sueno, although only the four-bed dorm room is cordwood. We could have actually stayed in the dorm room, which was unoccupied, but we had already booked into another nearby hostel when we'd arrived on the island. Nevertheless, we had a very nice visit with Luis and Esperanza and bought several of the excellent brightly painted balsa carvings that they make right there with their family of six children, all of whom happened

22.7. It is easy to see which panel was built first.

22.8. An early section is pretty rough.

22.9. Nice log placement and pointing on the long entrance side.

22.10. One side of the large dorm room. The other side is similar.

22.11. Hang your jacket on the bottle-end coat hook…

22.12. …and pick up a few hand-made balsa bird carvings.

to be home for Easter vacation while we visited. As at the Walker/Parker/Mendez homestead, it was easy to see the improvement in build quality as work progressed at the cordwood dorm. The pointing was almost non-existent on the first panel, rough pointing graced the second panel and it was pretty nicely performed over three quarters of the building. Luis had a good eye for log placement and variety, as can be seen in the pictures. Most of the log-ends appeared to be a variety of red cedar, native to Nicaragua.

If you want to stay in a cordwood room on beautiful Isla Mancarrón in the Solentiname group, contact Luis and Esperanza by email at esperanzarosales29@gmail.com. Or, if you speak Spanish, phone them in Nicaragua at 8478 5243. They do not speak English.

When We Got Home…

We were amazed by the events that led us to find these cordwood buildings in this little paradise called Solentiname. Once again, extending ourselves cultivated the coincidence.

What had happened to Jim and, especially, Carolyn seemed to be a bit of a mystery, even to the local people. What seemed clear was that this was where the couple intended to live out their years, at least during the long Vermont winters. When we got home, Google searching revealed that Carolyn did, indeed, die first, in Solentiname on March 14, 2012, at the age of 52. In an obituary, Jim wrote:

> I am very sad to share with you from Solentiname, Nicaragua, that Carolyn passed on at 5:25 PM. Wednesday, March 14, 2012. Carolyn Parker was my companion in life, and partner in BattenKill Canoe Ltd. She was suddenly and dramatically taken ill in the morning. I was with her the whole day, along with many close friends; the nurse was here, but she died in my arms surrounded by

> friends. In local tradition, friends and the community stayed with us from that moment on through the night. Many folks I did not know, but they wanted to be with her. Friends brought food and the men built a beautiful casket. We had a community service at 3 PM; she was buried at 5:15 Thursday and then we had a fiesta to celebrate her life. We lit a fire when she died, paused by the fire before burial, and we will keep her flame going for ten days. On Sunday March 25, at 3 PM we will gather together to plant a garden in her memory.

Having spent just a day on Mancarrón, we already had a sense of the strong sense of community that exists on this beautiful island, and can clearly envision the scenes that Jim Walker described in his moving obituary.

Jim was a big, burly man. Just over two years after Carolyn passed—and less than a year before our visit—Jim also died, apparently of a heart attack. The mystery of why we never heard from them again (after Carolyn's passing) was finally solved. Pedro, his family, and all the large family at Hostal Sueno Feliz carry on the legacy of what is almost certainly the first cordwood masonry in Nicaragua.

PART 4

Economics and Code

CHAPTER 23

The Mortgage-free Cordwood Home

Here's a simple question: Do you want to own your home, or do you want the bank to own it for you? Kind of loaded, isn't it? Who would want to sign up for a lifetime of economic servitude? And yet people will wait in line at banks to do just that, especially in these times of relatively low mortgage rates.

In feudal Scotland—when the masses of people were known as serfs—three months of your labor went to the laird. In return, you got your land, shelter, defense, etc. Today in California, nearly half of people's after-tax income goes toward shelter alone. In New York, "tax freedom day" is late in May; the first five months of the working year go toward state and federal taxes, none of which contributes toward your shelter. If the medieval folks were serfs, what should we call ourselves today? You see, the questions get more difficult.

I realize that some folks will have to get a loan to proceed with even a low-cost housing project, such as a cordwood home. And many cordwood masonry builders have done so—usually taking out personal or construction loans. But I'm not the right guy to tell you how to do this. Jaki and I have always paid as we go. I was heavily influenced by my father on this. Back in the 60s he said: "If a man makes $100,000 a year, but spends $110,000, he's poor. But if he makes $10,000 a year and spends $9,000, he's rich."

My last comments on lending institutions (before I tell you how to own your cordwood home mortgage-free) are that they frown on the unconventional, be it cordwood, underground, straw bale, cob or whatever. They are hung up on such phrases as "track record" and "resale value." They want a drilled well, even when there is a perfectly adequate dug well on site. They want central heating, in an underground house that can never freeze. They want connection to commercial electricity—another good method of signing up for economic servitude. Well, one of the aims of this book is to give cordwood masonry more credibility and to make it easier to deal with building inspectors, insurance agents and other paper people. Maybe even give it—hang on to your knees and things—"mainstream acceptability." What the heck, why should the benefits of cordwood masonry be limited to the radically sensible?

Okay, how do we avoid a mortgage and other insidious forms of enslavement? By adapting a few useful time-tested strategies. The first big step, which you've already taken, is to consider building a cordwood home, certainly one of the most economic building methods going. And for someone with suitable wood on site, cordwood's economy is even better. *But wait:* as a bonus, you get pleasing aesthetics, energy efficiency, ease of construction and ecological harmony.

Roy's First Law of Empiric Economics is this: "Work to save money, not to earn money to pay someone else to do what you can do yourself. A dollar saved is worth a whole lot more than a dollar earned, because we have to earn so darned many of them to save so precious few."

The Grubstake

The word "grubstake" originally referred to money or provisions advanced to a prospector in return for a share of his findings. "Grub" was advanced for a "stake" in the claim. Nowadays, the term commonly refers to monies laid aside for the purchase of land or building materials.

And where do you get this grubstake? You may already have it. There is no better return on your investment than building a house, so any monies tied up in savings accounts—at next to nothing interest—are far better put toward lowering shelter costs. Maybe you've got equity in the home you are now paying a mortgage on. Maybe you've got an outrageous car, the sale of which would finance a cordwood house. Really. You'd be surprised what your net worth might be.

But some of you will be starting with almost zero liquidity. (A shocking, and rising, percentage of Americans are actually in debt.) Roy's First Law of Empiric Economics is this: "Work to save money, not to earn money to pay someone else to do what you can do yourself. A dollar saved is worth a whole lot more than a dollar earned, because we have to earn so darned many of them to save so precious few." Take advantage of genuine bargains on building materials during this pre-building period. Get into money-saving routines. Rent videos and fix a special dinner instead of going out to a restaurant and a movie. Give up smoking. (The cost savings here are compounded by greater lifetime health care savings.) Make your own wine or beer instead of buying it. What? You don't have any of these vices? Too bad. You are, as Mark Twain said, "like a sinking ship with no freight to throw overboard." The point is that toughing it out for a year or two will often yield enough bucks to get to the land, where the real savings start.

The Land

Land can be expensive. Thoreau's $28.00 home on Walden Pond is all very impressive, but he built the house on his friend Emerson's land, not a bad strategy. Maybe you have a relative that will give you a chunk of the "north forty."

If you are contemplating making a major lifestyle change, maybe you should consider moving to where land is cheap. This is what Jaki and I did in 1975. Land is still cheap around here. And it's a great place to live. But I'm not trying to bring people into northern New York, only to let you know that there are places where there is good, relatively cheap land. To give you an idea: land in Vermont, just across Lake Champlain from us, is easily three times the cost of similar land here. Vermont's a great state, but it's not much different from northern New York, and the population density is similar. But there's this mystique about Vermont. Rich people from New York City and Connecticut buy land near the ski areas or quaint villages and drive real estate values up.

It is beyond the scope of this book to go into all that must be considered in a land search. As for saving money, though, be aware of hidden costs down the line. If you absolutely must have commercial electricity, what will it cost to bring the lines in? This can be a shocker. What will a well cost? Is a dug well a possibility or will you have to drill? How deep did the neighbors have to go? Are the soils conducive to an ordinary septic system, or will a very expensive system have to be built? Are alternative sanitary systems allowed? What about access—not only for you but also for concrete trucks, building materials, etc.? Is the land blessed with indigenous building materials? Do you have wood, stone, sand, topsoil (to grow food and for an earth roof)? These resources can save you a fortune later on.

The Temporary Shelter

This is the first really great strategy you can use to avoid sub-serfdom, particularly if your land is still relatively close to your place of work. Build a temporary shelter (TS)—not necessarily a temporary *structure*—on your land and move into it, thus eliminating whatever shelter costs you are now paying, be it rent or mortgage. Now the savings mount up fast, as the formerly biggest part of your expenditures has been eliminated. For some, this might be $700 to $1,200 a month.

And what is the nature of this temporary shelter? Well, it should be small, quick and easy to build, and should employ the same building techniques that you plan to use in the main house later on, i.e., cordwood masonry. You see, there are several other advantages to this strategy besides eliminating shelter costs: Building experience is gained—a $600 mistake on the TS might save a $6,000 error on the

23.1. La Casita, a guesthouse at Earthwood, would make a good TS for a single person, while providing a lesson in simple post and beam framing.

main house. Knowledge about the land is gained while living on it—such practical information as where the sun rises and sets at different times of the year, and where the sensible access, well and septic locations are. Maybe you're just not a builder. Better to learn that on a 300-square-foot shed than a 1,500-square-foot house. If you can't build the shed, don't start on the house.

Finally, as the structure itself is not temporary (only its use as shelter), you will have an outbuilding for later use as a guesthouse, studio, workshop, sauna or whatever. You could even incorporate the structure into the final house plans. The TS might become the master bedroom, for example.

Our "six-poster" design, which we have used for a sauna, garden shed, mess hall for students at Earthwood and three guesthouses, would make an excellent temporary shelter and yield valuable practice in its construction. It would suit a single person, or a friendly couple sharing the same life goals. It has only 120 square feet of actual usable internal area. There are just 15 heavy timbers in the structure. If you and your partner have never built anything in your life, you still have a very good chance of erecting the frame over the course of a weekend. For help, see my *Timber Framing for the Rest of Us* (New Society Publishers, 2004) and the following sidebar.

