Chapter 8. Breathable Envelope Materials

8.1 Introduction

Prior to the Industrial Age, traditional building methods utilized natural materials close to the construction site. Homes were crafted by the owner or by local craftsmen. There was no mass production, indeed there was hardly a building industry. Steve Servais, historian and principal of Pragmatic Construction in Milwaukee, observed that "As shelter is a basic component of survival, one could say that home construction is as old as humanity itself. Often using locally available resources, humans around the globe devised perhaps thousands of unique ways of achieving the same end—providing a barrier between themselves and the outside world of rain, wind, sun, and often enemies. From thatched mud huts to stone villas, a home often reflected the culture of its society, the environment in which it stood, and even the individual personality of its builder."[118]

To satisfy the building biological criteria set forth in chapter 6, our building materials must be permeable, hygroscopic, and have the desired degree of capillarity. We call these characteristics breathability. Moreover the materials should ideally have a high thermal mass and be progressively more insulating towards the outside of the wall, providing what we call "out"sulation. Clearly the structure should be strong and stable enough to bear weight indefinitely. Lastly we prefer walls constructed from primarily natural materials, as they alone provide the full range of desired properties as well as health-promoting subtle energies, without outgassing

Arguably in an ideal world every dwelling would be meticulously hand-crafted with locally available natural materials that satisfy our criteria, with little regard for the cost of labor. In recent years, beginning in the 1960's and 1970's with the back-to-nature movement, there has been a revival of these time-honored building techniques. But what was taken for granted is now considered as "alternative." Therefore these methods tend to be used by mavericks, artisans, and free spirits who build a very small number of homes. Doing it the old-fashioned way may be highly satisfying to builder and owner. Unfortunately the labor-intensive methods and the absence of standardized materials mean that a conventional modern contractor finds it difficult if not impossible to economically build using these age-old techniques. This is changing, however, as more and more builders jump on the "green" and sustainable band wagon, seeking materials to stay competitive in the marketplace, which itself is going green. As you will see, there are several manufacturers who use traditional materials to produce modern building products that satisfy our criteria for health, sustainability and thermal performance.

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118 Steve Servais' essay, "A Few Thoughts on the History of Home Construction," was posted on his company's website: http://pragmaticconstruction.com/History.pdf (last accessed November 2007; broken link when checked in April 2008).

With the caveat that there are dozens of books on "natural building" methods whose wisdom we will not try to reproduce or augment, we start this chapter by briefly describing just a few traditional construction materials and techniques, such as earth, straw and clay. We include them because these traditions fulfill all the requirements for a home compatible with Building Biology®. With a lot of effort and determination, a small number of specialists in the industry may find a niche by using these traditional materials. More significant, we think, for the majority of builders and people considering building, is the fact that some of the raw materials have been integrated into the modern composite materials described later in this chapter. Moreover a few entrepreneurs are always working to develop more "practical" technologies based on traditional materials. Therefore we organized this materials-based chapter such that the detailed section on each composite material is preceded by briefer sections on its component raw materials. To some extent we have also taken chronology into consideration in determining when to discuss each material.

For at least 9,000 years *earth* has been used for construction by humans, and it remains one of the most popular building materials in the developing world. Some of the variations are wattle-and-daub, rammed earth, compressed earth blocks, adobe, and cob. Recently, earth-based technologies that can be mechanized and potentially practiced on a wider scale have been developed. *Clay*, a variable fraction but sometimes major component of earth, is a remarkable, finely divided substance that has earned its place as a valuable material with numerous physical and healing properties. Clay is the essential binding ingredient in any earthen building system and is an ingredient in modern composite building materials.

Straw was initially used as in a bird's nest to reinforce earth, improve workability and prevent it from cracking. Much more recently, bales of straw have been stacked to make massive walls. Later in the chapter we will describe advanced building materials made from other plant-based products such as hemp hurds.

Straw-clay construction is a post-World War II improvement on wattle and daub which takes advantage of the insulating properties of straw.

