

# Affordable & Innovative Home Building Technologies Explored at BETEC Symposium

Some of the nation's leading proponents of sustainable building technology described such construction techniques as straw bales, rammed earth, rice hull, and papercrete at a program hosted by NIBS' Building Environment and Thermal Envelope Council (BETEC). The workshop was held from October 13-16 at the Northern New Mexico Community College in El Rito. The Santa Fe, N.M. symposium was held on October 17-18. Community-based green building projects and Seattle's LEED-based green building program were also discussed.

Workshop topics included: adobe wall construction, Quentin Wilson; light straw-clay walls, Carl Rosenberg; strawbale walls, Andre de Bouter and Ari Gore; papercrete construction, Lex Terry; improved rammed earth walls, Wolfgang Fritz and Scott M. Merry; and compressed sustainable insulation walls, Arun Vohra.

Lex Terry presented his paper fiberizer and cement mixer used to make the building material papercrete. Terry's equipment attaches a platform on top of a automobile rear axle and differential. A differential driven shaft rotates a 30 inch lawnmower blade mounted inside a tank on the platform when it is towed behind a pickup truck, just like a giant kitchen blender. In one



Lex Terry



Workers demonstrate papercrete forming.

eighth of a mile it "fiberizes" 100 pounds of old newspaper, 100 pounds of Portland cement, sand and water. Terry fills a series of in-line forms by pulling the tank of papercrete slurry over to create papercrete blocks.

The symposium's keynote speaker Robert M. (Mike) Unthank, director of the State of New Mexico's Buildings Industry Division, and chairman of the National Conference of States on Building Codes and Standards, fostered building codes' support of green building practices. He said New Mexico's codes support new building technologies through experimental and limited-use permits to get new products into the building system. He cited New Mexico's rich and multi-cultural building history's use of time-tested building technologies like adobe, rammed earth and baled straw.

Arun Vohra, manager of the Thermal Insulation and Building

Materials program at the U.S. Department of Energy, offered a historical overview. Vohra showed how geometry from Greece, numbers from India, and astronomy from Europe allowed Newtonian science to be developed and accepted. Art, building technologies, and other

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Robert (Mike) Unthank

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inventions and products from the East were conveyed along the Silk Road from Rome to China and eventually to Iberia and allowed the development of ocean going vessels and the discovery of America.

Vohra displayed images of the dome of tomb of Tamerlane's queen, built in Samarkand, Uzbekistan, in the late 1300's, the dome of the Taj Mahal, built in Agra, India, in 1652, and the dome at the Spanish Mission, built in Carmel, California, in 1765. The similarity in the shapes of the domes showed that this element of architecture had transcended centuries, countries, continents, cultures and religions.



*Wolfgang Fritz*

Wolfgang Fritz and Scott Merry of the University of Arizona's Department of Civil Engineering and Engineering Mechanics discussed the use of compaction and water for hydrating cement used in improved rammed earth construction. A transparent sealant is used for protection. They noted that the higher the percentage of cement, produces greater strength but a more brittle material. Low water content and high compaction give higher compressive strength.

A. Michael Peters of Los Alamos National Laboratory talked about the characteristics and use of advanced concrete, which uses supercritical (SC) carbon dioxide to treat fly ash, kiln dusts, and other waste feedstocks. After SC treatment, flyash-cement mixture gains strength and density. SC treatment of roofing tiles



*Arun Vohra*

composed of 80% flyash and 20% Portland Cement are more rigid, stronger, and lighter than those without. See [www.scrub.lanl.gov](http://www.scrub.lanl.gov) For information

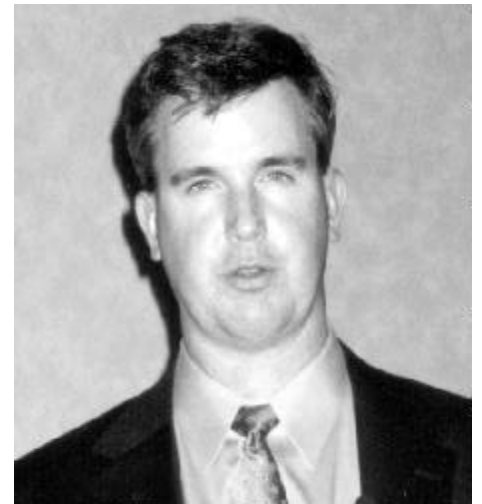
David Riley of Penn State's Department of Architectural Engineering discussed a community-built housing project using load-bearing straw bales. In this three-year project, students design and build straw bale structures. The initiative focuses on hands-on and design-build courses with attention to cultural implications. It also researches the mechanical properties of straw and workshop methods, integrating research and education by allowing students to contribute to ongoing research. The effort is focusing on such performance questions as the load-bearing capacity, effects of lateral forces, and deterioration.



