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A Turning of the Soil

Building an Earth House by Hand

By Ellen Rowland

Our adventure in earth construction began ten years ago in the aisle of a bookstore in New York City. My husband and I had just returned from a trip to Park City, Utah, where we visited a recently completed straw bale home. We were so taken with both the use of natural materials and the interior aesthetics that could be achieved that we decided to research alternative building methods. A designer and builder passionate about architecture, my husband had worked on several sustainable residential projects and had come away with the impression that sustainable building required finances we didn't have. We were, at that time, green novices, doing our part in preserving the planet by making sure our recyclables were sorted, walking to work, and avoiding plastic whenever possible. But we were living, working, and (as I like to say) "renting" a hectic life in one of the fastest-paced cities in the world, dreaming all the while of building our own home. It was clear that our lifestyle, habits, and finances were not in line with our objectives. We needed a drastic change.

Then my husband spotted a book on the work of the late Egyptian architect Hassan Fathy, whose revival of mud-brick building techniques and use of local materials not only helped shape communal architecture in third world countries but continues to influence the use of earth as a modern building material in the developed world. According to Fathy, building with earth was both environmentally and socially responsible and attainable for all.

Pouring over the pages of earth walls, vaulted ceilings, pierced decorative details, and air chimneys – all constructed with dirt and water – we knew the seed had been planted. The results were not only beautiful, but they spoke to our goal of living responsibly within our budget. More books on earth building began to find their way onto our nightstands, and preliminary sketches of house plans, drawn in the margins of newspapers and on the backs of grocery receipts, were carefully filed into a folder we called "A Turning of the Soil," symbolizing both our dream of building an earth house and our desire to start a more conscientious, purposeful life.

As often happens with important life projects, momentum took over. My husband, a French native, had visited Senegal, West Africa many times and had always felt drawn to the people and place. We had purchased land there some years before as a place to build a retirement house. When the financial crisis hit the United States in 2008, we made an instinctive decision to step up our plans and move to Africa with our two small children, build our earth house, and realize a simple life closely connected to Nature. Two and a half years later, through lots of trial and error, we now live in a 2,500 square foot home built with earth excavated from our property (the hole now a lap pool) and powered by wind and sun. The walls of our house were built using the earth under our feet, water from our well, a few pieces of plywood and iron, and eighteen pairs of hands, including our own. Our children, then three and four, learned to make earth bricks by throwing mud into wood frames and watching the sun turn them into usable bricks, which they then helped lay.

We combined two types of construction: rammed earth for the two-foot thick walls, and earth bricks for the arched windows and doorways. Both of these methods allow for relatively quick construction and no "baking" time, as is necessary with adobe or cob construction, where the materials are cured. Rammed earth or "pise de terre" is the successive layering of a prepared earth mixture into wooden formwork. Each layer is approximately fifteen centimeters (six inches) deep and is manually compacted with a large wooden (or pneumatic) ram to approximately fifty percent of its original thickness, allowing for minimal micro-fissures that may trap moisture. Because the compacted earth is immediately self-supporting, as sections of walls are completed the frames can be moved vertically or horizontally to either dove-tail or butt against a new section.

While the water content for rammed earth is typically low, mud bricks require a more humid mixture, which is poured into wooden frames and left to dry for one day in the sun, then laid horizontally following the curve of a metal frame and mortared with additional mud. We constructed two iron frames of different sizes, one for all the half-moon windows and one for the curved doors. To complete the walls of the main living area (two bedrooms, a living room, kitchen, bath, and separate classroom) took us six months, using only manual labor. Apart from a bulldozer to excavate the original quantity of earth needed to build the house, no machinery was used on the project.

Because Senegal has a tropical climate with significant rainfall, we needed to protect the walls we worked so hard to build. During the dry season, the sun continues to cure the earth walls, with optimal stabilization occurring after three years of exposure. In the interim, they need special attention. Although earth buildings are never completely waterproof, they can be made water-resistant by adding a natural polymer mixed with earth as a final layer. We experimented with many different formulas, including natural soap, shea butter, vegetable oil, even okra and rice starch, which contain a natural glue-like substance. Our kids participated in our laboratory; a section of the back exterior wall which shows the trials of all our formulas. After each square foot application had dried, we would throw buckets of water on the wall and watch for the reaction. Although okra and shea butter proved equally effective, we didn't have the quantity necessary to cover the entire surface. In the end, vegetable oil created the most consistent, available barrier and two coats were painted on all the exterior walls. The experiment section now

The author's children were an integral part of the process of building the family's earth house. Here, at ages three and four, they help make the bricks that will be used for doorways and arches.

looks like a patchwork quilt, just another aspect of our hand-made house.

