Chapter 1

Introduction

What Is Cordwood Masonry?

Cordwood masonry (sometimes called *stackwall* construction in Canada) is a term describing the construction of exterior or interior walls out of short logs — *log-ends* — laid transversely in the wall and supported by an insulated mortar matrix. The mortar portion of the wall can be made with cement- or lime-based mortars, cob (clay, straw, and sand), "papercrete," or — a new development — *hempcrete.* The walls can be load-bearing in non-seismic zones, but are more commonly used as infilling within a strong timber frame. A relatively small number of cordwood homes — probably less than five percent — use a *double-wall* technique: separate interior and exterior cordwood walls with the space between them completely filled with insulation, as described in Chapter 6.

Cordwood masonry has a long history, which I discussed in my book *Cordwood Building: A Comprehensive Guide to the State of the Art* (New Society Publishers, 2016). There are existing cordwood buildings in North America and Europe dating back to the 19th century, which are documented in that book. More recently, cordwood has spread to South and Central America, and has enjoyed a rebirth in Scandinavia as well as in Britain, where cob has become a popular alternative for mortar amongst the natural builders.

I have recently learned of an exciting new development in cordwood's history, a site called Slawenburg Raddush (Slavic Fort Raddush), near the town of Vetschau in the German federal state of Brandenburg. Raddush was originally built around the 9th or 10th century AD, employing log and cordwood techniques on the inner and outer surfaces of the massive walls. It was still clearly recognizable as a ring-shaped wooden structure in the early 20th century. The fort was reconstructed during the 1990s using the


1.1


1.2


1.3

1.1: *Raddush Fort in eastern Germany.*

1.2: *Raddush Fort, cordwood detail.*

1.3: *Raddush Fort, interior wall.*

original techniques. See Figures 1.1, 1.2, and 1.3. The internal cavity between the wooden walls was filled with sand, earth, and clay, whereas today we use some form of insulation. Raddush can be visited today and houses a museum, a conference room, and a restaurant. The website is www.slawenburg-raddusch.de/english/.

Chapter 2

Rationale

Why Build with Cordwood Masonry?

Since the 1980s, I have been answering this fundamental question with my "5-E" list of cordwood masonry advantages. It still holds 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 (used as insulation and/or as a cement retarder) can usually be bought quite inexpensively. Sand might even be indigenous to the building site.
2. *Energy Efficiency.* Built properly, and with a wall thickness appropriate to the local climate and building size, cordwood homes are easy to heat in the winter and keep cool during the summer.
3. *Easy to Build.* Children, grandmothers, and beavers can all build with cordwood masonry … and have done 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 built Driftwood, his own cordwood home.
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. A hollow log is not much use at the sawmill, but it can be an interesting feature in a cordwood wall.

Mortgage? Or Mortgage Freedom?

Cordwood buildings have been built for next to nothing (our Hermit's Hut guesthouse cost less than $1,000 in 2011) to many millions (the architect-designed and contractor-built 10,000-square foot Arcus Center at Kalamazoo College came in at around $5,000,000). Most cordwood homes have been built without a mortgage, including some big, beautiful energy-efficient ones like Bruce and Nancy's Ravenwood, Alan Stankevitz's two-story hexadecagon in Minnesota, as well as our own Earthwood home, and Mushwood, our lake cottage. In a recent phone conversation, Alan and I compared notes on what we knew of cordwood builders' home ownership situations. Offhand, we could not think of any with a mortgage. But why? Well, banks may be reluctant to loan money to owner-builders, especially for a building style out of the mainstream. Or, maybe cordwood builders don't need a mortgage. They own a piece of land and adopt a pay-as-they-go (or proceed-as-they-can-afford) strategy. Alan commented that cordwood makes "a superior house, costs less than most others, and is environmentally sound."