*A. Michael Peters*

Bruce King, structural engineer and director of the Ecological Building Network, explored the history, uses, and properties of plastered straw bale construction. Non-load-bearing straw bale construction is more common, because it is difficult to obtain permits for load-bearing construction. Straw bale walls are plastered to protect against insects, rodents, and the elements, and to provide more effective insulation. Because cement stucco, a common material used over straw bale walls is brittle, there is a movement to lime and earthen plasters.

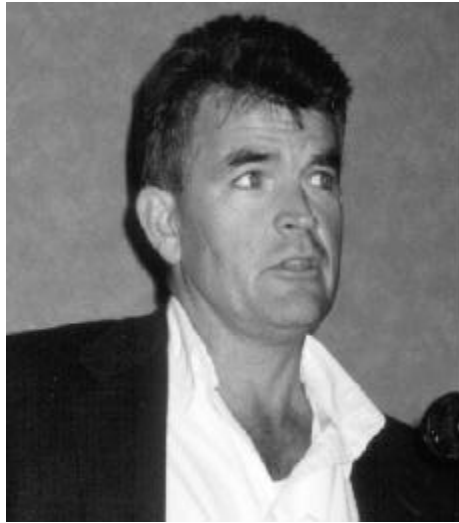
Paul Olivier, president of Engineering, Separation & Recycling LLC, described the availability, insulating properties, and benefits of using rice hulls as building insula-



*David Riley*

tion. Because rice hulls are low in protein and available carbohydrates, they are not as easily metabolized by insects as are walls made of other agricultural waste products. Rice hulls are high in fiber, silica, and lignin, which resist fungal decomposition and water penetration. There are over 100 million metric tons of rice hulls in the world. In 1995, there were 1.26 million tons in the United States, alone. Rice hulls do not burn or biodegrade easily. They form an effective thermal barrier. One ton of rice hulls can insulate 250 square feet of a 12-inch thick wall. The total cost is \$0.19 - 0.25 per square foot, which includes the cost of the rice hulls and transporting them.

Bill Steen, co-author of *The Straw Bale House* and *The Beauty of Straw Bale Houses*, described his efforts to build using earthen and local materials, such as straw bale and adobe. The first project, an office building for Save the Children in the southern Sonoran region of Mexico, was constructed mostly by women and children. It uses clay wall finishes and shelving made of bamboo, clay, and straw. The vaulted ceiling used chariso, a local reed. The clay/straw mixture offers structural possibilities and decorative work for buildings. They have also built simple, one-room (300-400 ft<sup>2</sup>) houses for about \$500 using recycled concrete foundations and floors.



Bruce King

the use of adobe construction and site-appropriate building design in modern housing. Adobe is a sustainable, mainstream material. Adobe, straw bale, rammed earth, and other alternative materials techniques make up about 30% of the N.M. housing stock. Dirt can be made into sun-dried bricks and used to build walls without using machinery. Wilson said adobe is a worldwide building product with homes being built in Russia, Germany, Ireland and many other nations. But nowhere else is adobe use growing as fast as in New Mexico, he added. A good source on adobe construction is the *Earth Construction Handbook* by Minke.

