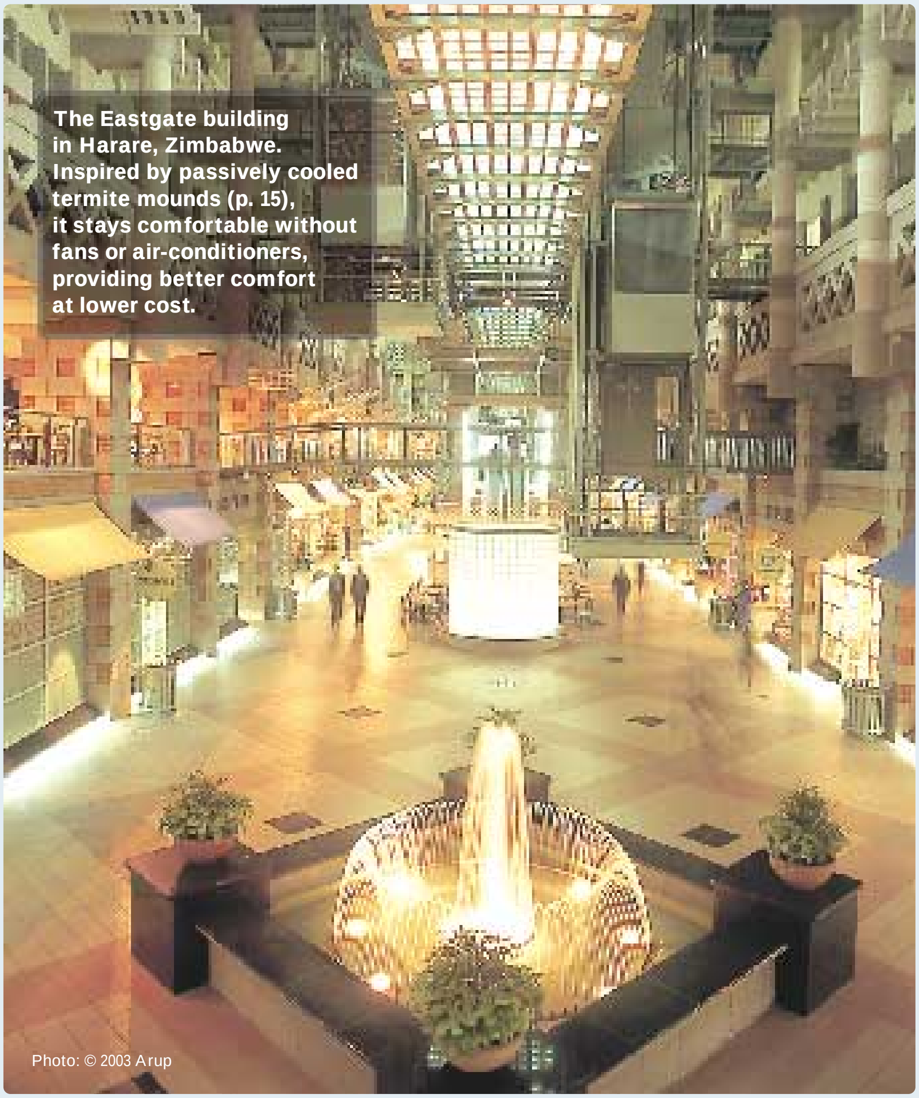
An Introduction to Green Building

Part 2: Environmental Sensitivity with Building Materials

By Alexis Karolides, AIA

Like most animal species, humans have long crafted their environments with collected, nontoxic, easily manufactured, and naturally recycling materials. Then along came the Industrial Revolution, and suddenly we began using the most intense energy source yet known: the plants and animals buried beneath the earth's surface as fossil fuels. We learned to manufacture useful materials, like steel and plastic, and we could transport them around the world. The seemingly endless supply of fossil fuels and the environment's ability to absorb the toxic byproducts of burning them seemed to ignore the simple, evolutionary rules followed by all other animal species: local supply, low energy, non-toxicity, recyclability. And this ignorance is a problem.

First, a stored resource is like a savings account, and the United States' account of fossil fuel reserves—once seemingly endless—is dwindling. Second, the earth's ability to assimilate the toxic and slow-to-degrade byproducts of human manufacturing is no longer guaranteed—all of the earth's major life support systems are either stressed or in decline. Finally, our own products are making us sick—they are made with chemicals that our bodies cannot process. Worse, we have made our buildings nearly airtight, and we are spending 90 percent of our time indoors. So how do we pick the right products to make our buildings more environmentally sensitive?