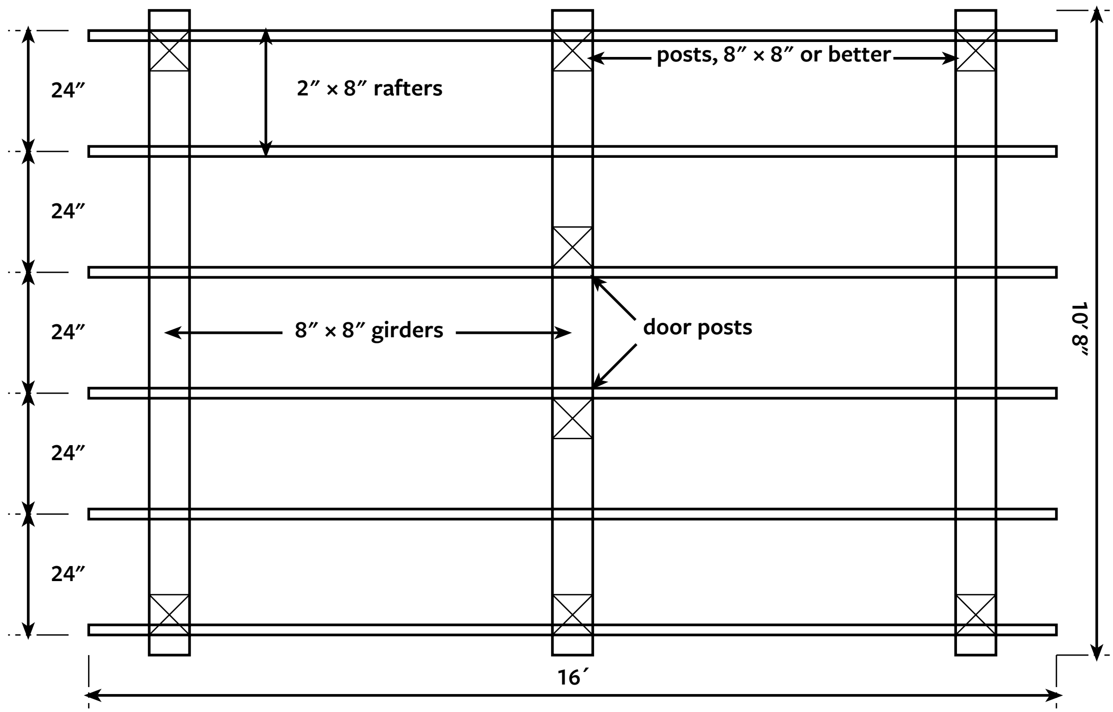
Building the Six-poster

1. Scrape away the topsoil to a heap nearby, for use later on. Build up a 12-inch-thick "pad" of compacted sand or gravel, so that its top surface extends a foot out from the intended building, all around. Slope the skirts of this pad away from the building, as per Figure 23.2 below and the lower drawing on the next page, Figure 23.4.
2. "Float" a thickened-edge concrete slab on the pad, as seen in Figures 23.2 and 23.4. Alternatively, on the same pad you can float a wooden foundation of pressure-treated 6-inch by 8-inch timbers or old railroad ties. Dig them into the sand pad 2 inches and set them by tapping with a sledge hammer.
3. Build the timber frame as per Figures 23.3 and 23.4. Here is a complete cut list for the required timbers:

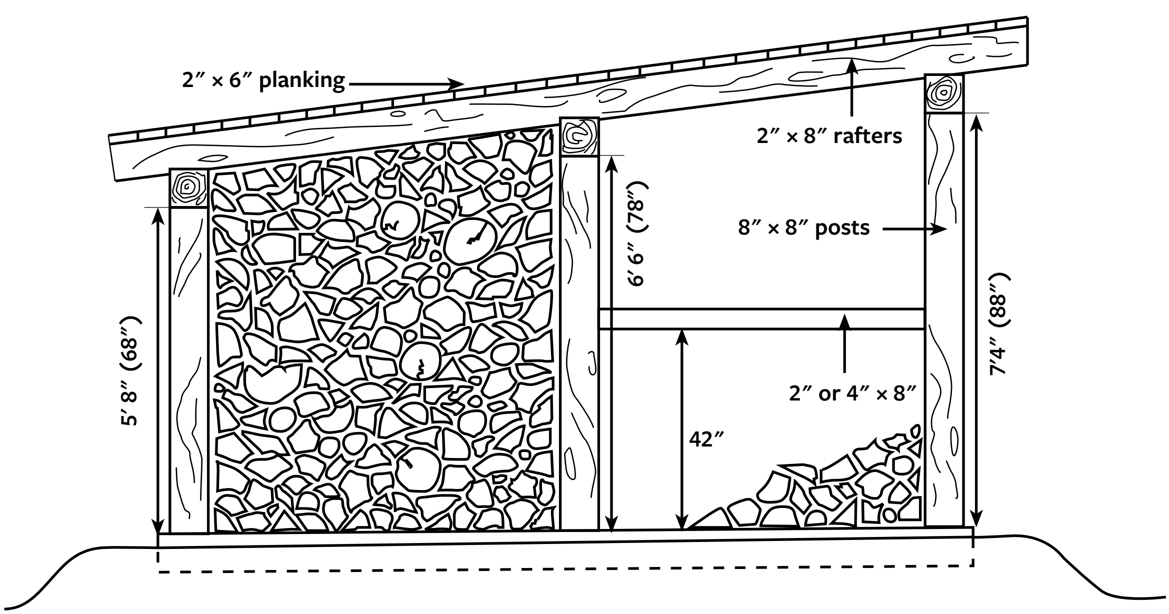
Posts (8″ × 8″)	Girders (8″ × 8″)	Rafters (2″ × 8″)
2 @ 5′8″ (68″ or 1.73m)	3 @ 10′8″ (128″ or 3.25 m)	6 @ 16′ (192″ or 4.88m)
2 @ 6′6″ (78″ or 1.98m)	—	—
2 @ 7′4″ (88″ or 2.24m)	—	—

4. Incorporate recycled doors and windows into your timber frame, as described in Chapters 3 and 4.
5. Using the cordwood masonry methodology described in Part One, build your cordwood walls.
6. Roof with 12-foot tongue-in-groove planking or six sheets of plywood. Cover roof deck with roll roofing or install a living roof as described in my books *Stoneview* (New Society Publishers, 2008) or *Earth-sheltered Housing* (New Society Publishers, 2006).

23.2. The six posts are plumbed, then braced to stakes with scrap lumber.



23.3. Framing plan for the six-poster TS design.



23.4. Elevation plan for the six-poster.

23.5. Stoneview, another guesthouse at Earthwood, has twice the usable space as La Casita, and might be more suitable for a couple, even with a small child.

If toughing it out in the little six-poster is simply too much (little?) to consider, Stoneview, our premier guesthouse at Earthwood might be an alternative. It has 256 square feet of usable space. But it will take at least twice as long to build and cost two to three times as much money, depending on bathroom considerations. The good news is there is a book that details the step-by-step construction of the building, from soup to nuts: *Stoneview: How to Build an Eco-friendly Little Guesthouse* (New Society Publishers, 2008.) See also Chapter 18, which tells how Rarilee and James Conway elaborated on the Stoneview design, added a bathroom mini-wing and commercial electric, and made the plan into an Airbnb income-producing guesthouse. But they spent a lot more money doing it, out of the boundaries for a TS. Jaki and I originally spent just under $5,000 to build Stoneview in 2004, but we figure almost double that today.

Keep It Small

Over 300 years ago, Thomas Fuller said, "Better one's house be too little one day than too big all the year after." This is true once again, after an unfortunate period of wasteful use of the planet's capital. The good news is that small houses, even "tiny" houses, are becoming popular again. But building small just for the sake of it serves no useful purpose, either. A family's space requirements fluctuate. Young couples with a small budget can live comfortably in a small house that would not be suited to a family with three teen-aged children. A small house can be expanded, as need dictates and personal economy allows.

Although economy is the obvious reason for building small, it is not necessarily the most important one. The most important reason for building small is to get the thing completed. Inexperienced builders, even those with plenty of money, should not tackle a house larger than 1,200 square feet, particularly a cordwood house, which is labor intensive. There is a very real danger that the place will never be completed. Or if it is, that the stress of building will irrevocably stress the marriage or relationship, too. Listen…

One woman, responding to our Cordwood Database Questionnaire said, "It's a beautiful home, visitors are thrilled by it, but it destroyed our relationship. We are presently trying to rebuild our marriage. I personally know two other couples who are going through similar problems after their cordwood home projects."

Another woman, in response to the question, "What would it cost you to build this home today?" replied, "A new husband!" Jaki and I experienced marital stress building the large Earthwood house, and this after having built two homes previously. So you have been fairly warned. In reality, cordwood masonry isn't any more stressful than other building styles. We know of more broken marriages where other forms of building were employed. Size of the home and frame of mind (karma) are more important concerns than technique. In fact, many cordwood builders find the masonry work itself to be quite therapeutic, but both partners need to be enthusiastic about the project and realistic about what it involves.

There are lots of questionable reasons why people think they need to have a big house, aside from bank propaganda and outmoded zoning regulations. Here are two biggies.

The overreaction syndrome. Jack and Jill (not their real names) have been cooped up in their little apartment for so long that all they can think of is, "When we build our cordwood house, there's gonna be plenty of space!" They've got lots of time to plan; paper and pencils are cheap. They finally get started on their 3,000-square-foot masterpiece. The possibilities from there, in descending order of probability are: (1) There is great enthusiasm to begin with. After six months, money, energy and patience run low, then run out. Jack and Jill split up. (2) After a while, J and J perceive that they've really bitten off too much. They move into a third of the place. Someday we'll finish the rest, they say. (3) They pull it off, as planned. I have only heard rumors of this scenario.

Bedroom mania. The functions of a bedroom are to supply a peaceful venue for horizontal storage of the body and to act as a catch-all, generally for clothes that are no longer used. You may think of other activities. But the bedrooms in most

American homes could be divided in two, and each would still meet these needs. Sure, other considerations come into the planning: building codes; an adjustment, perhaps, of the individual value system; working out how a small bedroom will accommodate the furniture. One thing is certain: the larger the bedroom (or house, for that matter), the more unnecessary clobber one accumulates.

How many bedrooms? Americans seem particularly concerned with the issue of privacy. Every kid has got to have his/her own bedroom, and then we throw in an extra one for the pot: the guest room, used three percent of the time or less. Our living room has a futon, so it accommodates guests, too. That it's not too comfortable has the side benefit that guests are less likely to overstay their welcome.

Keep It Simple

"Keep It Simple" should not be confused with "Keep It Small." A small house can be hopelessly complex, and a large house can be wonderfully simple. Here are some corollaries:

Keep to one style. There is a style that suits your karma and pocketbook better than others. Once you find it, stick with it. If two house shapes are to be combined or intersect in some way, let there be a unifying force to the architecture: the use of cordwood masonry, for example, or a constancy of roofing material. A hodgepodge house always looks like a hodgepodge house.