Common strategies that enable debt-free cordwood home ownership (and this is probably true with other natural building methodologies as well) are: (1) already owning the land, (2) building it yourself, (3) making use of indigenous and recycled materials, (4) paying for materials as you go, (5) keeping it small, and (6) keeping it simple. Watch out for 5 and 6, though: A small house can be hopelessly complicated — therefore expensive — whereas a large house could be of simple design, saving time and money. With regard to (3), Alan said "Once people found out I was doing cordwood, they really got into it. They wanted to help. And they'd tell me where I could get good materials for little money."

Widely Varying Costs

I hesitate to give actual cost estimates for a cordwood home. The one truth I have learned in 70 years is this: *Everybody's different.* Their abilities to save and budget are different. Their talent for "cultivating coincidences" (procuring materials) is different. Their design aspirations — for size and complexity — are different. Their access to indigenous materials is different.

The reality is that the cordwood masonry is not a very large part of the home's material cost. Foundation, roofing, stairs, heating, electric, and plumbing systems: these are all — or can be — big ticket items common to any style of home.

Two areas where a lot of money is spent, even on owner-built housing, are kitchens (cabinets, countertop, sinks, etc.) and doors and windows. But Jaki and I have always saved a tremendous amount by making our own doors, getting perfectly good thermal pane windows from the "back room" of local manufacturers, and watching for deals when people "upgrade" their kitchens — tearing out perfectly good cabinets, sinks, and countertops in the process.

Where you build makes a huge difference, too. I know of cordwood buildings in Central America — particularly Belize, Guatemala, and Nicaragua — that were built at incredibly low cost and others, in places like Massachusetts and northern California, that ran up a pretty high tab (but these people were not short of money).

Owning the land makes a huge difference. You have to have the land before you can build the house. And it enables you to start with a small practice building, maybe a "temporary shelter" that you can live in while you build the main home, saving shelter costs immediately. You can employ an add-on strategy and pay for expansion as you go. (One caution here, though: Plan for any desired add-ons at the initial design stage. Some buildings are difficult to add on to — round ones, for example.)

I learned the best part of my economic strategies — which has kept us debt-free for 44 years — from two sources: my father and Henry David Thoreau. My father said, "If a man earns $100,000 a year, but spends $110,000, he's poor. If he earns $10,000 and spends $9,000, he's rich." I never forgot that. And from Henry I learned about real — *empiric* — economy. In the first chapter of *Walden,* "Economy," we learn that the "necessaries of life" are food, fuel, shelter, and clothing. These are the things that keep our body temperatures at 98.6 degrees F, and, therefore, healthy. Of these "necessaries," shelter is the single biggest cost — up to 50 percent of expenditure in places like California. Cordwood is cheap. Like me.

I wrote a book called *Mortgage Free!,* which is full of strategies for avoiding mortgage — a word, incidentally, that derives from the Old French meaning, literally, *death pledge.* The book is out of print, but you can find used copies through Amazon, or get an ebook from Chelsea Green Publishing. I will not attempt to rehash its 300 pages here, but will give you my First Law of Empiric Economics:

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.

Shockingly, a high percentage of Americans are net *negative* savers: they are going into debt. It is rare to find someone who saves (puts away) ten percent of their income. For these people, if they find a dollar on the sidewalk — or save a buck through thrift — what is that dollar actually worth to them? Well, even for the good savers it's worth $10 that they didn't have to earn in order to save it.

In short, cordwood masonry is labor intensive but materials cheap. When you build a cordwood wall, you are simultaneously attending to many things: structure, interior finish, exterior finish, insulation, and a thermal mass not commonly found in conventional walls. With insulated stick-frame, you've got to frame it, sheathe the outside, and apply some sort of siding. On the interior, you have insulation, vapor barrier, sheetrock, taping and spackling, painting three coats … you could easily have ten different operations to complete the wall. Lay a log-end and it's done.