The Eastgate building in Harare, Zimbabwe. Inspired by passively cooled termite mounds (p. 15), it stays comfortable without fans or air-conditioners, providing better comfort at lower cost.

Photo: © 2003 Arup

We can start by specifying materials that don't release large quantities of volatile organic compounds (VOCs) or contain other harmful substances. Instead, specify low-VOC paints, adhesives, and millwork, as well as low-mercury lamps. Minimize porous surfaces upon which mold might thrive (for example, if tile is used, seal the grout), and carefully detail building assemblies to avoid condensation. Finally, if possible, eliminate finish materials, such as ceiling tile or carpet, altogether.

If carpet is to be used, modular carpeting (carpet tile) is recommended because only tiles in the wear pattern need frequent replacement. Recyclable carpet further enhances waste reduction and raw materials savings.

Purchasing local products reduces transportation and its associated energy consumption and pollution, supports the local economy and culture, and maintains regional identity by promoting the use of indigenous and traditional materials.

A more technical way of evaluating a material is to consider its embodied energy—the energy required to produce it. Estimated embodied energy of some common materials is listed in the box on the next page.

The high embodied energy in plastic and aluminum means these products are especially important to recycle—recycling saves most of the energy in certain plastics and 95 percent of the energy in aluminum. Life-cycle assessment, a very involved process, takes a much larger perspective on the comparative impact of material use. It considers a material's embodied energy as well as its durability, efficiency, reusability/recyclability, and overall environmental impact (in both its extraction and its use). Although there is not enough space here to go into great detail about various materials, I'll outline some important considerations.

Troubles With Concrete

The manufacturing of cement, the binding agent used in concrete, accounts for approximately 0.6 percent of total U.S. energy use, and is a major source of greenhouse gases. The energy to make cement comes from coal-fired power plants, and the cement manufacturing process also releases CO_2. Indeed, for every ton of cement manufactured, 1.25 tons of CO_2 are released into the atmosphere. World-wide, cement production accounts for over eight percent of human CO_2 emissions. Also, concrete can cause water pollution if washout water from equipment at concrete plants finds its way to local waterways. The pH of washout water is high, and thus toxic to aquatic life. Fortunately, up to 70 percent of the cement used in traditional concrete can be replaced with fly ash, a waste product from power plants. Replacing a high percentage of the cement with fly ash reduces energy consumption, reduces solid waste, and makes the concrete stronger. Because power plants are common in most cities, the fly ash can usually be obtained locally.

Estimated Embodied Energy of Common Building Materials (in MJ/kg)

baled straw =	0.2
kiln-dried hardwood =	2.0
cement =	7.8
float glass =	15.9
fiberglass =	30.3
virgin steel =	32.0
recycled steel =	10.1
expanded polystyrene plastic (EPS) =	117.0
virgin aluminum =	191.0
recycled aluminum =	8.1

Source: www.physics.otago.ac.nz/eman/403downloads/AS4_EmbodiedEnergy Coeffs.pdf.

Green Building Blocks

In general, masonry (brick, block, and stone) has very little embodied energy. It can usually be obtained locally, and masonry is resistant to deterioration from moisture and insects. It is also well-suited for warm climates where less insulation is required. Adobe is an especially environmentally friendly masonry product, using less than one-sixth the production energy of concrete block.

Metals

Metals are strong, durable, and generally don't cause indoor air quality problems (airborne dust from lead paint is a notable exception). However, there's no clear answer to the debate over which is the "greener" framing material—steel or wood. While wood is a renewable resource, steel is highly recyclable and its raw materials are plentiful. Clear-cutting forests has caused habitat destruction and siltation of streams (and pesticide-laden, monoculture plantation forests are not much of an improvement). Strip mining for the iron and limestone used in steel

RMI *in the news*

Sustainable Settlements Work Grows Global Roots

Rocky Mountain Institute's 2001–2 work on sustainable settlements is getting wide distribution. Several organizations have taken information from the two refugee camp charrettes and are sharing it with the world.

CareBridge.org, a website devoted to helping displaced people live healthier, better lives in environmentally sustainable ways, was created during the summer of 2002 by RMI friends **Eric Rasmussen**, MD, FCAP, former surgeon for the U.S. Navy's Third Fleet, and **Barrett Brown** of the Boulder, Colo.-based Sustainable Village. CareBridge has also reprinted an RMI article (by Staff Editor Cameron Burns) about our February 2002 charrette in Santa Barbara. (See **www.carebridge.info/community/charrette2.jsp**.)