Avoid difficult lines. If you think they're tough to draw, wait until you try to build them! Keeping simple lines is of particular importance if you're inexperienced. Gambrel, hip, and valley additions (and dormer additions) should be avoided on the roof line, for example. Sunken living rooms, complex stairways and split levels all add to the complexity—ergo, to the time and cost of building. Domes and polygons may have a strong appeal, but know that the finish work is long and tedious; furniture is designed on the premise that gravity runs perpendicular to the horizon; and it's unlikely that there will be local people experienced in these techniques to help when you get in trouble. If in doubt, build a model of the intended structure. "Cordwood Jack" Henstridge liked to say, "If you can't build the model, don't try to build the house."

Don't be afraid of round just because few people do it. Amongst the other building animals—not to mention so-called primitive people—practically no one does it any other way, precisely because round is simple, particularly with masonry units like cordwood. Keep in mind what birds, bees and beavers know instinctively: a round house of any perimeter will enclose 27.3 percent more space than the most efficient rectilinear shape of the same perimeter: the square. And most people don't even build square. They build a rectangle twice as long as it is wide, like we did at

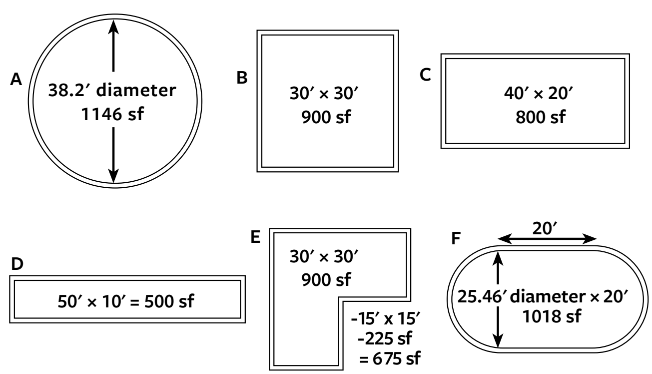
Log End Cottage. The free space gain of round over this rectilinear shape is better than 40 percent! So for the same amount of labor, materials and money, the external walls of a round house enclose 40 percent more space than the rectangle. (See the sidebar "Impact of Perimeter Shape on Area.")

Now that's big savings! And if it saves you from building with hired money, the continued saving is compounded daily. And the round house is easier to heat because it has less skin area (heat loss) to enclose unit volume. If you do decide to go round, I strongly advise the radial rafter system, as opposed to parallel rafters or

Impact of Perimeter Shape on Area

- Shape A: the circle. The choice of other building species. The most space per foot of perimeter.
- Shape B: the square. The most efficient rectilinear shape, seldom seen today.
- Shape C: the rectangle. The most common house shape today. Why?
- Shape D: the 1950s mobile home. The longer and narrower we make it, the less space we enclose. We could build 59 feet long and 1 foot wide and have 59 square feet.
- Shape E: the architect gets involved. If those two "inner" walls had been left on the outside where they belong, we'd have the efficient Shape B. The roof is more complicated to build with Shape E and 225 square feet are lost.
- Shape F: the "hockey rink." Many people are building cordwood homes like this, and not just in Canada. Still over ten percent more space than the most efficient rectilinear shape (B), which almost no one builds. The roof is not complicated if a radial rafter system is employed for the half-circles. The radial rafter corresponding to the internal arrows on the diagram is also the first of any number of parallel rafters for the rectilinear section.

In fairness, it must be pointed out that if you enclose more space, you will spend more time and money on roofing, foundation and flooring. However, these components go faster than the labor-intensive cordwood walls. The important point here is that, with a circle, you can get any desired floor area by building less perimeter wall. Also, with less skin area, the home is more efficient to heat. Just thought I'd share this with you.



23.6. All six of these house shapes have a perimeter of 120 linear feet. Look at the varying square footage figures.

pseudo-hip roof systems. Much easier to build. Think about it. Now, having waxed on the benefits of round, I must tell you the one change that Jaki and I would make if we were doing Earthwood again: We would make it 16-sided, like the two houses featured in Chapter 20, so that we could build it under the umbrella protection of the roof. This "hexadecagon" still *looks* round, and has almost the same spatial advantage as the perfectly cylindrical house, with 97.45 percent of the area of a circle with the same diameter.

Okay, you've thought about it, and you, or your spouse, just can't make the jump to round. At least keep it square. (Sorry, Bruce and Nancy!) And for heaven's sake avoid Ls, Ts, Us, and other projections, which further decrease the ratio of usable space per unit cost of materials and increases the time of labor (which is *your* time we're talking about here).

Avoid basements. It is surprising how many people in North America continue to view a basement as a prerequisite to house construction. This is despite the fact that in a low-cost home, particularly a cordwood home, a basement will eat up a third of the building budget while providing low-quality space that gets used less than ten percent of the time. Most typical basement functions, including heating systems, are best enclosed in the house proper. Pure and simple, basements are not cost effective, require familiarity with additional structural systems and provide low-quality habitat for almost anything except large-scale mushroom propagation. If you are still not convinced, then I implore you to spend a little more money on insulation, waterproofing, ventilation and natural light sources, and transform the basement into warm, dry, bright, airy earth-sheltered space, as we did at Earthwood.

Fit the floor plan to the structure, not the other way around. Novice owner-builders commonly draw floor plans first, then try to design a structure to fit them, which often leads to complicated structural plans. My approach is to design a simple (therefore economic) structural plan, and then allow the floor plan to be somewhat shaped by the structure. Although a few compromises might need to be made, the end result is a structurally sound, easy to build, low-cost home. Earthwood makes use of this strategy. Internal rooms follow the lines of the main bearing girders, posts, rafters and joists. If internal walls just miss these members, this makes for nightmarish carpentry. Slows the project right down. And the finish work never gets done.

Use Recycled Materials

Recycled building materials are often better, cheaper and have more character than new stuff. Using them is kinder to the planet, too. Enough said.

Work Parties

Occasionally, it will be advantageous to throw a work party, particularly when it's time for the floor and footing pours, and again at rafter and roof work. Cordwood work parties aren't too effective, unless your volunteers are willing to donate a few days of work. It takes a couple of days to train people, during which production actually slows down. Also, you want to be very careful about the build quality. After all, you've got to live in this house and look at any shoddy workmanship every day.

Be organized on the big day, *before* the big day. I've seen owner-builders arrange for several friends (sometimes too many) to come over to help and end up playing hosts, serving up a case of beer while the crew stands around jawboning. Bummer. The owner-builder must be sure that all the required materials are ready the day before, that jobs are properly organized, that the workers will have—or be supplied with—the right tools for the job and that there are no pesky little details that have to be attended to before work can begin. You'll get a week's work done in a day with organization. People come expecting and wanting to work. If they don't have a job to do, be sure that they'll start in on the beer, thinking, "Might as well make a party of it. I've blown this day coming over for nothing anyway." Don't let this happen. Plan ahead. And involve everyone. Don't bring the beer out until the work is done!

The Add-on House Strategy

Sometimes the temporary shelter that we've discussed will serve as a part of the completed house, either by plan or by evolution. However, get one part of the house completely finished before moving on to the next part. Living in a house under construction puts tremendous strain on a relationship. If you can retreat to a clean and uncluttered space, this refuge may prove invaluable on all fronts.

There are two different approaches to the add-on house strategy. One is to have some specific expansion plan in mind at the initial design stage. The other is to let the house grow organically as needs arise. Either approach will work, so tailor your strategy to your personality. If you have an analytical mind, like me, you may be happier knowing that you are working toward some specific end. And it is easier to add on to something which has had expansion as an intended strategy at the design stage. Having said all that, a more spontaneous individual might feel cramped by such a plan, preferring free creative rein throughout.

The add-on strategy is, essentially, a "build as you can afford" approach. Like the temporary shelter strategy, with which it is sometimes combined, it requires the ability to tough it out in less than the desired space for a while. Let's look at how it affects cordwood masonry in particular.

Of the three primary styles, the order or adaptability to the add-on strategy is: (1) timber framing with cordwood infilling; (2) stackwall corners; and (3) round or curved wall. Timber framing construction is a modular system, which is what we are looking for in a home with add-on potential. The stackwall corners method also has flat straight walls to add on to, but there is the slight problem of knitting the new building into the existing stackwall corners. However this method has been used successfully many times. Round houses are extremely difficult to add on to. If you absolutely must, follow the radial rafter lines outward and make a trapezoidal addition, such as the solar room at Earthwood. What really looks bad is to add a square room to a round house. And it's difficult to do.

One final technical point: it is easier to add on to the gable ends than to the eaves of a square structure. Adding on to the eaves involves a shallow-pitched, shed-type roof, which can be very troublesome in the winter with heavy snow loads and potential ice dam damage. Ceilings will be low in the addition unless the core unit had very high walls. It is easier, cleaner looking and structurally superior to add on to the gables.

I hope there's something in this chapter that will help you on your way to economic freedom, for it is my sincere belief that if you build your own mortgage-free cordwood home, you'll be more than halfway there.

CHAPTER 24

Getting a Building Permit for a Cordwood Home

Part 1: An Engineering Viewpoint

by Dr. Kris J. Dick, P.E. and Professor A.M. Lansdown

There is a need for methods of house construction that are different from standard frame or brick structures, methods which employ indigenous materials and skills. Examples of this need for decent housing abound for individuals in small, often remote and economically marginalized communities.

Over the years, the Northern Housing Committee at the University of Manitoba in Winnipeg has observed that for innovative housing to be acceptable by those who need it the most, it must meet some rather tough sociological criteria. Innovative housing techniques must be seen as acceptable by the dominant society, both in terms of style and technical merits. That is, they must incorporate standards equal to, or greater than, those of the conventional housing solutions that dominate the market. At the same time, these techniques must be much more accessible to the very users who need them the most—the people of the small communities mentioned above. Relatively few people involved in the self-help housing movement are aware that they are, *de facto*, on the cutting edge of regional and local economic development. This represents the real strengthening of North American communities, in spite of the mean-mindedness of the financially driven economies of North America.

Obtaining a building permit can be a relatively simple procedure. For some owner-builders, however, it is perhaps the most traumatic and angst-producing component of the entire building process. This chapter lays out the basics of building inspection, indicating the principles behind codes and permits, with a focus on the construction techniques of cordwood masonry as they relate to presenting a proposed design to building inspectors. A study of the technical side of building reveals that there are six fundamental aspects associated with the approval of a building permit for a dwelling: structural safety, durability, energy management, moisture management, fire protection and site location.

Structural Safety

Structural safety concentrates on foundation design and the structural strengths of walls, roofs and floors. Foundation concerns normally focus on the basic load-carrying capacity of the foundation and the ability of the proposed design to resist heaving due to frost and moisture changes. If the proposed design addresses these issues directly and knowledgeably, then problems should not arise in the permit application.