Ballpark Cost Estimates

The cost of the cordwood itself varies tremendously around North America, and around the planet. It is a building technique that should be employed where wood is plentiful. But, even in those areas, wood procurement costs can vary from "next to nothing" to "quite a bit." Those who have appropriate wood on their own property are very well off in this regard, but there are often other sources of free or nearly free wood. I have gone to sawmills and found wood unsuitable for cutting into lumber — too short, too small in diameter, hollow core — and carried it away in my pickup truck for next to nothing. One cedar log home builder nearby lets me "clean up the yard" once a year; I carry away all the ends and pieces too small for his purposes. It is a great advantage that short pieces — 8 to 24 inches — can be used for cordwood masonry. I have also visited wooden furniture makers for the same reason. Another source is standing deadwood, trees which have died from fire, insects, or encroaching water. After checking that the wood is still sound (i.e. no bugs or rot), strike a deal with the owner.

If you have to purchase wood, you might get it from the same loggers who supply your local sawmills. Or firewood suppliers. In our area, people want hardwood for firewood, and the suppliers know this all too well. But let them know that you are in the market for pine, spruce, fir, or quaking aspen — frowned on in the Northeast as firewood — and they may be happy to supply you with a load.

You will work in *face cords,* which are described in Chapter 5. This is a unit well-known to loggers. The cost of a purchased face cord can vary greatly in different areas, with $60 to $100 dollars per face cord being the current parameters in northern New York.

Sawdust for insulation can also vary quite a bit in price from place to place. In some areas, it has a value as bedding at farms (as it does where I live), but my sawyer still lets me fill up my small pickup truck — I use a snow shovel — for $5 a load. At that rate, insulation costs for a cordwood wall are very low indeed.

The easiest cost estimate component for a cordwood wall is probably the mortar, but, even here, the masonry sand can vary from free — if it is on site, as is the case for quite a few towns near us — to quite a bit, if it has to be delivered some distance. The sand itself is not the big cost here (just $20 a cubic yard in New York); it is usually the transport. For both Portland cement and lime, $11 a bag is a fairly average cost for North America, although it might vary up to 20 percent on either side of that number.

So, with all these variables in mind, we can make a "ballpark" chart for the cost per square foot of completed wall (Table 2.1). Remember, this includes interior finish, exterior finish, structure, and insulation. To create this chart, I used $11 per bag as the cost for both Portland and lime, $40 per cubic yard for masonry sand (delivered), and varying costs for face cords depending on the length of the log-ends (width of the wall): $40 for 8″, $60 for 12″, $80 for 16″ and $120 for 24″. Sawdust is tough to figure because the cost range is so wide, but, for our purposes here, I have used a value of $10 per cubic yard. Mortar and sawdust insulation widths are as per Figure 12.7 in Chapter 12.

These are the approximate materials costs per square foot of cordwood masonry at various wall widths, based on the materials' prices mentioned above. To use the chart, tally the total square footage of all the cordwood masonry in your design, and multiply by the total cost per square foot (the last column). For example, if your little sauna with 8-inch walls has 280 square feet of cordwood, multiply 280 times $2.53 for a materials cost of $708. A small house with 16-inch walls and 800 square feet of cordwood will cost 800 times $4.46, for a total of $3,568. If you have your own wood, the cost of the cordwood masonry can be cut almost in half. You might have your own sand. If you are using cob instead of mortar, and the materials are indigenous to the site, the lime and Portland costs are eliminated. So, the chart reflects a kind of a worst-case scenario. Use your own local dollar figures for greater accuracy, adjusting proportionally.

Table 2.1: Ballpark cost estimates

Wall Width	Lime & Portland	Masonry Sand	Wood Cost	Sawdust Insulation	Total Cost per sq. ft.
8″	$1.14	$0.35	$1.00	$0.04	$2.53
12″	1.38	0.40	1.50	0.04	3.32
16″	1.83	0.57	2.00	0.06	4.46
24″	2.75	0.82	3.00	0.08	6.65

Chapter 3

Appropriate Use

Cordwood masonry is appropriate for large and small homes and outbuildings, including guesthouses, garages, garden and storage sheds, and playhouses. Cordwood masonry makes an excellent sauna — as hundreds of builders have found. It has also been used to make specialty internal walls in homes, bars, and restaurants.