The same article will appear in the soon-to-be-released book *Building Without Borders: Sustainable Construction in Cross-cultural Contexts*, edited by Joe Kennedy and published by New Society Publishers. Kennedy is the Director of **Builders Without Borders**, a California-based non-profit organization. The same article is also to be used on **Design for the World's** website (**www.designfortheworld.org**). The Barcelona-based Design for the World "works in partnership with various organizations, ranging from grass-roots associations to international humanitarian organizations and governmental agencies."

Carebridge.org is seeking seed funding to promote field applications of the RMI charrettes' design innovations.

has caused severe erosion, ecosystem destruction, and leaching from tailings piles into water systems.

The choice of wood or steel should depend on the application. Wood, for instance, is a natural insulator, whereas steel is a conductor (it is 400 times more conductive than wood). The "thermal bridging" that occurs at exterior walls where steel studs span from inside to out can halve the overall R-value of a wall with cavity insulation (as compared to the R-value of the same wall framed with wood). This presents a major energy-efficiency problem for steel-framed exterior walls. Although providing a layer of continuous exterior insulation does not completely solve the thermal bridging problem, it can significantly increase the overall R-value of the steel stud wall.

Structural Support Members

Years ago, the dwindling supply of old-growth timber spurred the wood products industry to manufacture structural products with smaller, lower-quality logs. Engineered wood products include glu-lam beams and prefabricated wood trusses and joists. These products enhance quality control while reducing pressure on remaining old-growth forests. They can make use of up to 80 percent of each log as compared to solid-sawn lumber, which only uses about 50 percent. Glu-lam beams are composed of wood boards glued together to create high-strength beams with depths ranging from five inches to four feet (or more—depths and spans are limited only by shipping constraints). Trusses are more structurally efficient than solid beams (because forces are aligned along components of the truss); therefore they achieve high strength with smaller dimensional components. Similarly, prefabricated I-joists are more structurally efficient than solid joists, so they require less wood. Unfortunately, they can be toxic to factory workers if the wrong glue is used.

Sheathing

Composite sheathing products made with recycled wood fiber or using sawmill waste or small-dimensional lumber help to conserve forests. For applications that do not require high strength, consider recycled and recyclable sheathing products. Some currently available are made of up to 100 percent recycled wood fiber, are themselves up to 99 percent recyclable, and use a relatively nontoxic bonding agent. Recycled sheathing products are manufactured using less energy than oriented strandboard (OSB) or plywood.

About the Author

RMI's Alexis Karolides, a former Richter Fellow, holds a Master of Architecture degree from Rice University. A registered architect with six years' commercial experience, she was previously the sustainability manager for the architectural firm Sussman Tisdale Gayle. This three-part series on the basics of green building is adapted from the recently released book Green Building: Project Planning & Cost Estimating, *coauthored by Karolides. It is available from the publisher at 1-800-448-8182 or at www.rsmeans.com, in the website bookstore under "New Releases."*

Outdoor Wood Applications

Avoid wood that is pressure-treated with CCA (chromated copper arsenate). This chemical is toxic, both in production and transport, and the CCA-treated wood cannot be disposed without potential issues of toxic runoff (or toxic smoke if the wood is burned). Using naturally rot-resistant woods (redwood and cedar) is also problematic because these woods generally come from old-growth forests. Better alternatives are to use wood treated with less toxic preservatives, such as ACQ (for wood exposed to weather) or borate (for wood not exposed to weather, but requiring pest-resistance), or to use wood substitutes such as plastic lumber.

Architectural Woodwork & Cabinetry

Use of reclaimed timbers where available helps preserve old-growth forests while making use of, rather than discarding, a valuable existing resource. To reduce VOCs, fiberboards with formaldehyde-free glues should be specified. Some products are additionally ecologically friendly because they are made out of agricultural waste products such as wheat straw.

Choosing "green" building materials is not a cut-and-dried process. There are many considerations—sometimes conflicting—including indoor environmental quality, energy use, embodied energy, location of product source, durability, end-of-life considerations, resource renewability, and environmental impact. No project will be composed of a perfectly green set of materials and strategies; rather, designers and owners must determine what the most important characteristics are for the project and what the occupants need.