Next came the roof and with it, a lesson learned. The original was made of earth and employed Nubian vaults, which are constructed without frames. Earth bricks are laid following the arc of a suspended metal chain, a technique revived by Fathy in the 1940s.

Several days after the roof was completed, which happened to coincide with the onset of the rainy season, we returned to the United States to visit with family and arrange transport of our belongings. When we returned to Senegal six weeks later to move into our house, sections of the walls and roof had been severely damaged by the rain. The tarps we had secured in place to protect the newly constructed roof had blown away, exposing the earth to the elements. We learned that we were in the midst of one of the worst rainy seasons in fifteen years. So it was back to the drawing board in a rented hotel room.

French masons used to say that any house built with earth needed sturdy boots and a good hat to weather the storm. After much additional research and consideration, we decided to tear down what remained of the existing vaulted roof and replace it with a flat cement roof which would leave no room for uncertainty. The considerable overhang (two feet) would not only reduce rain flow to the walls but allow us to collect rainwater in reserve for the dry season. It was a difficult decision to make as our purist tendencies gave way to reason. As an environmental offset for the cement roof, this year we will be planting an organic roof garden, using the available space to provide food for our family while at the same time creating a micro-climate to cool the rooftop. During our research, we learned that due to the mass of the walls, they can support multiple floors, leaving open the possibility to build additional rooms in the future.

Earth walls provide natural insulation, adjusting to heat, humidity, wind, and rain. They regulate the interior temperature by absorbing excess moisture in the air and releasing it when the air is too dry. As our walls are two feet thick, they keep the interior of the house very cool. Conversely, the density, thickness, and thermal conductivity of rammed earth make it a particularly suitable material for passive heat in cooler climates. We added natural terra cotta tile floors, which also help keep the rooms cool. To augment air circulation, each room was constructed with a light well, which also serves as an air chimney. Modernizing an ancient technique, we installed large square openings in the ceiling covered by a UV filtering piece of glass that can be completely closed (for when it rains) or opened to varying degrees for ventilation. The openings are placed strategically to maximize the effect of dominant winds, acting as a vacuum, carrying heat up and out.

Because we wanted our project to be completely off the grid, we built our own wind turbine, installed solar panels, dug a well, and use a dry toilet system. Our house is still an ongoing project, as is our effort to train local masons in earth techniques. But the

space we built together has connected us to Nature, each other, our community, and the principles of living responsibly for ourselves and the environment – all within a modern earth structure.

A Universal Style of Building

Although our experience is specific to the terrain, climate, and people of Senegal, earth buildings – both residential and commercial – exist in various forms on six continents in environments ranging from temperate and wet regions to mountain and desert areas, as well as the tropics. Earth is the oldest known building material, with the earliest examples dating back over nine thousand years. It is estimated that approximately thirty percent of the world's population live in homes made of earth. While that percentage increases in third world countries due to the scarcity and high cost of industrialized materials, there are earth building standards in China, Peru, Turkey, New Zealand, and Australia. Earth is currently being revived as a building material in Europe and North America due to the increasing awareness of its environmental, health, and often financial benefits. Old and new examples exist in the UK, France, Germany, Spain, the southwest United States, and Canada.

The availability of useful soil and an appropriate design based on local climate are important factors when considering an earth house. Although some subsoils may be more suitable than others, most are appropriate for earth construction and can be ameliorated naturally with lime. A wider range of soils can be used when altered with small amounts of cement, a material called "stabilized rammed earth," however there is debate about its long-term usefulness. When cement is used in the earth mixture, sustainable benefits such as low embodied energy and humidity control are sacrificed.

Ideal subsoil is composed of four elements: course sand, fine sand, silt, and clay, although one or more of these may be reduced or lacking and still work. If all four are present, these elements contribute to strength, low moisture absorption, limited shrinkage, and high resistance to erosion. Although laboratory tests can be done, anyone can perform a simple field test using a glass jar and water. A handful of the proposed soil is placed in the jar and covered with water, then shaken and left to settle overnight until clear. Four distinct layers should form showing the composition of the soil with clay as the topmost layer. Another simple method to evaluate soil quality is to dampen a handful, roll it into a rope, and let it dry. Plasticity and ideal clay content will produce a rope with few to no cracks. ▷

This beautiful home combines rammed earth for the two-foot thick walls and earth bricks for the arched windows and doorways. Both of these methods allow for relatively quick construction and no "baking" time, as is necessary with adobe or cob construction where the materials must be cured.