Laboratory tests on cordwood masonry segments in the 1970s indicated that they could carry about 30,000 to 40,000 pounds per lineal foot which turned out to be 20 times the design load for a single-story building in regions with the heaviest snow loads. We concluded that, for one- and two-story houses, wall strength was not a problem with cordwood masonry. Conventional floors and roof systems, following manuals of good practice, have kept our house builders out of trouble on this front.

Durability

Durability of a cordwood structure is mostly a matter of moisture movement and foundation design. The question really is: How fast is the strength and integrity of the house compromised through rot and differential settlement? Durability can only be proven with time. Old structures, however, indicate that stackwall buildings are at least as durable as heavy timber structures. Known ages of some structures are: Manitoba—50 to 100 years with poplar; Ottawa and St. Lawrence valleys—100 to 200 years with various species. The oldest we have heard of is a monastery in northern Greece built about 800-900 AD and still in use. By way of comparison, many conventional frame structures in remote communities in northern Canada are in serious trouble within ten years.

Energy Management

The management of energy—via insulation standards; size, nature and position of windows and doors; and management of fresh air—influences the annual cost of operating the home. Energy code standards are set in an effort to minimize energy costs in a home; hence the specifications for minimum R-values in walls and attics, for example. (See sidebar.)

R-value Testing

Author Dick, in his comprehensive seven-page article "Thermal Monitoring of Cordwood Walls," appearing in *Cordwood and the Code: A Building Permit Guide* (cited in the Bibliography), tells of how he tested R-values for a 24-inch panel of cordwood masonry within the Department of Biosystems Engineering Strawbale Research Facility at the University of Manitoba in Winnipeg, Manitoba, Canada. Temperatures were monitored at the outside, middle, and inside of the walls over a period of about three months during the winter of 2004–5.

The article provides documentation which could be useful to sway a code enforcement officer. Dr. Dick's Summary/ Conclusion to the article, says, in part: "Based on approximately three months of mid-winter temperature data the wall was determined to have an RSI value of 6.23 (m^2K/W), R35 for a 24-inch (60-centimeter) wall system. This value exceeds Manitoba's requirements for insulation in both the south and north of the province."

It is important to recognize the effect of thermal mass on heating in a building, since a large mass of material with a high unit heat capacity acts as a heat storage reservoir. A heavy building often turns out to be easier to heat (and stays cooler in summer) than a light frame structure having identical R-values for insulation. Experiments with full-scale stackwall buildings have indicated effective R-values considerably higher than calculated R-values.

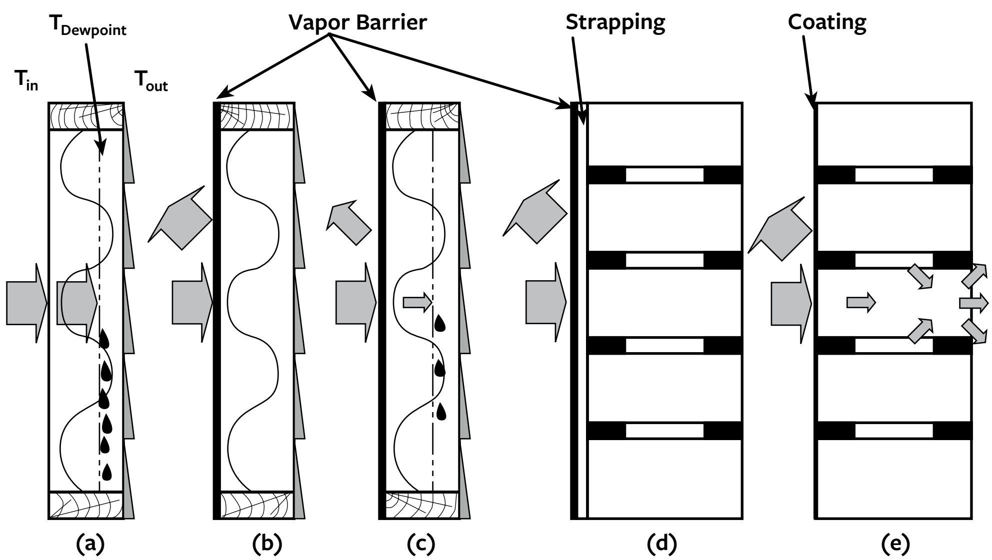
Moisture Management

Moisture management is perhaps the least well understood of the inspection criteria. Witness the almost slavish dependence on poorly installed vapor barriers in many structures, especially in northern communities. Consider that a normally functioning residence is constantly generating water every day—from perspiration and exhalation of its residents, to cooking, bathing and clothes washing. In the summer or in a warm climate, the moisture is not a problem since windows and doors are often open, allowing for the escape of excess moisture. In a northern climate, however, to conserve energy during winter, the house is often rather tightly sealed. Any generated moisture has to really struggle to get to the outside atmosphere.

A substantial portion of the excess moisture will try to escape through the walls. A framed wall filled with insulation provides a particular challenge. Without a vapor barrier, the situation is as shown in Figure 24.1a. Moisture passes through the wall and even though the whole section is permeable to vapor, trouble strikes.

As moisture passes through the insulation the temperature drops to the dew point (point of condensation) where it condenses to liquid in the insulation. The soggy insulation loses R-value, and this retained moisture can actually rot the studs and outer wall. Figure 24.1b illustrates what a good vapor barrier should do. It sends the moisture back into the room. Your windows may be a mess of frozen and melting ice, but your walls will be safe. Figure 24.1c illustrates the usual situation—a good vapor barrier with a few pinholes provided by tears, punctures, nail holes, staple holes, and gaps around electrical fittings. Most vapor is sealed in but some escapes and condenses in the insulation. Tests in Sweden have indicated that a pinhole in a vapor barrier is enough to allow 12 to 25 pounds of ice to form in a wall over one winter. Only one drop of water is needed for the dry rot bugs to get started, and once they are off and munching your walls, they'll give off water to keep the process going.

Figures 24.1d and 24.1e indicate cordwood masonry walls. Figure 24.1d shows a cordwood section with strapping and vapor barrier on the inside. This ruins the aesthetic effect of the wall style but may have to be done to meet some regulations. Figure 24.1e illustrates perhaps the optimum solution—exposed cordwood masonry with a waterproof coating on the inside of the logs, acting like a leaky vapor barrier. The coating should be something that will slow down moisture movement along the end grain. The coating can be urethane, PEG (polyethylene glycol) or even paste wax. The key concept here is that there is a route for the vapor to the outside. The



24.1. Moisture management in walls. Credit: Kris Dick.

whole wall acts as a vapor dump, in effect. Our experience here has been that even unprotected walls are naturally drying and do not pose a moisture management problem.

Fire Protection

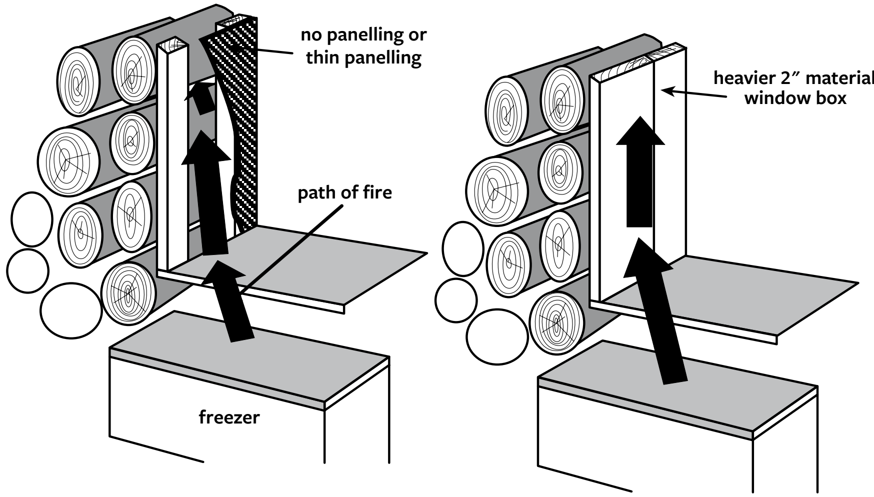
Advice received by the Northern Housing Committee indicates that fire protection aspects can be considered under the headings of smoke generation, flame spread, fire penetration, egress and electrical distribution details.

Smoke generation. A major issue in dealing with potential fire in a house is the volume and quality of smoke generated. Usually, wood-based smokes are less hazardous than those generated from plastics, clothing, carpeting and furniture stuffing. With cordwood masonry, so little flammable material is present in the wall that the generation of smoke in a fire is minimal.

Flame spread. A major question in residences is: how fast can flames spread along a surface? In Canada, ratings are measured against asbestos panels (Rating = 0) and red oak paneling (Rating = 150). Cordwood masonry, because of the mortar breaks, has a flame spread close to zero, if left exposed. The mass of the mortar draws heat from the fire.

Fire Penetration. Penetration of fire through walls is a measure of fire protection from room to room or from adjacent buildings, and it is measured in minutes. Only a short time is required to exit a single-family dwelling, while two to four hours is a typical requirement for a commercial building. Cordwood masonry, because of its mass and mortar content, is rated at two to six hours. The senior author was advised by the National Research Council (NRC) Fire Division that tests were clearly not necessary, as stackwall met fire standards for tall adjacent urban structures. An interesting case is illustrated in Figure 24.2. A stackwall store near Traverse Bay, Manitoba, had a propane-fired freezer that exploded, causing a fire. In this case, a weak point was found by the fire as shown in Figure 24.2, left side. The windows had not been boxed in with 2-inch lumber (Rating = 65 minutes) but had been formed with almost no fire barrier to the insulation. The short-duration fire caught hold of the insulation. This could have been prevented by the detail in Figure 24.2, right side, recommended by virtually all cordwood masonry author-builders.

The fascinating feature of this fire was that it took two days for the building to be destroyed. During that time, with the guidance of the insurance adjuster, all furniture and fittings were removed at leisure. The committee was told that it was the best fire the insurance company had ever witnessed. Insurance rates for cordwood buildings dropped like a brick after this fire. The senior author, an ex-firefighter, wondered what would have happened if the owner and the insurance adjuster had



24.2. Fire penetration examples. Credit: Kris Dick.

put the fire out by sprinkling water into the insulation from above in the two days allotted to them.

Egress. Your cordwood home must meet the same fire escape regulations as any other, such as having at least two escape routes from any point in the home. Opening windows, meeting certain guidelines of size and distance off the floor, can provide a second means of escape. Check your local code on this.

