



### SUSTAINABLE DEVELOPMENT

## How Do Paper Houses Stack Up?

In the tale of the Three Little Pigs, children learn that houses made of heavy brick or wood are preferable to those made of lightweight straw. That axiom is being challenged by the reemergence of a building material known as fibrous cement, or “papercrete.” Composed of recycled paper, water, sand, and Portland cement, papercrete makes a strong, lightweight, and inexpensive building material that could replace concrete block and wood used in traditional construction—or could it?

Papercrete is currently enjoying a boom among builders in the Southwest who are looking for low-cost building materials that have minimal impact on the environment. “Paper houses make sense,” says Gordon Solberg, author of



*Building with Papercrete and Paper Adobe.* “Our landfills are clogged with waste paper and cardboard. Millions of people live in substandard housing or have no housing at all. With papercrete, we can solve both of these problems at once.”

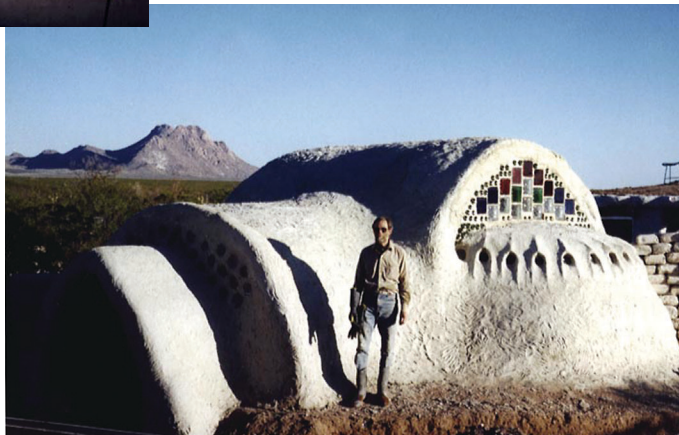
According to the National Association of Home Builders, the average U.S. single-family home contains 13,127 board feet of lumber, 13.97 tons of concrete, and 2,085 square feet of flooring. Trees must be cut down to supply that lumber

and energy consumed to manufacture and transport building materials. Much of the material later ends up as land-filled scrap.

Papercrete, on the other hand, uses primarily locally available material and is prepared on-site. Using a customized mixer, dry ingredients are mixed with water to make a slurry that can be molded or dried into stackable blocks. Leftover papercrete can be thrown back into the mixer and ground up to make new material.

Because papercrete is not manufactured commercially, comparative building costs are hard to determine. However, contractors claim figures of less than \$2 per square foot of finished wall using papercrete versus \$6 and \$9 per square foot for wood frame and block construction, respectively.

According to Solberg, papercrete blocks are capable of a compressive strength—the measure of how much weight can be put on the material—of 260 pounds per square inch, compared to approximately 1,800 pounds per square inch for concrete block. Papercrete can also attain an R-value—the measure of how well a material insulates—of approximately 2.0 per inch. Theoretically, a 10-inch-thick papercrete wall would have an R-value of 20.0, superior to a conventional wall made of fiberglass batting, gypsum wallboard, and wood or vinyl siding.



**Recycled technology.** A revival of the alternative building material known as papercrete may offer a sustainable substitute for traditional materials such as wood and concrete.

However, Leonard Jones, an engineer from Littleton, Colorado, has done some experiments with papercrete that reveal less desirable qualities. He says the physical characteristics of papercrete vary widely, depending upon the relative amounts of sand and Portland cement used. Mixtures with a lot of sand and cement tend to have a high density and a relatively high tensile strength, but a low R-value—less than 1.0 per inch. Mixtures with less sand or Portland cement tend to have a lower density, a relatively low tensile strength, and a higher R-value—but still generally less than 2.0 per inch. In addition, because papercrete loses most, if not all, of its strength if it gets wet, Leonard says he would not recommend that papercrete be used for any structural components; instead, it should be used as in-fill in a building with an independent metal, pole, or wood frame.

Papercrete is also not necessarily free of health concerns, although it has not been extensively tested. Portland cement contains silica, and respirable crystalline silica, created when cutting or drilling through cement, has been implicated in silicosis-related death and disease among construction workers. In addition, low-density papercrete mixtures could catch fire and burn slowly.