The lion's share of this chapter is devoted to more widely economical methods of construction that are still based upon time-tested traditional building materials, but are made by companies that use modern manufacturing techniques and have a proven track record in the field, backed by industry-accepted structural testing and code approval. We offer them here in the hope that those readers in the building industry will join their colleagues who already use them in this and other countries and will fully embrace them over time. The methods used to build with these materials will be expanded upon later, beginning in chapter 9.

Wood is the first of our recommended materials to be covered and represents a transition from old to practical. Of course log homes were popularized by the American pioneers but they have been around for at least two thousand years. In the last 40 years an industry has risen to manufacture these structures. An alternative but time-tested method is timber frame construction, in which large timbers are used as the major structural support in a post-and-beam configuration. A lesser-known method called cordwood construction is used by some adventurous do-it-yourselfers. Wood chip is also a key component of fiber-cement composites and of "wood wool" panels popular in Europe.

Cement in the form of concrete is a significant component of most modern buildings, primarily as a slab and foundation material. In the middle of the 1800's Portland cement took over from traditional, magnesium oxide and lime-based cementitious materials. Unlike these traditional cements, Portland cement is *not* a breathable material so the reader will immediately wonder why it belongs in a chapter on breathable envelope materials. For a number of reasons we feel that its inclusion is merited, despite some significant health and global environmental concerns. Portland cement provides the structural skeleton of some breathable composite materials. Portland cement also imparts an alkaline environment to the wall form, disallowing mold to grow. The health concerns pertaining to the use of Portland cement are mitigated by combining it with the right materials. Furthermore, in order to be fully load-bearing, some breathable wall form systems do require structural reinforcement with concrete and rebar.

Autoclaved aerated concrete is a less energy-intensive and breathable Portland cement-based material that has been available for seventy-five years. AAC is made by a unique process that incorporates air bubbles, air being the best insulator, such that the product has a density of only about twenty percent that of ordinary concrete.

Low-density fiber-cement wall form, based on mineralized wood chips and Portland cement, has a proven track record of over half a century and is one of our preferred wall systems. The mineral coating on the wood chips consists of either clay or a ceramic material that neutralizes the sugars naturally present in wood that would otherwise render it incompatible with Portland cement. Generally the stacked wall forms are filled with Portland cement and rebar, allowing buildings to be many stories high.

Traditional or "alternative" cements, in most cases formulated with magnesium oxide and chloride or phosphate-containing minerals, are seeing a renaissance which we fully endorse, for these materials solve the many problems associated with Portland cement. Magnesium oxide, as we will see, was the world's first cement, and it has seen an explosive revival in recent decades, particularly in Southeast Asia. It is now receiving attention in North America. This chapter describes an impressive array of related building products.

For example, two entrepreneurs in Iowa have revived a formula based on magnesium oxychloride, hemp and rice hulls to create a solid building envelope based upon techniques used for over 600 years in France. Their low-density fiber-cement product is a solid block containing no hollow core and no Portland cement.

Magnesia-based sheeting products have recently become available in North America, following the lead of the Chinese building industry, where over 900 factories now make building boards for domestic use and for export. Plans are underway to have these products made in the U.S. and Mexico for the North American market. In thick-wall construction these products are suitable for floors, walls and ceilings. For homeowners and builders not prepared to use cement-bonded wall forms or AAC to construct massive envelopes, using these sheets to replace drywall and plywood or OSB sheathing makes possible and affordable a breathable, mold-resistant wood-frame structure.

Lastly, we will take a brief look at some well-established breathable building technologies that are only available in Europe or other countries. We are hopeful that these will become available soon in North America.

In fact, many of the materials and methods recommended in this chapter are already in wide use in Europe, where occupants enjoy a significantly higher level of health and comfort than their North American counterparts. We in this country are often trapped in unhealthy and uncomfortable building envelopes, particularly since the widespread introduction of plastic vapor retarders after the oil embargo in 1973.