Electrical distribution details. We recommend that all wiring be done with protected armored cable such as flex cable or conduit. We feel that Chapter 9 in this book, "Electrical Wiring in Cordwood Masonry," covers this subject very well and with a view to the requirements of the National Electrical Code in the United States.

Site Location

Site location matters tend to be simple but significant, nonetheless. They include issues such as height clearances, boundary clearances and proper access concerns. If each of these has been addressed, there should be no inspection problem. Water supply and waste disposal are somewhat more formal requirements, and you will need to follow health code regulations in your jurisdiction: town, county, state or province. Your water supply must be safe from natural problems, from your neighbors and from yourself. Cordwood masonry does not present any extra issues not present in the correct siting of any home.

Having a good understanding of the issues discussed above is very important. Now it is time to get that building permit.

The Approval Trail

Those two little words—*building permit*—can cause acid to grip the stomach. This need not be the case, if you keep three basic things in mind when embarking on the approval process for cordwood construction:

1. In most cases, the building inspector is likely unfamiliar with the cordwood concept.
2. By virtue of the lines of accountability within the local government structure, the building inspector may adopt a bureaucratic approach. It may not be possible to discuss the *principles* of this construction style but only where it fits the local rules.
3. In spite of local codes and restrictions, most building inspectors are interested in this construction style. Their main concern is that good building practice is maintained throughout design and construction.

The applicant must have a thorough understanding of the building technique. If you are not confident that you can explain details during that first visit to the inspector's office, take someone with you who can. The initial step in the approval process must be a constructive one, helping the process to move forward and not stalling it. Preparation is the key. Foundation design and vapor management, for example, are two primary concerns of many inspectors. Preparation of the site, drainage, foundation materials, behavior of the foundation under load and the migration of moisture in the structure are issues the applicant should be intimately familiar with and able to explain. Make a copy of this chapter and leave it with the inspector to go over at leisure, outside of a busy office environment. Or leave him the whole book. Another excellent 55-page book called *Cordwood and the Code: A Building Permit Guide* appeared as a result of the 2005 Continental Cordwood Conference, and is available from Earthwood Building School. See its Bibliography for a list of the code issues covered in the book.

Feedback from inspectors should be welcomed, not feared. Based on their wide experience, they can provide valuable input that may enhance the performance of your structure. Patience and humor are valuable life skills. Take them with you into the approval process, and the experience should be virtually painless.

Three Brief Scenarios

Approach is everything. The following are three possible ways to get a building permit. It is left to the reader to choose the one most suitable to them. These scenarios may or may not be true.

1. I need a rubber stamp. I'm on a mission.

Applicant: (Monday, March 20.) "Good morning. I'm building a cordwood house five miles south of town. Got materials coming this morning. If you'd just stamp this drawing, I can be out of your hair in five minutes."

Inspector: "Oh yes. Do you have plans? I'm not familiar with that style of building. Could you leave me a copy to go over for a couple of days?

Applicant: "Ah, don't worry. Here's a sketch. I talked with a guy who built one of these. He had an engineer do the design. No big deal. Can I have the permit?"

Inspector: "Well, I'm pretty busy at the moment, got five major construction projects in town. Contractor's waiting for me out on the site. Let's see, it's March. Best come back and see me in, say, late August. Probably be a good idea to phone first."

2. Not ready yet?

Applicant: "Hi. I was in a couple of days ago and left you two books, five articles, six drawings, and a video about this cordwood house I'm building. Permit ready?"

Inspector: *Groan!*

3. Let's work on this together.

Applicant: (January) "Good morning. My name is ___ and I just bought the old Miller place south of town. I'd like to know the process for getting a building permit to construct a cordwood house."

Inspector: "Cordwood? Never heard of it."

Applicant: "Well, I brought some information and design details to leave with you. It won't be building season for another three months, so no big rush. When would be a good time to meet on this again?"

Inspector: "A couple of weeks should give me time to go through this. Thanks."

Conclusion

We've discussed some of the design details related to cordwood construction that would likely be of interest to your local building authority. The actual building of a cordwood home can be undertaken by a few people or by many, as the case studies in this book have shown. If the fundamental design principles are adhered to, the end result should be a functional structure that will demonstrate an economically sustainable option for housing and one which is kind to the planet at the same time.

Three things to remember: Have a thorough understanding of the principles behind the structure you are about to build. Formulate reasonable and realistic time lines for your project. And cultivate patience and humor. These strategies will not only help in the approval phase but will also help you to see the project through to a successful conclusion.

Part 2: A Code Enforcement Officer's Viewpoint

by Thomas M. Kwiatkowski

(This section is an abridgement of Chapter 28 in the first edition of *Cordwood Building*, by the late Tom Kwiatkowski. Tom was a Codes Enforcement Official registered with the state of New York. He designed and built a cordwood home in 1979 and lived in it for 13 years.)

The purpose of building codes is not to keep you from building the type of structure you want. The codes are there to help assure that the structure will not impede on your health, safety and welfare. Of all structures, owner-occupied single family homes have the least restrictions placed on them by the code.

Now for the first (and what I consider the largest) stumbling block. Your plans for the structure will have to be signed and sealed by an architect or engineer that is licensed by the state or province where you live. Some states or local jurisdictions may not have this requirement. Others, like New York, may only require stamped plans for houses over 1,500 square feet or some other size. In New York, an engineer does not have to be a structural engineer. He or she can be an electrical, industrial, environmental or any other kind, as long as they are licensed by the state. This is a loophole you might be able to work to your advantage. Also, the architect or engineer does not have to be the one to draw up the plans. You or someone else can draw the blueprints, then pay an architect or engineer to review, sign and stamp them. Shop around for prices, which vary a great deal.

As far as cordwood construction, getting your plans signed and stamped may be the most difficult steps in the process. This is due to a shortage of engineering tests available on cordwood. However, if you choose the timber frame style with cordwood infilling, all of the loads and stresses will be based on the framework. Also, there are companies out there that provide blueprints for timber frame structures already signed and stamped.

There are many discretionary aspects to the code, and final permit approval rests at the local level. Therefore, I strongly suggest that the better the working relationship between you and your local official, the easier it will be to complete your project. You will probably be building in a rural area, and in those areas the building inspector is usually a part-time position, so you will not be scrutinized or inspected as if you were in a more suburban area.

24.3. Tom Kwiatkowski's 12-sided cordwood home near Plattsburgh, New York.

As for the discretionary aspects, one example is electricity, which may or may not be required for an owner-occupied single-family home, at the discretion of the local jurisdiction. The same is true for the required plumbing fixtures and hot water. Hookup to local commercial power, however, must be approved by the local power company, and they will most likely require adherence to the National Electrical Code (NEC) and might even have other local service entrance requirements. The rules for how many feet of electric service line will be supplied for free can vary widely from place to place, too, so if your site is remote, it is good to check up on this in advance with the local power company. If hookup costs approach $10,000, alternative energy may be a viable economic option. Incidentally, the NEC also has regulations and codes on the installation of photovoltaic panels.

Another example of a discretionary situation is the use of unmarked structural lumber, such as locally sawn, rough-cut timbers. If you and your local official have an adversarial relationship, he or she could require certification of the unmarked structural lumber by a structural engineer. This can be expensive.

I hope that you are not discouraged or deterred from using cordwood due to fear of building codes. Most building inspectors will try to help you in any way they can. Do not try to sneak something by them. Remember that they are actually there to help you.

Part 3: Other Cordwood Code Issues

by Rob Roy

I hope that the first two parts of this chapter, written by engineers and a code official, will help prospective cordwood owner-builders through the permitting process. To conclude the chapter, I will share some insight into the specific code issues of compression strength and cordwood in a seismic zone.

Certified Compression Tests for Cordwood Mortar

Way back in the 90s, Paul Agnew of Cameron Geotechnical in Morrisonville, New York, performed compression tests on six test cylinders of cordwood masonry mortar. The reader must keep in mind that while the tests were conducted according to standard New York State approved testing procedure, the words of this chapter are my own, not Paul's. The figures in the table below, however, are Paul's certified test results. I am not a licensed engineer nor do I play one on TV. I do have considerable experience with cordwood structures, though.

Code enforcement officers have little or no problem with the compression strength of wood. They regularly approve conventional horizontal-log structures all the time. The second component of a cordwood wall is the mortar, so Paul conducted several core tests on that, using the same standard test cylinders (6 inches diameter by 12 inches deep) that he employed when testing the compression strength of concrete.

Cylinders 1 and 6 were filled with mortar made in a wheelbarrow with the following ingredients, by volume: 9 parts sand, 3 parts soaked softwood sawdust, 3 parts Type S hydrated lime and 2 parts Type I Portland cement. Cylinder 1 was tested to failure one week later. Cylinder 6 was tested to failure after 30 days.

Cylinders 2 and 4 were filled about 5¼ inches with the same mortar used with Cylinders 1 and 6. Then a wooden insert, a 6-inch-diameter disk cut from a pressure-treated 2-by-6, was set into the mortar. Six roofing nails were nailed into each side of the wooden cylinder, but were left extending half an inch proud of the wood, in order to "grab" the mortar. This simulates the same detail used on wooden plates used to distribute the concentrated load of rafters onto a cordwood masonry wall. The cylinder was then topped up with another 5¼ inches of mortar. Paul tamped all samples a certain number of times with a particular tamper, as he had been trained.

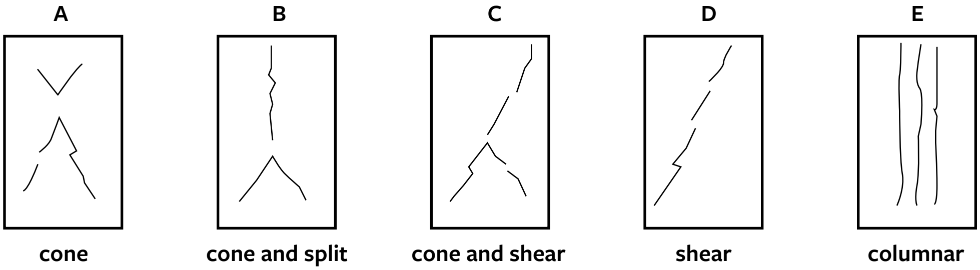
Cylinders 3 and 5 were filled with mortar made in a wheelbarrow with the following ingredients, by volume: 8 parts sand, 4 parts soaked softwood sawdust, 3 parts Type S hydrated lime and 2 parts Type I Portland cement. The purpose of these tests was to learn the impact of extra sawdust and less sand on the strength of the sample. Cylinder 3 was tested to failure one week later. Cylinder 5 was tested to failure after 30 days.

Here is a summary of the tests. Paul's original Cylinder Compression Test Report is on file at Earthwood Building School.