General contractors do not use papercrete, so home builders must either do it themselves or find an “alternative builder.” Papercrete has not yet been approved under commonly used building codes such as the International Building Code. Thus, builders generally use it in areas that do not have building codes or that allow experimental permits.

“The challenge this and other alternative building materials face is passing all the testing requirements for code approval,” says Alex Wilson, executive editor of *Environmental Building News*. “It’s hard [for alternative materials] to get a foot in the door.”

—John S. Manuel

## REPRODUCTIVE TOXICOLOGY

## Men at Work—Sperm on Break

Men who are regularly exposed to moderate to high levels of organic solvents on the job may increase their chances of having a low active sperm count, or reduced sperm motility, report Canadian and British researchers in the October 2001 issue of *Occupational and Environmental Medicine*. The researchers found that among infertile couples, men with the highest solvent exposure—including professional printers, painters, dry cleaners, and marine craft builders—were twice as likely as men without such exposure to have a low number of active sperm. Reduced sperm motility can contribute to male infertility.

Organic solvents are chemicals found in paints, adhesives, lacquers, and cleaning agents. Some commonly used organic solvents include styrene, perchloroethylene, trichloroethylene, and ethylene glycol ethers. Solvents, whether inhaled or absorbed through the skin, are known to invade the part of the male reproductive system where sperm are developed, says lead author Nicola Cherry, a professor of occupational health at the University of Alberta in Edmonton.

The researchers reviewed data from two Canadian cohorts comprising 1,200 manual workers attending fertility clinics. Over half of the subjects went to one clinic in Montreal between 1972 and 1991 (the Montreal series). The other subjects went to 10 other Canadian clinics between 1984 and 1987 (the Canadian Infertility Therapy Evaluation Study series).

The researchers used a job exposure matrix to classify how likely each man was to have been exposed to organic solvents at work. Cases were defined as men with less

than  $12 \times 10^6/\text{mL}$  active sperm.

The researchers found that cases were more likely to have been exposed to solvents at work than were controls. Among the Montreal series subjects, moderate occupational exposure to organic solvents was associated with a doubled risk of having low numbers of active sperm. In both series, exposure to high solvent levels was associated with triple the likelihood of a low active sperm count.

The team also factored in alcohol and tobacco use data (where available) as possible confounders, but found no evidence that use of either was related to lowered numbers of active sperm.

“Even though only a small number of subjects were exposed at high doses, this study suggests that effects on sperm increased with amount of exposure,” says Peter Rabinowitz, an assistant professor of medicine in the occupational and environmental medicine program at Yale University in New Haven, Connecticut. The study provides further evidence that exposure to high levels of solvents may interfere with normal sperm formation.

However, Rabinowitz adds that, as with any retrospective case-control study, some caution should be taken in interpreting the results.

Regardless of whether organic solvent exposure actually does affect active sperm count, Cherry says, men exposed to high levels should try to minimize their exposure because of the solvents' known adverse effects on the nervous system. Such effects include nervous system depression and possibly death at very high levels of exposure, as well as chronic effects on mood and behavior following repeated exposure over years at work. —Ed Susman

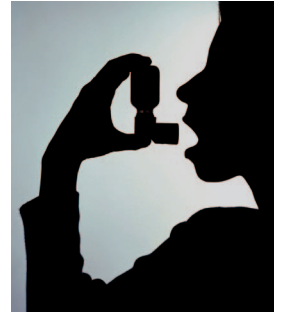


**Lying down on the job?** Exposure of men to organic solvents in some occupations may lower sperm motility, possibly hindering fertility.

## Worse for Women

On the heels of an earlier survey finding that women are more likely than men to have severe persistent asthma, a new survey of U.S. women with asthma has found that the condition profoundly affects the lives of female sufferers. Of 500 women questioned, 30% had been hospitalized for an attack, and over three-quarters said their asthma is a source of worry to their spouses, partners, or children. Many fell far short of national treatment goals, including minimal asthma symptoms and minimal or no need for asthma-related emergency medical care.

Study advisor Phyllis Greenberger says women with asthma may still be able to lead more active, healthy, and worry-free lives through better education about asthma and how to manage it.