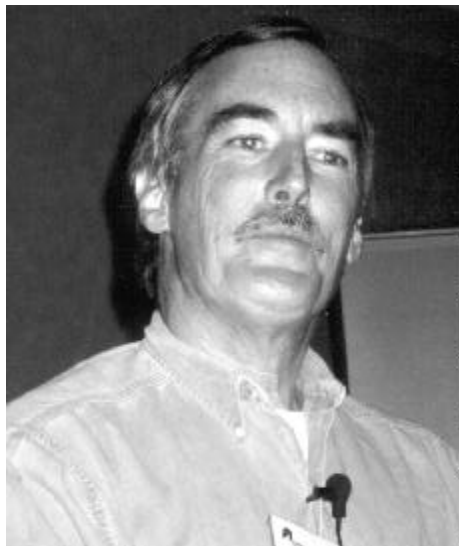
system. The wall is constructed by using a push rotary lawn mower to vacuum sawdust (or any suitable bulk insulation material) and blow it into a long woven polypropylene fabric tube that is layered over itself. Chicken wire mesh is attached to both sides and plastered to comprise a wall. The polypropylene is porous, allowing the air to escape while the material is being filled; however, it is not waterproof. If the wall becomes damp, the southwestern climate allows evaporation, and it dries out in a short period of time. Vohra doesn't recommend the use of sawdust as a fill in a moist climate like Florida's, but pumice or another non-absorbent filler material could be used. If the fill material has a R-value of at least R=1/inch, the wall



Paul Olivier

Tarun Bhatia of U.S. Borax Inc. discussed the benefits of using borax-treated wood to resist insects in interior structural systems. Most wood species do not resist wood-destroying organisms, such as termites, Bhatia explained. Formosan termites, came to the U.S. on ships after World War II. Nearly half of all new homes in the southeast are damaged by these termites. In 1998, the termites caused \$750 million in home damage. It is not appropriate to use borates in outdoor applications; however, they can be used indoors. Borates' toxicity to pets and people is similar to that of table salt. The use of borax-treated wood, according to Bhatia, results in less termite damage and fewer homeowner complaints.

Quentin Wilson of Northern New Mexico Community College explored



Bill Steen



Tarun Bhatia

will provide at least an R-12 insulation. For a 16' x 24' structure, the fabric costs only \$78.

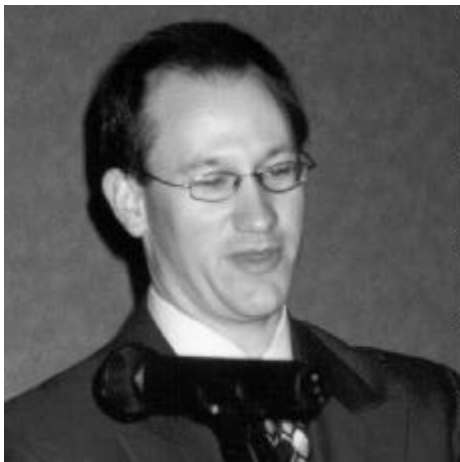
Michael Aoki-Kramer, a code and policy development specialist for Seattle's Department of Design, Construction and Land Use, described Seattle's LEED-based green building initiatives. Seattle is making sustainability in product choices a major public works focus. The Civic Center master plan, for example, incorporates sustainability and whole systems (social, environmental, and economic factors). For all of the city's LEED buildings, the projected savings are 1,000 tons of construction waste, 4.3 million gallons storm water runoff each year. It will yield a \$19.3 million payback.

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He estimates that meeting a LEED rating, increases project costs by 4-6%.

John Gajda, senior engineer in the Building Science and Sustainability section of Construction Technology Laboratories, Inc., illustrated the environmental life-cycle inventory (LCI) of single-family housing by modeling several exterior wall assemblies for a two-story, 2,450 square foot home, over a 100-year life span. All assemblies (roofs, attic insulation, windows) met the 1998 energy code. Emissions findings indicated that building occupants and related activities generate 95-98% of the house's total emissions and building materials generate about 3-5%. 99 percent of the energy use comes from heating



Michael Aoki-Kramer

and cooling related to occupancy; one percent comes from the embodied energy of the house construction.

Paul Norton, a senior engineer with the U.S. Department of Energy's Building America Program at the National Renewable Energy Laboratory, explored the energy performance of insulated masonry walls in residential construction. Building America's program goals are to reduce energy use in building operations by 30-70%. Based on one specific home design, the mass credit tables in energy code prescribe higher allowable U-values for massive walls than lightweight walls. Homes with massive walls built in Florida, Colorado, and Arizona were



Quentin Wilson

tested. Annual heating and cooling costs for each wall type were compared against no ventilation, 4 ACH, and 8 ACH. They found that while mass can reduce annual energy consumption, it is no substitute for insulation.

