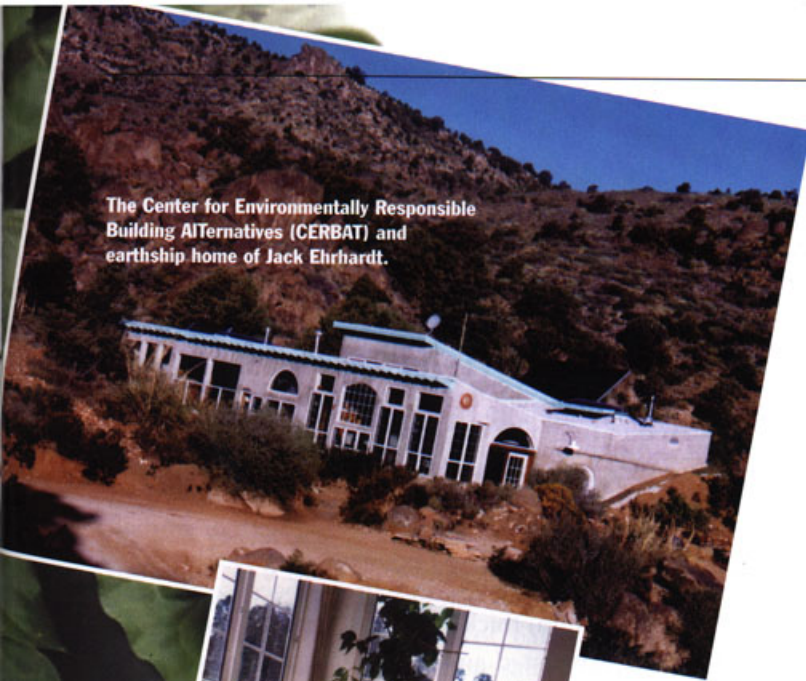


Earthship Building: An Ecocentric Method of Construction

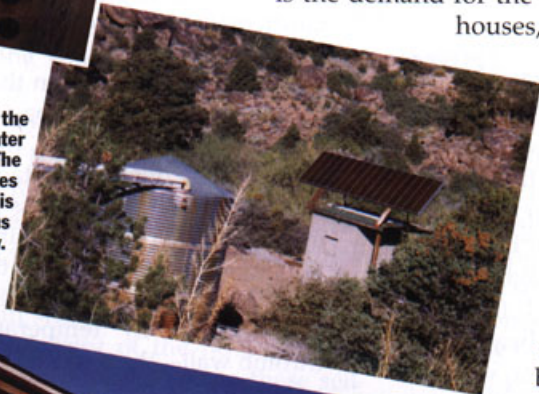
by Jack Ehrhardt

The Center for Environmentally Responsible Building Alternatives (CERBAT) and earthship home of Jack Ehrhardt.

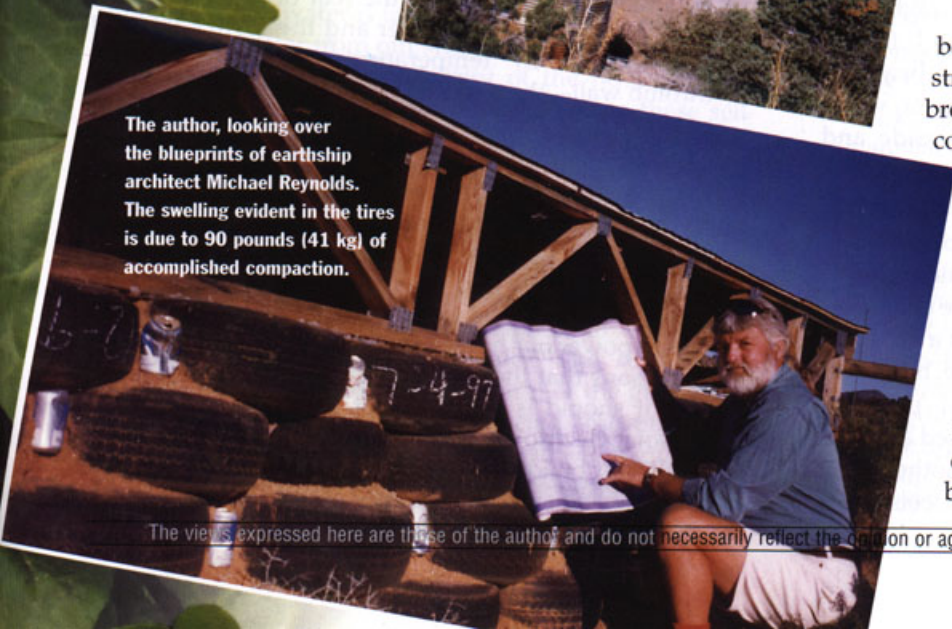


"Kitchen sink" planters. Grey water, reclaimed from sinks, is used to irrigate organically grown flowers and vegetables. Note the decorative use of recycled bottles.

The well house and one of the cisterns used to store rain water runoff from the sloped roof. The well house's solar panel generates 300 watts of electricity, which is used to pump 3,000 gallons (11 356 L) of water a day.