Except for Antarctica and Africa — as far as I know — cordwood masonry has been used on all of the world's continents and in a variety of climates, wet and dry. Special considerations — to be discussed — must be adhered to in wet climates, but a successful and beautiful cordwood home was built in Mountain View on Big Island, Hawaii, with its 200 inches of rain per year. The home is featured in *Cordwood Building: A Comprehensive Guide to the State of the Art.*

In all cases, care must be taken in the selection and preparation of the wood. Special considerations pertain to the various species of woods, usually a function of the wood's density, and these are discussed in Chapter 5.

Inappropriate Use

Inappropriate use would be a situation where favorable wood must be hauled a long distance to the building site. Therefore, sites in or near forested areas are more appropriate than deserts or prairies. Also, be advised that cordwood may not be the best choice for below-grade applications. We tried that in 1981, but standing rainwater on the unprotected concrete floor caused log-end swelling in the first course of cordwood. As the building (Earthwood) was round, this caused a tilting out of the curved wall as it hinged on the outer mortar joint. Although our problem was exacerbated by the deliberate use of dense hardwood log-ends for thermal mass, backfilling cordwood masonry is rife with potential waterproofing and structural problems.

Many people have built freestanding cordwood masonry walls outside — in parks and on private property — and that seems to have worked. Keep the cordwood off the ground on a concrete or stone foundation, and put some kind of cap with overhang to both sides to prevent constant water draining down the wall. Not taking these two precautions would, indeed, be "inappropriate."

Fire Resistance of Cordwood Masonry

A mostly wooden wall suggests a fire danger. In point of fact, cordwood masonry is very difficult to set on fire. Fire needs fuel, heat, and air. The fuel is there, right enough, but 40 percent of the wall, typically, is massive noncombustible mortar, which takes the heat out of any fire that starts. Once the outer quarter-inch or so of the cordwood has charred, oxygen is greatly cut off, and rapid combustion ceases. "Cordwood Jack" Henstridge had an interior fire in one of the rooms of his home in New Brunswick. The cordwood wall was charred, but the fire went out. No permanent structural damage. I imagine he either sanded the log-ends or plastered over them, I'm not sure.

In his paper "Fire Endurance Test of a Non-Load-Bearing (Cordwood) Wall," appearing in *Cordwood and the Code* (2005), Vincent Hartung reports on testing a cordwood wall for fire endurance at the University of New Brunswick in 1995. It is an illustrated 2,000-word paper and has lots of details about how the test was performed (according to standard testing procedure) that should satisfy any building code enforcement officer on cordwood's ability to resist fire spread. Incredibly, the researchers put "a single propane-powered burner of the hand-held type used to melt roofing materials" against the wall. The highest flame temperature reached was 2,100 degrees Fahrenheit (1,150 degrees Celsius) at 12 inches from the wall. Vince concludes his paper with this: "Cordwood masonry can be considered a safe material to work with with respect to fire resistance. The fire test showed that the wall is able to withstand a blast flame for over five hours. A practical fire resistance rating for the purposes of the National Building Code of Canada assembly comparison system of at least one and a half hours is recommended."

Cordwood Wall Thickness

Cordwood masonry is used for large and small houses in a variety of climates, for outbuildings such as garages, garden sheds, and saunas, and even as decorative interior walls, so wall thickness varies greatly.