## Magic Mushrooms

Mushrooms are serving a new purpose besides flavoring dishes and sheltering leprechauns. In a promising alternative for toxic waste cleanup known as mycoremediation, strains of mushrooms are being bred to speed up their natural process of decomposing organic material. The mushrooms' vegetative mycelia act as a biofilter, degrading compounds such as *E. coli*, petroleum compounds, heavy metals, and pesticides without generating secondary waste that must be further treated.

Tests conducted so far have cleaned up soils to the point they can be used for landscaping. Battelle Laboratories scientist Jack Word says that edible mushrooms may someday grow in areas once contaminated with nerve gas.



## U.S. Army's New Weapon

To make equipment-heavy military operations more fuel-efficient, the U.S. Army's National Automotive Center, along with industry and academic partners, is developing new fuel cell technologies. Technologies currently being tested include reformer-based liquid hydrocarbon fuel cells, which Army officials propose for use on vehicles to power communications equipment that now runs off electricity generated by the vehicles' engines. If these cells prove viable, they could not only greatly improve Army fuel-efficiency but could also reduce vehicle emissions. Also being developed are plug-in fuel cell units to provide electricity for medium-range tactical and high-mobility vehicles.



## INFECTIOUS DISEASE

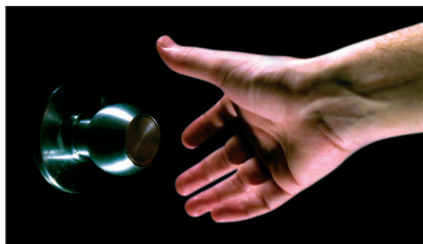
## On the Surface: A Good Idea for Killing Germs

Consider the travels of the lowly cold germ: First, it latches onto a hand swiping across a drippy nose. From the hand, it makes a cool getaway onto a doorknob, and from there to the hand of another guy, who scratches his own nose and then gets sick. Now consider an alternative scenario conceived by researchers at the Massachusetts Institute of Technology (MIT) in Cambridge: the bug lands on the doorknob and dies. Why? Because the doorknob killed it.

Actually, it's a coating on the doorknob that delivers the deadly blow. Surfaces coated with poly (4-vinyl-*N*-alkylpyridiniumbromide), or hexyl-PVP, a bactericidal material created at MIT, are lethal to many common household and hospital pathogens. "It's a simple coating that you can put on any ordinary surface—for instance toys, computer keyboards, hospital trays, bedsheets, or doorknobs—that will kill bacteria on contact," says principal

investigator Alexander Klibanov, a professor of chemistry and bioengineering at MIT. Addition of the coating during manufacturing could render the surfaces of many industrial products permanently sterile.

A coating of hexyl-HVP polymers might be envisioned as a "shag carpet" of flexible strands. One end of each strand binds permanently to the surface to be protected. The free end shreds the cellular walls of passing bacteria, releasing their internal structures. In a study published in the 22 May 2001 issue of *Proceedings of the National Academy of Sciences*, Klibanov and his colleagues describe laboratory tests showing that surfaces coated with hexyl-PVP kill up to 99% of deposited *Staphylococcus* species,



**Dead as a doorknob?** A new antibiotic coating may help rid common exposure sites of infectious bugs.

*Pseudomonas aeruginosa*, and *Escherichia coli*, all common disease-causing organisms.

"As far as applications, the first thing that comes to mind is using the coating in a hospital environment to contain the spread of microbial infections," says co-investigator Kim Lewis, now a professor of biology at Northeastern University in Boston, Massachusetts. "We know the transfer and dissemination of some important pathogens is via surfaces that come in contact with poorly washed hands."

Some observers question whether such wide-scale use might enhance microbial resistance to the coating, a concern Lewis plays down. According to Lewis, the density of the polymer on a coated surface is so high that natural microbial defense mechanisms will be overwhelmed. With such a high kill ratio, he says, resistance genes won't be passed on to a new generation of hardy survivors, which might otherwise reside as comfortably on a hexyl-PVP-coated surface as if they were sunbathing on the beach.