The author, looking over the blueprints of earthship architect Michael Reynolds. The swelling evident in the tires is due to 90 pounds (41 kg) of accomplished compaction.



The World Watch Institute estimates that if the rest of the world used natural resources at the rate we do in America, it would take two additional Earths to meet the global demand. Overall, the 1.1 billion wealthiest people in the world consume 64 percent of the resources, while the 1.1 billion poorest consume only two percent. With the Earth's population having doubled since 1950, it would seem that the real shortage of affordable housing has just begun. Sustainable building—using earthen and recycled materials and implementing principals of energy efficiency to take advantage of free, clean, renewable energy—will help to solve many of these problems.

The European-American wood-framed building system, the way we have built our homes for centuries, is being challenged by more ecocentric methods of construction. We have to face the fact that a leading cause of global deforestation is the demand for the wood products used to construct wood-framed

houses, apartments and small commercial buildings. We can't put a "tree-hugger" in every forest in the world to save the old growth, but we can change the way we think. The Cartesian mechanic paradigm we have lived by for the past 2,000 years assumes that the world is a human-centered machine. We now know that this is simply not the case.

It is certainly not just Sierra Club members who are building sustainable homes using strawbale, adobe or the earthship design. A broad cross-section of people enjoy the feeling of contributing to natural resource conservation through energy efficiency. As physics teacher and author of *The Web of Life*, Fritjof Capra, describes it:

"What this implies is that the connection between an ecological perception of the world and corresponding behavior is not a logical but a psychological connection. If we have deep ecological awareness or experience, of being part of the web of life, then we will [as opposed to should] be inclined to care for all living nature."

continued

The views expressed here are those of the author and do not necessarily reflect the opinion or agreement of the International Conference of Building Officials.

Operating from this premise, designers and builders of sustainable homes work intuitively to interface natural environmental services with building design. A modern home needs an interior temperature-control system, a system providing clean water for consumption and common use, and systems to manage both human waste and socio-economic behavior waste (garbage)—all of which have recyclable elements, if imaginatively conceived and intelligently executed.

Perhaps no other building designer has more radically interfaced all of these living systems than Michael Reynolds of Solar Survival Architecture. He started designing homes based on sustainable principles in Taos, New Mexico, more than 25 years ago. Now over 1,000 homes around the world incorporate his “living” building systems. These homes, called *earthships*, have built-in systems that take into account every human impact and need, hence why they are called “ships.” They are designed to make a family feel as independent and free as if they were on a long voyage, only in this case the ship is their home, their voyage is on Earth and their goal is to live equably with their environment.

My wife Sharon and I have lived in our 2,000 square foot (185.8 m²) earthship for five years. It could be described as typical or generic but, like each, has a certain uniqueness to it. Many people have seen or heard of Dennis Weaver’s earthship video on public television. Ours is of the same design and by the same architect.

The building is oriented such that its long front faces south. This is part of the heating system design, which uses solar gains penetration coming through the windows to “charge” the home in order to heat it in the winter. For those of us in the business, the two special days when the earth is balanced along its axis are the times we know which way the solar gain is moving in our homes. Right now, in mid-October, the solar gain is 10°F (6°C), warming the house for winter’s coming cold nights. By the winter solstice, the gain will penetrate 20°F (11°C). The system works so well without any backup heat that even if it gets down to 16°F (9°C) outside at night, when we get up in the morning it’s 62°F (34°C) inside and quickly warms up with additional solar penetration.

An element “married” (as Reynolds would say) to this system makes use of thermal mass. Earthships, whether built on flat ground, dug down into the ground a couple of feet or built into a south-facing hillside, have earth burial on three sides (some people, like me, cheat a little and put some windows and a door on the east side, but doing so reduces energy efficiency). The burial provides thromb walls that store the solar energy released at night. We have frequently commented to one another after coming home on a cold, windy night that it feels like a heater has been on.

The load-bearing walls that the burial is put against are constructed of engineered rubber-encased adobe building block (used car and truck tires). Tires are used for the following reasons:

- They have an estimated half-life of 30,000 years.
- They are free (except in north New Mexico, where so many earthships are being built that they have to be trucked in from elsewhere).
- Once they have been filled with on-site dirt and compacted to 90 pounds, tires make the most earth-friendly and strongest walls I have worked with or studied. They are earth-friendly because, being flexible, they do well in earthquakes and strong because they are 2½ feet (762 mm) thick and possess such longevity.
- They are exhausted and do not outgas. Studies based on leach-aid monitoring of old dumpsites have not shown traces of tire material. You may not have noticed, but you can smell tires when you walk by new ones in a store, but not when you go past a parking lot full of cars mounted with used ones. However, they do outgas when piled in sunlight, which is another reason to build with them and cover them up. This solves the problem of how to recycle waste tires in an environmentally sound way that surpasses any life-embodied energy analysis evaluation for a solid waste product problem that I’ve seen.
- Tire walls covered with natural adobe or stucco are fire- and termite-proof. They have gone through fires, hurricanes and earthquakes and have remained standing.
- Earth may be an excellent conductor (I guess that’s why it is called “ground”), but as a thermal mass wall it also works great. When the first row of tires are laid directly on existing compacted ground and then filled with dirt and compacted, they form a spread footing. Subsequent courses are staggered, as in a block wall. The resulting thermal mass provides excellent cooling in the summer and warming in the winter. In addition, openable skylights at the rear of the home draft warm air out in the summer and the earth’s thermal mass 72°F (40°C) temperature transfers up the tire thromb wall—the super-insulation of the burial.