Small outbuildings. Built within a stout timber frame, such as 8-by-8-inch timbers for posts and beams, an 8-inch cordwood wall works very well in any climate. Walls thinner than 8 inches make for very fussy building — I call it "cordwood needlepoint" — and any thicker is simply unnecessary. Even a sauna, typically heated to 165 degrees F or more, is a small enough building that it can be fully heated (Finns say *seasoned*) in just two hours with a woodstove, even on sub-zero winter days. You can build the walls 10 or 12 inches thick if you like, but there is little upside from a practical standpoint, and you will need 25 to 50 percent more wood and other materials. Eight inches works for a garage, too, even if it needs to occasionally be heated. A regularly heated large workspace should have thicker walls — say 12 or 16 inches, unless it is small, where, again, 8 inches is fine.

Houses. From, say, 600 square feet and up, you will want to follow energy code for your area. Indeed, you may have to. In New York, where we live, this means an R-value (insulation value) of R-19 for the walls. R-values will be discussed more thoroughly in Chapter 4, including the thermal performance of a cordwood wall and how to determine its R-value. For the moment, suffice it to say that for houses a 16-inch cordwood wall should be considered as the minimum thickness in both warm and cold climates. (Cordwood walls are effective in reducing cooling costs, too.) In Canada, cordwood walls for houses are commonly 24-inches thick, R-30+.

Small to tiny houses. 600 square feet down to …? Energy codes usually have a one-size-fits-all attitude about R-value requirements for habitations. This can get ridiculous when we get to "tiny houses," which have become the rage in the past few years. Say your desired actual living space is just 100 square feet, so just 10 feet square. If you put an R-19 cordwood wall of white cedar around this — that is, 16 inches thick — the footprint would be 12′8″ by 12′8″, or 160.5 square feet, so that a third of the foundation footprint is caught up in the walls! With a less favorable species, say maple or oak, you would need 24-inch walls, requiring a 14′ by 14′ (196 square feet) footprint, 68 percent larger than the desired living space. With even a 16-inch overhang all around — recommended for cordwood — the roof area would be 16′8″ square, or almost 278 square feet for a 100 square foot living space! Ridiculous? Well, as they would say in cordwood's heartland — Wisconsin — "You betcha!"

The reality is that it is a challenge to heat a "code"-insulated small building without *over* heating it. We can heat a small sauna to 165 degrees in two hours with 8-inch cordwood walls, just R-8, even on the coldest winter's day.

Chapter 4

Building Science Notes

Two areas of concern often come up in discussions about cordwood masonry: thermal performance and moisture management.

Thermal Performance

Thermal performance involves *heat loss* (R-value, something building codes always specify) and *thermal mass* (something given short shrift in the building codes).

The only authoritative testing on the R-value of cordwood masonry was conducted by Dr. Kris J. Dick and Luke Chaput during the winter of 2004–2005, based on thermal sensors placed within a 24-inch-thick wall at the University of Manitoba. A paper reporting on their findings appears in *Cordwood and the Code* (see Resources).

The authors' Summary/Conclusion 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), R-35 for a 24-inch (60-centimeter) wall system."

While this is a very short summary of a long and detailed paper, the paper itself provides good evidence that can be used when trying to meet state or provincial R-value codes.

Insulation values of woods vary greatly amongst species. In engineering manuals, R-values for woods are generally given through side grain — as in the left-hand column of Table 4.1 — which might be appropriate for a horizontal log cabin, but they are less useful with cordwood. Some cordwood builders use these R-values for their wall calculations, but the reality is that heat transfers more readily through end grain than side grain, so an adjustment must be made. Some have suggested that end grain R-values are only 40 percent of side grain values, but I think this is unduly pessimistic. The consensus of research that I have been able to find suggests that if we use a value of two-thirds (66.7 percent) for the end grain, we will be much closer to the truth than using side grain values or the pessimistic 40 percent figure. Table 4.1 reflects side grain R-values in the left column and "closer-to-reality" values in the right-hand column for a representative sample of woods. Not surprisingly, the lighter, airier woods have better insulation value than the denser species.