Cylinder Compression Test Summary

Cylinder Number	Age in Days	Design Mix*	Max. Load (lbs)	Compression Strength (psi)	Type of Fracture
1	7	9-3-3-2	22,000	778	D
6	30	9-3-3-2	35,000	1238	D
2	7	9-3-3-2-w	16,500	584	E
4	30	9-3-3-2-w	24,500	866	E
3	7	8-4-3-2	7,000	248	E, D
5	30	8-4-3-2	23,000	813	D

* The proportions, in order, refer to sand, soaked sawdust, lime and Portland cement. The "w" refers to samples containing a wood insert at the approximate center of the cylinder mold.



24.4. Typical fractures in test cylinders.

With all three types of sample, the 30-day tests are stronger on compression than the 7-day tests, as would be expected: Cylinder 6 gained 59 percent in strength compared to Cylinder 1. Cylinder 4 was 48 percent stronger than Cylinder 2. And Cylinder 5 was 228 percent stronger than Cylinder 3. It is not expected that much additional strength would be gained by leaving the cylinders to cure for a longer period. The high percentage gain in strength of Cylinder 5 over Cylinder 3 might be explained by the very weak compression strength of Cylinder 3 after seven days. Samples 3 and 5 contained a relatively high percentage of soaked sawdust in the aggregate (4 parts out of 12, or 33.3 percent of the aggregate) when compared with all the other samples (3 parts out of 12, or 25 percent of the aggregate). The higher sawdust content may be responsible for the lesser compression strength, particularly on the seven-day test (Cylinder 3), where the influence of the sawdust in retarding the set of the mortar is still quite pronounced.

Cylinders 2 and 4 used the same mortar as Cylinders 1 and 6. The difference was that the wooden disk insert, already described, was placed at the center of the sample. The top and bottom mortar cylinders, then, were only about 5¼ inches high, which could explain the columnar failure of these testing cylinders, as opposed to the predominantly shear failure of all the others. Even with the wooden insert, intended to simulate cordwood masonry and the use of wooden plates under rafters, these samples were stronger on compression than Cylinders 3 and 5, which had the higher sawdust content.

The tests support the view that the soaked sawdust admixture accomplishes the intended purpose of retarding the mortar set, thus reducing the incidence of mortar shrinkage cracking. More sawdust retards the set even longer, but at the cost of strength. The 30-day test on Cylinder 6 (9 parts sand, 3 parts sawdust, 3 parts lime, 2 parts Portland cement) is 52 percent stronger than the 30-day test of Cylinder 4 (8 parts sand, 4 parts sawdust, 3 parts lime, 2 parts Portland cement). The 30-day compression strength of all the samples tested is way beyond what is necessary to support even the heaviest cordwood home. The two-story, load-supporting cordwood walls at Earthwood weigh about 2,000 pounds per square foot (or 14 psi) with a fully saturated earth roof load and a 70-pound snow load.

Cordwood Masonry in a Seismic Three Zone

Cordwood masonry is strong on compression—way beyond the compression strength required of any bearing wall. But cordwood masonry is not strong on tension. What is the difference?

Compression is the ability of a material or system (in this case, a cordwood wall) to bear vertical loading. Imagine loading a brick until it crushes. Most solid things are fairly strong on compression. Even Dow Styrofoam Blueboard can support 5,600 pounds per square foot (39 psi) with only ten percent deflection (compression). Tomatoes and your left thumb are not particularly strong on compression, as the impact load from a hammer will readily demonstrate.

Tension is the opposite of compression. It is the ability of a material or system to hold together when it is being pulled apart from opposite directions. Ropes, wire, rebar and beams are measured in terms of their tensile strength. Masonry is strong on compression but not so strong on tension. Concrete and stone masonry get some tensile strength because of the chemical bond holding the aggregate (or stones) to the cement, but reinforcing bar is placed in concrete to greatly increase its tensile strength. Cordwood is probably the weakest masonry system on tension because there is virtually no chemical bond between the mortar and the log-ends, only a weak friction bond.

A regular load-bearing cordwood wall provides a good "reactionary thrust" to vertical loading because of its compression strength, but during an earthquake, other thrusts are inflicted upon the system. As the building begins to oscillate under the Earth's lateral movements, a sideways thrust is imparted to the wall. First one side and then the other are subjected to tensile stresses, until finally the wall topples over. This is why mud brick buildings perform so poorly in Mexico and other parts of the world during earthquakes, causing great loss of life. In Peru and Ecuador, in areas subject to relatively frequent and strong quakes, I noticed that new mud brick buildings are framed out first in a strong concrete post and beam frame, with plenty of reinforcing bar. These new buildings have a much higher tensile strength. Even if a compartmentalized panel of mud bricks topples over, it is unlikely that serious injury or loss of life will occur.

A similar approach can be taken with cordwood masonry in areas of high seismic risk, except that instead of a concrete post and beam frame, a wooden post and beam frame can be employed. The various components of this frame must be tied to each other with either traditional timber framing methods or by the use of metal fasteners (truss plates, floor post brackets, joist hangers, etc.) made for the purpose. Again, in an earthquake the building will oscillate, but the cordwood panels are small enough that they are unlikely to shake loose of their surrounds.

Be sure to include a wooden key piece attached to the sides of the posts where cordwood is placed. The key piece is firmly nailed or screwed to the post so that it corresponds to the middle third of the wall. The friction bond of the mortar wrapped around the key greatly increases the effective value of the cordwood panel's tensile strength. A determined mule might kick a hole in a cordwood barn wall panel fastened with such a key piece, but without it, he might kick the whole section out in one piece.

Richard Kovach and Dawn Danielson built their "Earthwood West" house in Carlsborg, Washington, in the late 1980s. Although they had our architect-stamped plans for Earthwood, the Clallam County Building Department insisted upon four changes to accommodate the seismic Zone Three code requirements. Writing in the *CoCoCo/94 Collected Papers* ("Earthwood Structure in Washington State: Code Issues," pages 98-103), Kovach and Danielson list the changes. Here is a summary.

1. **Footings:** Twice the rebar and much deeper footings than required in New York State.
2. **Buttresses:** The buttresses at the original Earthwood, designed by an engineer to resist the lateral load of the earth-sheltering, had to be extended to the roof line at Earthwood West and be more heavily reinforced.
3. **Underground block wall:** The below-grade block wall had to be "locked" to the footing with L-shaped pieces of #6 rebar and the blocks themselves locked to each other with vertical rebar and frequent use of "bond beam" courses of block. A "knockout bond beam block" allows the placement of horizontal rebar slushed with concrete, greatly increasing resistance to lateral loads such as earth pressures and earthquake oscillation.
4. **Load-bearing external wall (cordwood):** As this is the part that will be applicable to any normal above grade cordwood home in a seismic area, I'll let Richard and Dawn tell the story.

> Code requires that all load-bearing masonry be reinforced. Since we could not envision threading rebar into our cordwood masonry matrix (at least not without losing our sanity), we chose to use posts and beams for the external wall loading. Douglas fir 8-by-8s were used for all of the post and beams. Rafters were 5-by-10s, and joists were 4-by-8s, also Douglas fir. All framing wood was purchased from a local mill, selected from "butt ends"

> near the ground for clarity and minimal knots, and had to be graded by a certified inspector. All pieces were found to be #1 grade or better. The cost of the timbers was $2,700 and the inspection was $35.
>
> First-story posts were connected to the footing by bolting them into Simpson CB88 connectors, which were placed before pouring the footing. Each post was bolted to its nearest beam with two ½-inch by 8-inch lag bolts at a 45-degree angle. Adjacent beams were connected together with truss plates. Care was taken to ensure plumb and level on all posts and beams, and our efforts paid off. For a couple of first-timers who had built nothing more complicated than model airplanes, we had no unpleasant surprises.

Even in a non-seismic area, the use of a timber frame for load support has a lot going for it. Besides enabling you to get the roof on early—and doing the cordwood work under cover—code enforcement officers love it. Incidentally, Richard and Dawn's home might be the first hexadecagon (16-sided) cordwood building. See Chapter 20.

Although this is the last formal chapter, it is not the end of the book. What follows has some good information, so stick around a while longer.

Afterword: Where We Go From Here

by Rob Roy

I hope you have enjoyed this trip through the world of modern cordwood masonry. But now what?

Just as watching an exercise video will not take inches off your belly, reading this book won't get a cordwood wall built. The book can only guide you. You have to do the work.

Many of the builders who shared their case studies here started with a practice building—a good idea. Jaki and I advise our students to build something small, like a well-house, garden shed, sauna or even a temporary shelter (as discussed in Chapter 23). If you can't build the practice building, or don't enjoy it, well, you've learned something valuable: cordwood is not for you. But grandmothers, children and beavers all build cordwood buildings successfully and enjoy it, too, although some of the beavers with whom I'm acquainted tend toward being workaholics.

After gaining practice, skills and a sense of how long it takes you to build (everyone is different in this regard), you will be far better placed to design and build your home. You will be far more likely to build something manageable. If you are unsure about structure, build a model. One cordwood builder of my acquaintance discovered some structural problems while trying to build his balsa model, problems he was able to work out with an architect.

Give yourself plenty of time for the permitting process. Stay on good terms with the code enforcement officer. Keep a sense of humor.

Where do Jaki and I go from here? Well, we'll probably keep building and teaching about cordwood until we can't lift a five-pound log-end. Old cordwood masons never die—although we may get laid up.

And cordwood masonry in general? The future remains bright. Three Continental Cordwood Conferences have been held since the publication of the first edition of *Cordwood Building* in 2003. Some of the CoCoCo/15 presentations appear in this volume in a slightly different form. We are hoping that the next conference will be renamed the World Cordwood Conference, and held off-continent, somewhere like Sweden, France or Australia. (Hawaii would be nice, Ben and Mirtha!)

Happy stacking!

— Rob Roy
West Chazy, New York

Annotated Cordwood Masonry Bibliography

(*Author's note:* I have confined this list to materials current at press time. Out-of-print cordwood books, including my own, have been replaced by better and more up-to-date works. If you are on a low budget, make use of your local library. If they haven't got a book you want, suggest that they purchase it, or ask them to get it for you on interlibrary loan.)

Cordwood Books

Dick, Kris and Allen Lansdown, *Stackwall: How to Build It*, 2nd edition, Building Alternatives Inc., 1995. This one revises the original 1977 edition and has lots of new information. It gives special attention to stackwall corners and the gravel berm foundation. Well illustrated, 114 pages, large paperback, spiral bound.

