Materials Profile: EARTH

the NATURAL BUILDERS

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Quick facts...

- Used in traditional building for thousands of years
- Comprised of clay, aggregate, fiber and water
- Can be load-bearing or non-load-bearing
- Thermal properties depend on the mix
- Utilizes locally available materials
- Variety of methods include cob, adobe, rammed earth, CEB, wattle and daub, and straw light-clay

Photo: Wattle and daub home in rural Haiti

Earth in Natural Buildings
Earth has been an important traditional material throughout the Americas, Africa, Europe and parts of Asia for thousands of years, and is used in a great variety of ways. Recently, the alternative building movement has developed a deeper technical understanding of the materials and their traditional applications, resulting in safer and stronger earthen building, sometimes by incorporating a judicious use of modern industrial materials and sometimes through improved design.

Earth Materials
There are four basic materials in earth construction: clay, aggregate, fiber and water. Changing the ratio of these materials in the composite mix will fundamentally change its characteristics. Therefore, earthen materials with different ratios serve different roles within a building according to the strengths or weaknesses of the mix.

Clay refers to a sediment with some clay content in it. Clay functions as the binding agent in earthen materials, much as cement does in concrete. Additional binders, such as flour paste, egg whites, nopale can also be added.

Aggregate is any stone, gravel, pebble, or sand component. In certain applications recycled concrete aggregate may also be used. Aggregate provides compressive strength in load-bearing applications, speeds drying, and reduces cracking and shrinking of the composite material. Aggregate and clay in an earthen material provide thermal mass.

Fiber provides tensile strength, as rebar does in concrete. Straw, dried grasses, manure, animal hair, metal or plastic mesh, burlap, paper pulp, bamboo, lath, wattle, and a host of other fibrous materials can be used. The amount of fiber also determines an earthen material's insulating properties.

Water chemically bonds with clay to become the binding agent. The ratio of water in an earthen mix will affect variables such as workability, drying time, and shrinkage.

Other Additives:
Stabilizers reduce or eliminate the expansion and contraction of earthen mixes on wetting and drying. The effectiveness of both industrial and natural stabilizers varies, and often depends on local skills.
Fillers make composite

materials lighter and add insulation value. Proportions must be controlled to maintain overall integrity. Common fillers include perlite, wood chips, rice hulls, paper pulp, and volcanic rock.

Major Types of Earthen Building

Typically a load-bearing earthen composite is high in thermal mass due to high ratios of sand and clay and low in insulation. A non-load-bearing or infill composite is generally low in thermal mass and either high in insulation or very thin and light-weight with negligible insulation value. Another important consideration is whether it can be pre-fabricated or if it is created in-place. Pre-fabricated earthen building materials, such as adobe blocks or straw-clay panels, allow labor to be invested over time and mate-rials to be stockpiled until construction is ready to begin. In-place building methods, such as cob or rammed earth, demand that all materials and labor be invested at the time of construction.

Cob

Thick, load-bearing walls are formed in place with the wet material such that there are neither horizontal nor vertical joints, creating a very stable, monolithic wall. A generous amount of long fiber provides tensile strength within the mixture itself so that additional reinforcing material, such as rebar, is unnecessary.

Rammed Earth

An earthen mix similar to cob is "rammed" or compacted into forms commonly built with plywood and lumber, creating a monolithic wall. Ramming can be done by hand or with machinery. Cement may be added as a stabilizer.

Adobe

Sun-dried blocks or bricks made of clay and sand, possibly reinforced with fiber, can be shaped by hand, with wood or metal molds, or by machines. Adobes are laid in mortared courses as baked bricks are, and can be used in both load-bearing and infill applications. As with other forms of masonry, adobe construction should be reinforced for improved multi-hazard resistance.

Compressed Earth Blocks

A machine, usually based on the Cinvas Ram, compresses a moist mixture of clay, aggregate, and often a stabilizer, such as cement into a block mold. This produces uniform blocks that have high compressive strength. Some brick forms allow space within the block for containment of vertical and horizontal reinforcing.

Straw Light-Clay

A high-fiber mix is either pressed into place within a framed wall, or compressed in molds to make light-weight, insulating, non-lead-bearing blocks or wall panels. This method of building can also incorporate wood chips, sawdust, pumice or perlite as a substitute for fiber.

Wattle and Daub

An earthen mixture similar to cob (daub) is applied to a woven lattice (wattle) of branches or similar material to create thin, often interior, non-load bearing walls or to infill exterior walls.

Additional Resources on Earthen Building

International Earth Building Standard (http://www.astm.org/):
• ASTM E2392 - 05 Standard Guide for Design of Earthen Wall Building Systems

New Zealand Earth Building Standards (http://www.standards.co.nz/default.htm):
• NZS 4297:1998 Engineering Design of Earth Buildings
• NZS 4298:1998 Materials & Workmanship for Earth Buildings
• NZS 4299:1998 Earth Buildings not Requiring specific Designs

2006 New Mexico Earthen Building Materials Code 14.7.4 NMAC (http://www.nmcpr.state.nm.us/nmac/parts/title14/14.007.0004.htm):

"The selection of soils for unstabilised earth building: A normative review," M. Carmen Jiménez Delgado, Ignacio Cañas Guerrero, Departamento de Construcció n y Vías Rurales, Escuela Técnica Superior de Ingenieros Agrónomos, Universidad Politécnica de Madrid, Madrid Spain, 2005, Science Direct (www.sciencedirect.com) Construction and Building Materials 21 (2007) 237–251

Building with Earth: Design and Technology of a Sustainable Architecture, Gernot Minke

Papers available at through the Ecological Building Network (www.ecobuildnetwork.org):

"Development of Alternate Building Materials for the EpiCenter Pilot Project: Cast Earth and Fly Ash Concrete", by Jerry Stephens, Doug Cross, Michael Frerking, Matt Ander

"Burlap Reinforcement for Improved Toughness of Low-Cost Adobe Residential Structures" by Nancy Ho, Patrik Meyer, Margaret Myers, Nakul Sathaye, Mark Wan

"Pisé -- a New Earthen Construction Technology" by David Easton

"Earthen Architecture: Materials, techniques and knowledge at the service of new architec-tural applications" by Hubert Guillaud and Hugo Houben