Dianne Griffiths, project engineer for the Consortium for Advanced Residential Building at Steven Winter Associates, discussed current research, the strengths, and the challenges associated with pre-cast concrete insulated foundation wall systems. Basement walls are usually made by pouring concrete into forms, but there is another way that has been developed by two primary manufacturers. Pre-cast concrete foundation wall systems are made of a 2" exterior concrete shell, concrete studs, a footer, and a top plate. A poured slab floor provides lateral



Paul Norton

bracing. These pre-cast concrete foundation walls can be installed during the winter, can be installed in hours, are strong and of good quality, and are impervious to moisture.

Michael Reynolds of Solar Survival described the earth-tire wall systems used to build earthships. An earthship is a building that uses tires to form its envelope. The walls are 3-feet thick and provide good thermal mass. The building is then wrapped with a perimeter insulation 6-7 feet out. The volume of that amount of earth approximately equals the amount of air space to be heated. Reynold's book *Comfort in Any Climate* discusses load-bearing earthships.

Tire work is done on site; kit building can be shipped anywhere. A two-bedroom home can be built in a few weeks with a 6-7-person crew.



John Gajda

For more information visit the web site at [www.earthship.org](http://www.earthship.org).

Joseph Kennedy, director of Builders without Borders, talked about locally appropriate design and building for an under-housed Native American tribal population. Builders without Borders uses inexpensive, easily available materials and enables people to create their own homes. The organization is working to educate Native American groups, as well as others from such diverse areas as Mongolia and Ethiopia. The goal is to share its best straw bale practices so that these groups can take the information back and incorporate it into their own building practices.

Charles Graham and Richard Burt of the Department of Construction Science at Texas A&M University discussed load-bearing, soil block home construction for an economically disadvantaged community in Texas. They described three main techniques for building with earth:

Unbaked earth in monolithic, load-bearing forms (e.g., adobe, clay, sod, compressed blocks)

Unbaked earth in conjunction with load-bearing forms (e.g., wattle and daub)



*Andre Desjarlais*

Soil blocks – compressed into molds and made under pressure (manual or machine)

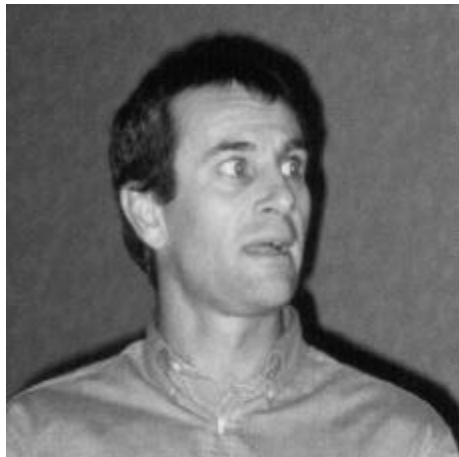
Graham and Burt use Advanced Earthen Construction Technologies (AECT) soil block machines in to produce soil blocks. Their 2001 AECT model is gas-driven and retails for just under \$20,000.

Andre Desjarlais, program leader for the Building Envelope and



*Joseph Kennedy*

Materials Research Programs at Oak Ridge National Laboratory, reviewed WUFI, a software tool that explores the durability of building envelopes by modeling moisture transport. Moisture in insulation exacts heavy costs, including energy inefficiency (e.g., moisture greatly reduces the ability of insulation to function effectively), causing 90% of all buildings/building material failures at



*Richard Burt*

a cost of \$9 Billion/year in the U.S. WUFI accounts for temperature, relative humidity, and other moisture-related variables. Once the user has defined the wall materials listed in the materials database and the wall thickness, the user can orient the wall, indicate building height (which indicates the amount of water that will fall on the wall), choose surface finishes and colors (impacts surface temperature).



*Charles Graham*

Using weather files, the model computes the thermal and moisture loading on the building envelope components. WUFI can be found at [www.ornl.gov/btc/moisture](http://www.ornl.gov/btc/moisture).

Arun Vohra (U.S. Department of Energy) ended the symposium with an update of the U.S. Department of Energy's Building Envelope Technology Roadmap.