Lewis believes the coating will be commercially available within two years. He and his colleagues are currently negotiating with an industrial partner, whom he declined to identify. —Charles W. Schmidt

## CHEMICAL EXPOSURES

## Problems with the Solution

Two chemicals singled out by the United Nations Environment Programme (UNEP) for their potential to damage the ozone layer may also cause human health problems. Based on animal data, one of these chemicals, 1-bromopropane (1-BP), was recently reviewed by the National Toxicology Program Center for the Evaluation of Risks to Human Reproduction (CERHR) for its potential to harm human reproductive health, with the conclusion that more research is needed on its human health effects. Due to evidence of kidney tumors in animals, the other chemical, hexachlorobutadiene (HCB), has been classified by the U.S. Environmental Protection Agency (EPA) and the National Institute for Occupational Safety and Health as a possible human carcinogen.

UNEP issued a warning in September 2001 about 1-BP and HCB following reports of their increasing use as alternatives to hydrochlorofluorocarbons, which are banned and being phased out under the Montreal Protocol, an international agreement to discontinue use of ozone-depleting chemicals. 1-BP and HCB are not yet included in the Montreal Protocol, and because they break down close to the earth's surface, scientists believed they pose only a negligible threat to the ozone layer. But recent studies indicate that their long-term use under certain conditions actually may contribute to ozone layer damage.

A CERHR expert panel recently reviewed 1-BP for reproductive and developmental toxicity and is scheduled to release its final report in early spring 2002. A draft report points to the need for a well-designed human study with adequate exposure measurements. The NIEHS Environmental Toxicology Program, in conjunction with the National Institute for Occupational Safety and Health, is already funding some occupational exposure studies of 1-BP, says John Bucher, the program's deputy director.

In 2001, two manufacturers—Albemarle Corporation and Atofina—recommended that 1-BP not be used in applications in which worker

exposure can't be tightly controlled, such as certain solvent or adhesive uses. Also, UNEP has asked parties to the Montreal Protocol to encourage industries to use 1-BP only when there is no alternative.

1-BP is known to be toxic in animals. Gaku Ichihara, a professor in the department of occupational and environmental health at Japan's Nagoya University, wrote in the May 2000 issue of *Toxicological Sciences* that after inhaling 1-BP, rats showed muscle weakness and deterioration of motor nerve function. Inhalation of 1-BP has also been shown to decrease fertility in male and female rats.

1-BP is used in spray adhesives and as a solvent in cleaning electronic components. People working with such applications can be exposed to 1-BP by inhalation or skin contact. There is currently no information indicating public exposure to 1-BP through air, food, or water, says CERHR director Michael Shelby.

According to Shelby, current usage of 1-BP is less than 5 million pounds per year. Although this may increase somewhat if 1-BP continues to be substituted for hydrochlorofluorocarbons, large increases in production don't seem likely because the chemical is very expensive compared to many other organic solvents and cleaners.

Although a December 2000 report from the California EPA titled *Evidence on the Carcinogenicity of 1,3-Hexachlorobutadiene* states that no data on long-term effects of human exposure to HCB have been found, there is evidence of toxicity in animals. Short-term skin contact with HCB has resulted in kidney, brain, and liver damage in rabbits, and rats and mice that ingested low concentrations of HCB over short and long periods developed kidney tumors and liver damage.

HCB is used as a solvent and to make lubricants and rubber compounds. The public could be exposed to HCB released into air, water, or soil during disposal of industrial waste, according to a toxicologic profile released by the Agency for Toxic Substances and Disease Registry. Some public drinking water contains HCB in amounts under the U.S. EPA maximum contaminant level of 1.0 ppb. The EPA Toxics Release Inventory for 2000 projected that 4,488 pounds of HCB would be released as waste that year in the United States. —Angela Spivey



## Electronic Library of Construction Occupational Safety and Health

In the year 2000, construction work had the highest number of fatal work injuries to date, with 1,154 deaths. The construction industry encompasses a wide variety of occupations, and construction workers face not only inherent physical dangers—for example, the hazards of working around heavy machinery, with electrical equipment and power lines, and atop ladders and scaffolding—but also environmental hazards such as exposure to dust, asbestos, lead, coal tar, and high noise levels. For example, driving a ready-mixed concrete truck may appear to be one of the less risky jobs in construction, but it may expose workers to a number of hazards such as high noise levels, silica dust from sand and gravel, oxygen deficiency and heat stress (from being confined in truck cabs), and hexavalent chromium from cement products.