Let's do a quick R-value calculation for a cordwood wall that is 50 percent wood and 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

Table 4.1: Comparative R-values for some representative woods

Wood Species	R/inch on Side Grain	R/inch on End Grain
White cedar	1.50	1.00
White pine, Aspen	1.32	.88
Basswood (Linden)	1.24	.83
Hemlock	1.16	.77
Douglas fir	1.06	.70
Red pine, Red cedar	1.04	.70
Southern yellow pine	.90	.60
Oak, Maple	.78	.52

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 it's 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).

New York code requires R-19. Our walls meet this requirement, and the house is very easy to heat in our area of almost 9,000 degree days, the same as Montreal. However, there is an added thermal benefit from our cordwood walls, not credited by the codebook. Due to the placement of a large thermal mass — the mortar — on each side of the insulated space, Earthwood's temperature stays steady. Even with no heat source, we can go away for a few weeks in the winter and the house does not freeze. Similarly, we do not require air conditioning in the summer. The massive walls act as a capacitor, and temperatures change very slowly. (It must be said, though, that 40 percent of our walls are earth-sheltered, which contributes to this benefit as well.)

Moisture Management

Moisture movement in or through a cordwood wall is a very close relative to air infiltration through the log-ends. When the wood shrinks, two kinds of infiltration can occur: through checking (shrinkage tangent to the edge of the log) and around the log-ends themselves (radial shrinking). Proper drying of the log-ends prior to building will greatly reduce this infiltration, but not eliminate it. And even with properly dried wood, infiltration through tiny gaps can double after a year or two, making the house more difficult to heat. A former student of mine from downstate New York built her cordwood home nearly 20 years ago. She used unsplit rounds for her log-ends, and they shrunk a good deal. After a year or two, she applied Log Jam chinking material (see Chapter 10) to the entire inner mortar joint of the home. She was meticulous, injecting the Log Jam into primary and even *small secondary* checks (checks are shrinkage cracks that extend all the way through the log-end). Peripheral shrinkage gaps were completely closed, of course. Upon completion, she found out that this chinking application — on the inside only — reduced her heating costs from $220 a month to $75 a month. Wow!

Jaki and I once visited a cordwood home with 16-inch cordwood walls in southern Wisconsin. If a strong west wind drove rain into the west wall of the home, moisture would sometimes make its way through the wall to the interior. But cordwood breathes wonderfully on end grain, and the wall would soon dry out again. We have seen a similar effect once or twice in extreme conditions on the west side of our Earthwood home, but, again, the wall soon dries out. What effect does this driven moisture have on the lime-treated sawdust insulated space? One time, bad flashing detailing on the small downstairs sunroom/greenhouse caused water to run down the cordwood wall. The log-ends were discolored but did not deteriorate. Some mortar cracking occurred. I decided to replace the wall as a workshop project, and found out that the sawdust had set up with the lime, then dried out, so that, now, instead of a loose-fill type of insulation, we had something more akin to a rigid bead board. But dry.

Another time, we removed a small section of cordwood wall to turn a window space into a door to the new upstairs solar room. The wall had never gotten wet, and the sawdust was the same light and fluffy insulation that it was when we had installed it 20 years earlier. I credit the natural breathability along the end grain of log-ends for the lack of moisture problems in the wall. In fact, cordwood walls seem to draw excess moisture *out* of the house. We maintain a pleasant relative humidity of 40 percent. In the sauna, when we throw water on the basalt stones on top of the woodstove, it turns instantly into steam, and it hits the bather almost like a physical slap. It's like a steam room for a couple of minutes. But, five minutes later, the stove room's atmosphere is back down to a very dry condition. We'll do this two or three times during a bath. There has been no deterioration in the cordwood masonry after 35 years of use.

With double-wall cordwood masonry, a vapor barrier is usually installed on the interior of the insulated space, following standard building practice. See Chapter 6.

Finally, Peter Robey and Blythe Tait built a large hexadecagon home in Tasmania. They plastered the interior — they call it "rendering" — and are pleased with the results. The rendering closed off air leaks. How they did it is told in Chapter 9.