Flatau, Richard, *Cordwood Construction: Best Practices*, Cordwood Construction Resources, 2012, revised and updated 2015. True to its title, the author details "best practices" methods about cordwood masonry and its relationship to foundations, electrical considerations, energy codes and more. Two recent case studies (the Cordwood Education Center in Wisconsin and the Whole Earth Reservation Cordwood Home in Minnesota) are by themselves worth the $26 price of this well-illustrated and meticulously documented work. 196 large 8.5″ × 11″ pages, including 259 color pictures and diagrams.

Roy, Rob, *Mortgage Free! Innovative Strategies for Debt-Free Home Ownership*, Chelsea Green, 2008. This one expands on Chapter 23 of this book and also includes a cordwood case study in Washington State. The paper edition is now out of print, but Chelsea Green still offers it as an ebook. Or find used copies on the Internet.

——, *The Sauna*, Chelsea Green, 2004. A cordwood masonry sauna is a great starter project and delivers a genuine Finnish sauna experience. This book is about saunas, but three of its nine chapters are really about cordwood. Chapter 4 is about building a post and beam log-end sauna and Chapter 5 is about building a round cordwood sauna. Other chapters deal with sauna lore, siting and design, stoves and how to take a sauna. Fully illustrated, 236 pages. Although out of print, this book is still available from Earthwood at cordwoodmasonry.com.

——, *Stoneview: How to Build an Eco-friendly Little Guesthouse*, New Society Publishers, 2008. Stoneview is an octagonal cordwood masonry timber-framed guesthouse with a living roof, located at Earthwood. It cost $5,000 to build, complete—about $16 per square foot for its 320-square-foot area. Over 130 clear line drawings and step-by-step images detail all the information needed to build Stoneview from start to finish and a color section shows the design features of this charming "green" cabin. All design considerations are covered, as well as a thorough discussion of octagon geometry. Chapters are devoted to site prep, forming and pouring the slab, timber framing, the lightweight living roof and the cordwood masonry walls. 244 pages, four in full color.

——, *Timber Framing for the Rest of Us*, New Society Publishers, 2004. Many natural building methods rely on a timber frame first, which is then in-filled with straw, cob, cordwood or more conventional wall materials. But traditional timber framing employs the use of finely crafted joints and wooden pegs, requiring a high degree of craftsmanship and training, as well as much time and expense. This book describes the timber framing methods used by most contractors, farmers and owner-builders, methods that use modern metal fasteners, special screws and common-sense building principles to accomplish the same goal in much less time. While there are many good books on traditional timber framing, this is the first to describe in depth these more common fastening methods. 176 pages, well illustrated.

Stankevitz, Alan, Richard Flatau, Rob Roy and Dr. Kris Dick, *Cordwood and the Code: A Building Permit Guide*. Print version: Cordwood Construction Resources, 2005; ebook: daycreek.com. Here's documentation for presenting a cordwood project to your building inspector. It answers, in a professional manner, the questions code enforcement officers most frequently ask. Topics include thermal monitoring (R-values) of a cordwood wall by Dr. Kris Dick, fire resistance of a cordwood wall, REScheck (energy) analysis and a fine paper by Richard Flatau called "Conversations with a Wisconsin Code Official." The 17-page Appendix includes a copy of Alan Stankevitz's own successful building permit application. You can use the CD supplied with each book to download that application to your computer and make changes for your own application. Share this document with your local building inspector. Many have benefited by doing so. 54 pages.

Wrench, Tony, *A Simple Roundhouse Manual*, Available from the author at thatroundhouse.info/courses or Amazon. Good on cobwood construction, group building, the reciprocal roof and getting planning permission. Tony emphasizes low-cost methodologies and making use of recycled and indigenous materials. Over 100 color photos. As I was finishing up this book, friend Tony told me, "If you prefer a Kindle version, Amazon has it for £4 or the equivalent in your local currency."

Cordwood DVD

Roy, Rob and Jaki Roy, *The Complete Cordwood DVD*, an Earthwood Building School/Chevalier-Thurling Productions video, distributed by New Society Publishers. Our *Cordwood Masonry Techniques* VHS video was filmed at our workshops and served as an excellent instructional video and refresher course for former students. Our *Cordwood Homes* VHS video was a tour of eight cordwood homes around North America. These videos are now combined into this DVD along with new footage, including the use of paper-enhanced mortar with Jim Juczak, the 16-sided post and beam frame, and the use of cement retarders. An extensive captioned slideshow rounds out the DVD, showing examples of round, post and beam and stack-wall buildings, as well as construction details and special features. 3.25 hours.

Cordwood Masonry Websites

cordwoodconstruction.org

Richard Flatau and his wife Becky conduct cordwood masonry workshops in Wisconsin and other states. Richard is the author of *Cordwood Construction: Best Practices*. His website has a wealth of interesting cordwood pictures and articles.

cordwoodmasonry.com

Our Earthwood Building School website. Since 1979, Earthwood has been conducting cordwood workshops in northern New York and around the world. The site serves as a clearinghouse for all things cordwood, including most of the books in this bibliography.

daycreek.com
Alan Stankevitz's website focuses on cordwood masonry, with lots of articles, including from back issues of *Mother Earth News* and *BackHome Magazine*. There is a detailed diary of his own two-story, round house project, which makes use of paper-enhanced mortar. (See Chapters 6 and 7.) As we go to print, Alan is working on completely rebuilding this long-running website, and, knowing Alan, it will be better than ever.

There are many more websites and blogs, too numerous to list, that tell of individual experiences with cordwood masonry. Simply plug "cordwood masonry" or "cordwood building" into a search engine and be prepared for a long and interesting afternoon.

Related Websites

greenhomebuilding.com
Kelly Hart's website covers all sorts of natural and vernacular building, including a section on cordwood masonry. The "Ask Our Experts" feature enables the visitor to ask questions about several different natural building techniques. Rob Roy fields the cordwood questions. There are hundreds of questions and answers listed. Some of the categories are: types of wood to use; where to find cordwood; debarking and curing the wood; foundations; appropriate mortar and methods; structural considerations; code and permit issues.

newsociety.com
This is the site for New Society Publishers. If you have enjoyed this book, you'll probably be interested in their other titles on natural building.

Glossary of Terms

Air infiltration: The transfer of air through the fabric of a building. Log-ends that shrink a lot are sources of air infiltration and thus promote heat loss by convection. A polythene vapor barrier greatly reduces air infiltration.

Bed: In masonry, the mortar upon which a brick, block, stone or log-end is laid.

Bottle-end, bottle-log: A mixture of two bottles or jars joined together to make a glass masonry unit for the admission of light. See Chapter 8.

Bonding agent: A liquid product made by various manufacturers designed to facilitate the bonding of mortar or plaster to other clean surfaces. See Appendix: Products.

Built-up corners: In cordwood masonry, a corner system by which corners are constructed of regular wooden blocks, called "quoins," laid up in an alternating crisscross fashion. Also known as "stackwall corners." See also "Lomax corners."

Cement: The hardening and strengthening agent in mortar and concrete. See also "Portland cement" and "masonry cement."

Cement retarder: One of a number of commercially available products used as additives to concrete or mortar for the purpose of slowing the set of the material.

Checking: The natural splitting of a log-end (or any piece of wood), resulting from rapid drying. A presplit log-end often has hairline cracks, without a primary check that goes all the way through from end to end. A single large check is a common condition with cylindrical log-ends.

Cob: A mixture of sand, clay, straw and water used to build walls. Can also be combined with log-ends to build a cordwood wall. See next entry.

Cobwood: A new term coined by cordwood and cob builders, referring to a cordwood masonry wall tied together with cob instead of mortar.

Concrete: A mixture of sand, stone aggregate, Portland cement and water. When concrete sets, it makes a strong wall, slab, deck or foundation material. Not to be confused with "mortar."

Cord: A unit of measure for stacking and purchasing firewood or pulpwood. While, technically, a cord of wood should refer to a "true," "full," or "real" cord of 128 cubic feet, the term now commonly refers to any stacked pile of wood with a sectional area of 32 square feet, normally 4 feet high and 8 feet long. If the stack is also 4 feet wide, it will be a true cord of 128 cubic feet. See also "face cord."

Cordwood masonry: A wall-building system in which short logs, often called "log-ends," are laid up transversely in the wall within a special mortar matrix, much as a cord of firewood is stacked. Also, "stovewood masonry," "stackwall," "firewood wall," and the like.

Double-wall technique: A thermally efficient wall system, made from two separate cordwood masonry walls separated by a fully insulated cavity. Although at least one double-wall barn from the 1930s has been identified in Michigan's Upper Peninsula, double wall for housing was developed by Cliff Shockey in 1977. See Chapter 6.

Drawknife: A sharp, single-edged metal blade with a handle at each end of the cutting edge. Used mainly for shaping wood, a drawknife can also make a good barking tool when all else fails. See Chapter 2.

Face cord: A stack (also "rank," "rick," or "run") of wood 4 feet high, 8 feet long and a certain agreed-upon thickness: 12 or 16 inches, for example. The face cord is a convenient measure to use in determining material requirements for a cordwood project. It is important that the buyer knows exactly what the seller means by the term "cord."

Firewood walls: An archaic term for cordwood masonry walls.

Floating ring beam: A ring of concrete footings floating on a pad of percolating material. See next entry.

Floating slab: A foundation method, whereby a concrete slab is "floated" on a pad built up from runs of good percolating material such as coarse sand, gravel or crushed stone. A favorite of Frank Lloyd Wright, the floating slab is an economic choice for a cordwood foundation in areas of deep frost. Not recommended on expansive clay soils.

Footer, footing foundation: A base for a wall or building.

Girder: A major horizontal beam that supports floor joists or roof rafters.

Girt: A beam that joins the tops of sidewall posts around the perimeter of a timber frame structure.

Lintels: Wooden timbers that carry wall load over doors or windows.

Lime: In masonry, a white alkaline powder added to mortar to improve its plasticity. "Mason's lime" (also called "builder's lime," "hydrated lime," or "Type S lime") is made by converting limestone by heat. "Agricultural lime," which is non-hydrated, is used as a soil conditioner in agriculture and is not suitable as a mortar additive.

Log-ends: The individual short logs, butts, blocks, ends or pieces of wood used as masonry units in a cordwood wall. Log-ends are most commonly used transversely in the wall, where, with their end grain exposed, they "breathe" very well, greatly reducing the danger of wood deterioration through rot.

Lomax corners: Built-up corners made from pre-built corner units, instead of individual quoins. Named for Gary Lomax. See Chapter 1 for details.

Masonry cement: A cement and lime mixture that has become popular with modern masons. There are several types, with varying characteristics.

Mortar: A mixture of sand, cement and water used for laying up masonry units such as bricks, blocks, stones or log-ends. Sometimes other ingredients are added for certain purposes. Colloquially know as "mud."