Part of the federal effort to improve construction worker safety is the Electronic Library of Construction Occupational Safety and Health (eLCOSH) Web site located at <http://www.cdc.gov/niosh/elcosh/index.html>.

The site was developed by the Silver Spring, Maryland-based Center to Protect Workers' Rights, along with the National Institute for Occupational Safety and Health (NIOSH).

The eLCOSH site is a database of resources on the environmental hazards encountered in construction work. It includes recommendations for reducing hazardous conditions, NIOSH and Occupational Safety and Health Administration data on hazards and the problems they can cause, and summaries of published research. From the home page, visitors can search for information by hazard, trade, or job site.

For example, browsing through the Chemical Hazards page under the Hazard link reveals a NIOSH article on controlling drywall sanding dust exposures, a training guide for using respirators, and a physicians' alert developed by the International Union of Bricklayers and Allied Craftworkers to help ensure that silicosis cases are properly treated, documented, and reported to state health agencies. The Biological Hazards page outlines various and often-overlooked threats to construction worker health such as Lyme disease, hantavirus, and the molds, bacteria, and protozoa that workers can be exposed to when working with sewer lines.

These same resources are cross-referenced by trade (for example, carpet layer, electrician, or welder), job site (for example, demolition, renovation, or heavy construction), and illness (under the Other link on the home page). Lung cancer, melanoma, mesothelioma, lead poisoning, contact dermatitis, and nervous and respiratory disorders are among the health problems covered.

The Building Trades Unions Ignite Less Tobacco project's guide for construction workers focuses on educating construction workers about the hazards of tobacco smoke by itself and in combination with toxic chemicals encountered on the job. It highlights misconceptions workers may have about smoking and secondhand smoke, using personal protective equipment, and the link between chemical exposures, smoking, and cancer. It also provides information on construction workers' health and safety rights.

As the U.S. workforce becomes more culturally—and thus more linguistically—diverse, construction employers will face even greater challenges in keeping their workers safe. Employment of Hispanic workers was up 6% in 2000 over 1999 figures, but fatal injuries among Hispanic construction workers, many of whom do not speak or read English, was up 24% for the same period. The entire eLCOSH site is available in Spanish, and a number of the documents are also available in Italian. —Erin E. Dooley

ELECTRONIC LIBRARY OF CONSTRUCTION

eLCOSH

OCCUPATIONAL SAFETY AND HEALTH

## The Curse of Copper

Heavy metal waste generated millennia ago still plagues areas of southern Jordan today. British researchers F. Brian Pyatt and J. P. Grattan found that even though the copper and lead waste from the mining activities of the Babylonians, Assyrians, Romans, and Byzantines has been subjected to centuries of wind and rain erosion, it still poses a health threat to the Bedouin population of the area known as Wadi Faynan.

Exposure to copper and lead can cause nausea, diarrhea, and convulsions, with extreme exposure possibly causing brain damage, coma, and death. In the September 2001 issue of the *Journal of Public Health Medicine*, Pyatt and Grattan urged the mining industry to take heed of the negative health effects of these long-unused mines and the durability of heavy metals in the environment.

## World's Lakes on the Wane

Many of the world's 5 million freshwater lakes (90% of usable freshwater resources) are at risk of ecologic death, according to William Cosgrove, vice president of the

World Water Council. In a November 2001 speech in Otsu, Japan, he said that every freshwater lake on earth has been affected by human activities such as industry and agriculture. When water has been thus compromised, a natural event such as a change in water temperature can trigger the complete transformation and eventual demise of a lake, a process that is difficult to halt once started. Poor lake health can lead to poor human nutrition and even starvation when it affects the livelihood of nearby human populations, and potentially fatal diseases can be caused by drinking polluted water.



## EU Gets a Taste of New Food Rules

In November 2001, the EU announced new, stricter limits for dioxins, furans, and PCBs in human food and animal feed. These chemicals, formed as by-products of chemical processes, can cause cancer and reproductive and immune system disorders in humans. They also bioaccumulate over time in fatty tissue.

The new rules take effect 1 July 2002 and are part of a broad EU strategy to improve food and feed safety and reduce these pollutants in the environment. EU health and consumer protection commissioner David Byrne said the ultimate goal must be to further reduce contaminant releases at the source.