We are living in harmony with the natural elements of the environment by having our windows on the south side so that solar gain does not come in during the summer, when we are tipped forward on the Earth’s axis. We have succeeded in not needing a forced-air conditioning unit, the most costly and energy consumptive appliance attached to a home, and can use a solar or wind electrical system to power our home independently. One of the primary reasons that the solar energy market has not taken off like it should is that it is not always economical to attach solar electric energy systems to conventional, energy inefficient buildings. They work best when integrated into a complete system of energy efficiency that uses all the free natural resource energy available.

Our earthship's 650 watt power system cost \$4,500 and has never gone out. As Sharon is typing this article on the computer for me (I'm still a pen and paper person), a clothes iron, sewing machine, DC refrigerator/freezer and outdoor fountain are all going at once. We always have plenty of the power that a normal home consumes because the design implements maximum energy efficiency in all respects. More importantly, if the energy-efficient designs of sustainable building were universally adopted, families would be able to maintain their homes without the need for dangerous nuclear power or polluting coal- or oil-fired power plants in this country. People choose to contribute to a clean environment for future generations when they build homes that use clean, renewable energy sources. Ninety-nine percent of earthships use wind and/or solar energy, and it is more satisfying than you can imagine to be a part of this healthy interaction.

Another design element of earthships that promotes independence and responsibility involves the cycle of water use. Their roofs are designed to harvest rain water and divert it to cisterns for storage. Premade tanks can be used, but cisterns are frequently built into the sides of earthships, using the tire walls to form water storage tanks. It is amazing how often people say something like, "it doesn't rain enough to store water." This is an example of the mechanistic paradigm. The director of a city planning and zoning department made a comment to that effect to me once when I was on the town planning and zoning commission. "That is why you harvest it," I responded, "so you can save it for times of drought."

Water from the cisterns is brought into the home, filtered through a multi micron system and used regularly, thereby reducing the huge developmental infrastructure requirements of water supply and the nonpoint pollution problems clean water is facing these days. We then recycle the gray water from our showers and sinks to irrigate produce gardens along the front of the house. Rather than being wasted, this water is reclaimed to these self-contained and sealed indoor planters. The organic vegetables and flowers are efficiently top watered, and the remainder flows through a gravel bottom to the deep roots of our fig and banana trees. Our "kitchen sink" irrigation system—which has a sediment containment box to catch uncaptured food particles—grows red peppers, broccoli and flowers, and is designed to absorb the appropriate amount of gray water. The size of the planters was calculated by the amount of the gray water use developed and the plants' projected absorption rate. The same with the water from the bath—we grow lush vegetable plants that increase our self-sufficiency while

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contributing to the reduction of mass agricultural production, which requires that pesticides and fertilizers be put into the earth. This is just a small contribution toward the greater good.

Our toilets also use gray water. In the design of a water conservation system, this water is actually used for the third time by the toilet. Michael Reynolds' "black water" system is especially efficient because a huge volume of gray water has already been reclaimed and used, thus dramatically reducing the amount of black water (human waste) to be treated. If you can't get yourself to use a modern compost toilet system, then his above-ground sealed system works the best. Designed as part of the earthship, the waste system does not need expensive community sewer plants or ground-contaminating septic systems. Just as in gray water sealed systems, the black water goes to a particle-sealed containment tank and then flows to second and third containment beds designed to keep the liquid from going into the ground.

High moisture absorbing plants are grown in the second and third containers of the system to draw out the liquids. Again, the size of the system is based on projected volume use. As almost everyone knows, water is a precious part of our environment and vital to all living things. Conservation measures keep our water safe to use and allow us to be in close contact with its life-giving processes.

The earthship and similar designs can use many other recycled materials, limited only by the imagination. The end product is something that personifies a paradigm shift to a whole systems approach to human-built sustainability. A sustainable society is defined as one that satisfies its needs without diminishing the prospects of future generations. Just as building codes are written to preserve the health and safety of the public, sustainable building is emerging as a responsible way for humanity to preserve the health and safety of the planet. ■

Jack Ehrhardt is the co-founder of CERBAT, the Center for Environmentally Responsible Building Alternatives. The center, which also serves as an environmental education youth camp, is based in Kingman, Arizona, as is Ehrhardt's general contracting business.

Ehrhardt has been involved in the building industry for 25 years. He has been a licensed general building contractor for 15 years, and has been building sustainable structures for the past five years. He has served locally on the Planning and Zoning Commission, on the Board of Adjustment, and as chairman of the Building Board of Appeals. He is currently contracting the construction of a 5,000 square foot (464.5 m²) straw bale house. He is also acting as a consultant to the Arizona Army National Guard on a 6,000 square foot (557.4 m²) earthship project in Phoenix.