Mortar mix: Common term for a dry, bagged, premixed mortar product, usually about three parts sand to one part masonry cement. Just add water for a good brick or block mortar. Not to be confused with bags of masonry cement, which contain no sand.

Mud: Slang for "mortar."

Panel: In cordwood building, a section of masonry enclosed within a timber frame.

Paper-enhanced mortar (PEM): A mortar with a high recycled-paper content. See Chapter 12.

Papercrete: A material made from paper, cement and water, used for building. The density and strength of papercrete varies widely with the recipe and whether or not sand or other admixtures are included. See also "paper-enhanced mortar (PEM)."

Peeling spud: A chisel-like tool made for removing bark. Many cordwood builders have made successful spuds by mounting a wooden handle to the leaf spring from an old truck. A heavy pointed mason's trowel makes a pretty good peeling spud, too.

Plate: In cordwood masonry, wooden planking (typically two inches thick) used to distribute joist or rafter load onto the cordwood wall. The plate can also tie corners together and provide a surface upon which to fasten floor joists or rafters.

Plate beam: In a post and beam frame, the topmost horizontal member; the top of a cordwood masonry panel. See also "girt" and "plate."

Pointing: The process of smoothening the mortar between masonry units. Also called "tuck-pointing" or "grouting." With brick or block work, the term "raking" is also used.

Pointing knife: A tool used for pointing. Can be made by bending the last inch or two of a smooth kitchen butter knife to an angle raised about 15 degrees from the plane of the knife blade.

Portland cement: A strong, unmixed cement used in concrete, made by burning a mixture of limestone and clay or other materials. Type I is the basic type, with standardized strength characteristics. Type II is almost the same, but is air-entrained.

Proud: In masonry, the opposite of recessed. Protrusive: the log-ends sit proud of the mortar background.

Quoins: In cordwood masonry, the individual blocks of wood used in the construction of built-up corners, usually made from regular dimensional material, such as 6-by-6 inch timbers. In stone masonry, squared stones used in corner construction.

R-value: A measure of insulation value in building materials. The higher the R-value number, the greater the insulation. Materials are often measured in terms of R-value per inch. Extruded polystyrene, for example, is about R-5/inch.

Rank, rick, run: See "face cord."

Random rubble pattern: In cordwood masonry, the use of a variety of sizes and shapes of log-ends, distributed randomly in the wall.

Retarder: See "cement retarder."

Ridgepole, ridge beam: The major carrying beam or girder of a roof system, supported by posts.

Sill plate: A wooden plate, often pressure treated, which caps the top of concrete footings, a poured concrete wall or a block wall. Also "toe-plate" or "sill."

Sills: Heavy horizontal wooden timbers sometimes installed beneath window framing. See also "sill plate."

Stackwall: Cordwood masonry, particularly in Canada.

Stackwall corners: Same as "built-up corners."

Stovewood masonry: Same as "cordwood masonry." The term is most commonly encountered in historical articles and is seldom, if ever, used in reference to cordwood structures built since 1960.

Thermal mass: The capacity of a material to store heat. Generally, a material's thermal mass characteristics are inversely proportional to its insulation characteristics.

Toe-plate: See "sill plate."

Appendix: Products

Cement Retarders

I have had good results with the first two listed below. A 5-gallon drum of Sika Plastiment lasted me for years. Also, ask at your local building supply outlets. They may have others not listed here.

Sika Corporation. "Plastiment is a water-reducing and retarding admixture." Sika has offices all over the world. Go to sika.com and search for your country. In the United States: Sika Corporation, 201 Polito Avenue, Lyndhurst, NJ 07071. Tel: 800-933-7452. Website: usa.sika.com. In the United Kingdom: Sika Limited, Watchmead, Welwyn Garden City, Hertfordshire AL7 1BQ. Tel: 01707 394444. Website: gbr.sika.com. From the British website: "SikaTard R is a liquid admixture developed for the control of cement hydration." Comes in a 25-liter drum.

W.R. Grace and Company. 62 Whittemore Avenue, Cambridge, MA 02140. Tel: 617-876-1400 (24 hours) or 800-354-5414 (8 AM–5 PM Eastern). Website: grace.com. Makes W.R. Grace Daratard 17: "An admixture for use where delay in setting time is required to ensure sufficient placement, vibration or compaction time. Comes in 55-gallon drums." W.R. Grace makes lots of other cement retarders. Search their site. (Tip: look for Grace retarders at your local concrete batch plant.)

Increte Systems. 1611 Gunn Hwy., Odessa, FL 33556. Tel: 813-886-8811 or 800-752-4626 Website: increte.com. "Increte Systems cement retarder is an easy-to-use, water-based additive to prolong the setting time for cement products. Use any time longer set times are desired."

Bonding Agents

I believe Lanco is the one we used in Hawaii with Ben Oliveros in Chapter 20. It is very big in Central America, where a lot of cement block work is done on concrete foundations. I have frequently used the next two bonding agents listed, with good results when bonding cement-based mortars to concrete foundations. They seem to be helpful with lime-based mortars, too. DAP is often a little more economical. Also, search "concrete bonding agents" for many more manufacturers. And ask at your local building supply.

Lanco & Harris. North America distribution warehouse: Miami, Florida. Tel: 305-638-5050. Website: lancopaints.com. Their Lanco CB-4000 is described as "A 100% acrylic polymer designed to be used as concrete bonding agent and additive for cement-based materials, and mixes."

DAP Products, Inc. 2400 Boston Street, Suite 200, Baltimore, MD 21224. Tel: 410-675-2100. Website: dap.com. "DAP Bonding Liquid and Floor Leveler Additive is a versatile product that can be used as an additive to increase adhesion and flexibility in plaster, mortar, concrete, floor leveler, stucco and weatherproof cement paint."

Thoro Consumer Products. BASF Corporation Building Systems, 889 Valley Park Drive, Shakopee, MN 55379. Tel: 216-839-7171 or 866-518-7171. Website: thoroproducts.com. Makes Acryl-60 Bonding Agent: "Acrylic, polymer emulsion additive for cement-based powders designed to improve adhesion, tensile, compressive, and flexural strengths. Non-yellowing, water-based ideal for both interior and exterior use."

Foam Insulation Websites and Manufacturers

You can spend a lot of time researching foam insulations on the Internet: open cell versus closed cell; "green" alternatives versus 100 percent urethane-based products. The websites listed here were useful in researching Chapter 7. They, or a search engine, will lead you to others. Some of these are trying to sell their product:

greeninsulationtechnologies.com/natural-oil-polyols.php
thegreenestdollar.com/2009/02/soy-based-foam-insulation-what-it-is-and-why-you-should-use-it/
nachi.org/soy-based-insulation.htm
thegreeninsulationco.com/faq.shtml#2
buildinggreen.com/article/biobase-501-foam-insulation

Here are three of the leading players in spray foam insulation, in the United States and Canada. Contact them to find a contractor near you who can apply their product. There are many others. Also, check directly with your local insulation installers.

BioBased Technologies. 3333 Pinnacle Hills Parkway, Suite 400, Rogers, AR 72758. Tel: 877-476-5965. Website: biobsed.net.

Icynene. 6747 Campobello Road, Mississauga, Ontario, L5N 2L7, Canada. Tel: 800-758-7325. Website: icynene.com.

Demilec, Inc. 3315 E. Division Street, Arlington, TX 76011. Tel: 888-224-1533. Website: demilec.com. In Canada: Demilec, Inc., 870 Cure Boivin, Boisbriand, Quebec, J7G 2A7 Canada. Tel: 866-345-3916. Website: demilec.ca.

Chinking products Useful in Repairing Cordwood Masonry

The following chinking products are useful in repairing a variety of wood shrinkage and mortar-related problems, as described in Chapter 4. These companies will send you flexible color samples upon request.

Perma-chink Systems, Inc. 1605 Prosser Rd., Knoxville, TN 37914. Tel: 800-548-3554. Website: permachink.com. Makes Perma-chink elastic chinking in 8 colors.

Sashco. 10300 East 107th Place, Brighton, CO 80601. Tel: 800-767-5656. Website: sascho.com. Manufacturer of the excellent "Log Jam" chinking product, which comes in 7 colors.

Weatherall Company, Inc. 106 Industrial Way, Charlestown, IN 47111. Tel: 800-367-7068. Website: Weatherall.com. Makes Triple Stretch® Chinking—"a water based flexible acrylic latex sealant"—in 12 colors.

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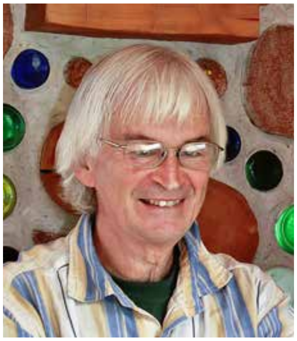
About the Author



Rob Roy was born in Webster, Massachusetts, in 1947. He lived seven years in the Scottish Highlands where, in 1972, he met Jaki, now his wife of 44 years. The couple has lived in West Chazy, New York, since 1975.

Rob is Director of Earthwood Building School, which he co-founded—with Jaki—in 1981. Earthwood teaches owner-builders how to build with cordwood masonry and "timber framing for the rest of us" techniques, making use of commonly available fasteners. Rob and Jaki also teach earth-sheltered housing—including living roofs—and megalithic stone raising using traditional methods available to people 5,000 years ago. Rob has written 15 books in these and related fields, including *The Sauna* and *Mortgage Free!* His New Society titles include *Cordwood Building: A Comprehensive Guide to the State of the Art* (2016), *Timber Framing for the Rest of Us* (2004), *Earth-Sheltered Houses* (2006), and *Stoneview: How to build an Eco-friendly Little Guesthouse* (2008).

Rob and Jaki have built four cordwood homes and numerous outbuildings, and have conducted workshops all over North America and around the world. Their love of travel resulted in their first co-authored book, *The Coincidental Traveler: Adventure Travel for Budget-minded Grown-ups* (Earthwood Publishing, 2014), in whcih they share strategies and philosophies they use to create memorable existential travel experiences.

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- The Greenpeace Guide to Greener Electronics
- Conflict Minerals: Raise Hope for the Congo
- Slavery Footprint

Recycle Old Electronics Responsibly

According to the United Nations Environment Programme some 20 to 50 million metric tonnes of e-waste are generated worldwide every year, comprising more than 5% of all municipal solid waste. Toxic chemicals in electronics, such as lead, cadium and mercury, can leach into the land over time or can be released into the atmosphere, impacting nearby communities and the environment. The links below will help you to recycle your electronic devices responsibly.

- Electronics Take Back
- Canada - Recycle My Electronics
- United States - E-cycling central

Of course, the greenest option is to keep your device going as long as possible. If you decide to upgrade, please give some thought to passing your old one along for someone else to use.