Advantages

There are many benefits associated with earth construction, most of which are not only good for the environment but have general health advantages as well.

Low Carbon Emissions: Rammed earth structures use natural, locally available materials and do not require machinery for construction. In addition, energy consumption for transportation of materials (if needed) is minimal, creating a significant reduction in CO_2 emissions. It is estimated that almost ten percent of global CO_2 emission comes from cement production.

Thermal Mass: Due to the high thermal mass of earth walls, energy required for cooling and heating is reduced or eliminated, further reducing CO_2 emissions. High thermal mass also allows for optimal acoustics and comfort. These benefits can also result in substantial financial savings over time.

Improved Air Quality: Earth walls contain no toxic or factory produced materials such as fungicides or pesticides because they are impenetrable to insects. This improves general air quality, particularly for children and asthma sufferers.

Local Materials: Since earth can be dug on site, transport costs and pollution are reduced. Earth also helps address the ecological impact of deforestation by using little to no wood.

Durability and Strength: Load bearing walls can handle multiple floors and have proven to be durable over long periods of time. Buildings that are hundreds of years old have been restored or maintained with little resources.

Creativity: While there are rules relating to wall depth and height in earth construction, the process can be very creative, allowing for different textures and details, for niches created during or after construction, or objects embedded in the earth.

Recyclable: Earth walls blend in with the natural environment and can be re-used on future projects or eventually broken back down to their original state.

Considerations

There are also considerations and responsibilities associated with earth building.

Labor Intensive: Although the materials used in building an earth house are inexpensive relative to cement and brick homes, the process is labor intensive and may require additional labor costs, equalizing the savings ratio. Additionally, although awareness and training of earth techniques are on the rise, it may be difficult to find trained masons in the area you wish to build.

Maintenance: Earth buildings require protection and maintenance against the elements to varying degrees depending on the local climate. While these materials are not costly, they do require time and effort.

Building Codes, Lending, Insurance: These vary widely

Earth construction has many advantages, including low carbon emissions, thermal mass, good air quality, recyclability, durability, and strength. It also uses local materials and allows for a very creative design.

according to country and even region. In the southwest United States (primarily New Mexico and Arizona) and Australia, where earth building is prolific, standards exist for lending and insurance, and building codes specific to earth construction are already in place. However, there is very little precedent for lending and insurance in most of Europe and North America.

As individuals, communities, and governments become increasingly aware of the benefits of alternative building methods, we should start to see financial institutions and insurance companies enacting protocol specific to earth construction. In the meantime, if you are considering building with earth techniques, there is a wealth of information available on websites and in print which may prove valuable for overcoming the current barriers to building with earth and provide general education about the significant advantages.

Ellen Rowland is an American living in Senegal, W. Africa in an off-the-grid earth house she helped build with her husband and two young children. She is a writer of sustainable issues, fiction, humor, and poetry and is currently working on a book about her experiences in sustainable family living. A lover of all things edible and a passionate cook, she is also working with several women in her village to produce a cookbook of local flavors and culinary customs. **- NL -**

Learn More

An Architecture for People: The Complete Works of Hassan Fathy by James Steele (Watson-Guptill, 1997)

Building with Earth: Design and Technology of a Sustainable Architecture by Gernot Minke (Birkhäuser Architecture; 2nd, rev. ed. edition, 2009)

Adobe and Rammed Earth Buildings: Design and Construction by Paul Graham McHenry, Jr. (U. of Arizona Press, 1989)

The Rammed Earth House: Revised Edition by David Easton (Chelsea Green Publishing, 2007)

Earth Architecture by Ronald Rael (Princeton Architectural Press, 2010) - www.eartharchitecture.org

www.uni-terra.org
World-wide listing of institutions and associations involved in earth architecture, building and education

North America Rammed Earth Builders Association
www.nareba.org

Earth Building UK
www.ebuk.uk.com

Earth Building Association of Australia
www.ebaa.asn.au

Earth Building Association of New Zealand
www.earthbuilding.org.nz