



Sandbag Shelter Prototypes

Various locations worldwide



Architect
Cal-Earth Institute

Design
Begun in 1992

Completed
Ongoing

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Various locations

Description

The global need for housing includes 17 million refugees and displaced persons – victims of natural disasters and wars. Iranian architect Nader Khalili believes that this need can be addressed only by using the potential of earth construction. After extensive research into vernacular earth building methods in Iran, followed by detailed prototyping, he has developed the sandbag or ‘superadobe’ system. The concept allows people to build their own shelter simply by packing whatever earth they find in their location into sandbags, which are then stacked into dome forms, held together by barbed wire. The shelters are structurally strong – able to resist earthquakes, fires, floods and hurricanes. They are extremely quick, easy and cheap to build. They can be made into permanent structures by rendering them with external plaster and adding any necessary ancillary spaces. They are sustainable in terms of energy, using only sun, shade and gravity. They are adaptable in terms of size, material and configuration, and the system can also be used to build roads and other infrastructure.

These shelters focus on the economic empowerment of people by participation in the creation of their own homes and communities to create sustainable developments that integrate traditional building materials with modern materials and technology, providing comfortable living spaces acceptable to modern safety standards.

Jury Citation

These shelters serve as a prototype for temporary housing using extremely inexpensive means to provide safe homes that can be built quickly and have the high insulation values necessary in arid climates. Their curved form was devised in response to seismic conditions, ingeniously using sand or earth as raw materials, since their flexibility allows the construction of single- and double-curvature compression shells that can withstand lateral seismic forces.

The prototype is a symbiosis of tradition and technology. It employs vernacular forms, integrating load-bearing and tensile structures, but provides a remarkable degree of strength and durability for this type of construction, which is traditionally weak and fragile, through a composite system of sandbags and barbed wire. Created by packing local earth into bags, which are then stacked vertically, the structures are not external systems applied to a territory, but instead grow out of their context, recycling available resources for the provision of housing. The sustainability of this approach is further strengthened because the construction of the sandbag shelters does not require external intervention but can be built by the occupants themselves with minimal training. The system is also highly flexible: the scale of structures and arrangement of clusters can be varied and applied to different ecosystems to produce settlements that are suitable for different numbers of individuals or groups with differing social needs. Due to their strength, the shelters can also be made into permanent housing, transforming the outcome of natural disasters into new opportunities.

Essay

Architect Nader Khalili started his career as a modernist and achieved success building conventional high-rises. But in 1975 he closed his offices in Los Angeles and Tehran and set out alone by motorcycle into the deserts of his native Iran, convinced that the only way the world's poor could ever afford homes was to build with earth and fire. He dedicated his time to researching traditional vernacular mud construction in Iran and began to work on ideas for using earth as a modern building material. As well as developing a concept for a 'Ceramic House' constructed from sun-dried mud and then fired, Khalili also developed 'Superadobe' – a structure made from sandbags secured with barbed wire. The basic construction technique involves filling sandbags with earth and laying them in courses in a circular plan. The circular courses are corbelled near the top to form a dome. Barbed wire is laid between courses to prevent the sandbags from shifting and to provide earthquake resistance. Hence the materials of war – sandbags and barbed wire – are used for peaceful ends, integrating traditional earth architecture with contemporary global safety requirements.

Using this technology, several design prototypes of domes and vaults were built and tested, including emergency shelters for refugees and the homeless, a sustainable small house called 'Eco-Dome', and a conventionally planned four-bedroom home using a three-vault design concept. The system is particularly suitable for providing temporary shelter because it is cheap and allows buildings to be quickly erected by hand by the occupants themselves with a minimum of training.

Khalili found inspiration for the technology and design of the structures in the principles of Iranian architecture and Sufi philosophy: the unity of the elements of earth, water, air and fire; harnessing sustainable energy – sun, shade, gravity; geometry and symmetry; and the unity of tension and compression. Each shelter comprises one major domed space with some ancillary spaces for cooking and sanitary services. The system is extremely flexible. The earthen materials of clay and sand with straw and water that have been used to make traditional sun-dried mudbricks for millennia are not always available, nor do those most in need of a home have the time to make blocks, dry them and store them. By filling bags directly from the land and reinforcing them with barbed wire, almost any earth can be used and the speed of building is much faster. The structures can be temporary or they can be made permanent by adding a layer of mud daub or other finishing. Incremental additions such as ovens and animal shelters can also be made to provide a more permanent status and the accommodation can be tailored to individual needs. The technology can also be used for both buildings and infrastructure such as roads, kerbs, retaining walls and landscaping elements.

The system employs the timeless forms of arches, domes and vaults to create single and double-curvature shell structures that are both strong and aesthetically pleasing. While these load-bearing or compression forms refer to the ancient mudbrick architecture of the Middle East, the use of barbed wire as a tensile element alludes to the portable tensile structures of nomadic cultures. The result is an extremely safe structure. The addition of barbed wire to the compression structures creates earthquake resistance; the aerodynamic form resists hurricanes; the use of sandbags aids flood resistance; and the earth itself provides insulation and fireproofing.

The earth used to fill the sandbags is taken from the site where shelters are required and comprises at least 90 per cent of the filling material, although stabilizers such as cement, lime and asphalt emulsion may be added. The barbed wire is four-point, two-strand, galvanized barbed wire and is recyclable. Materials research has shown that the majority of existing bags made of both natural and synthetic material can be used. The ideal is a synthetic, ultraviolet-resistant, degradable material. In a temporary building, the bags are allowed to degrade and the building returns to earth. For permanent structures, the synthetic bags are plastered over to provide an erosion-resistant layer.

Because the structures use local resources – on-site earth and human hands – they are entirely sustainable. Men and women, old and young, can build since the maximum weight lifted is an earth-filled can to pour into the bags. Barbed wire and sandbags are supplied locally, and the stabilizer is also usually locally sourced. The shelters are also sustainable and efficient in energy terms: the wind and the sun provide passive cooling and heating and the sandbags provide thick walls that resist changes in temperature.

Since 1982, Nader Khalili has developed and tested the Superadobe prototype in California. He has lectured widely on the concept, including presenting his ideas at NASA's first Lunar Habitat Symposium in 1984, where he proposed construction with lunar soil. In 1991 he founded the California Institute of Earth Art and Architecture (Cal-Earth), a non-profit research and educational organization that covers everything from construction on the moon and on Mars to housing design and development for the world's homeless for the United Nations. Cal-Earth has focused on researching, developing and teaching the technologies of Superadobe. The intense desert environment of California, with summer temperatures regularly exceeding 40°C and harsh winters with snow and freezing temperatures, flash floods, high winds, and the most dangerous seismic zone in the United States, has provided an ideal testing ground.

The prototypes have not only received California building permits but have also met the requirements of the United Nations High Commissioner for Refugees (UNHCR) for emergency housing. Both the UNHCR and the United Nations Development Programme have chosen to apply the system, which they used in 1995 to provide temporary shelters for a flood of refugees coming into Iran from Iraq.

Throughout the period of prototype building and testing, Khalili's educational philosophy has continued to develop. A distance-teaching programme is being tested for the live broadcast of hands-on instruction directly from Cal-Earth. Many individuals have been trained at Cal-Earth to build with these techniques and are carrying this knowledge to those in need in many countries of the world, from Mongolia to Mexico, India to the United States, and Iran, Brazil, Siberia, Chile and South Africa.

Project Data

Architect: Cal-Earth Institute, US: Nader Khalili, concept and design; Iliona Outram, Project Manager.

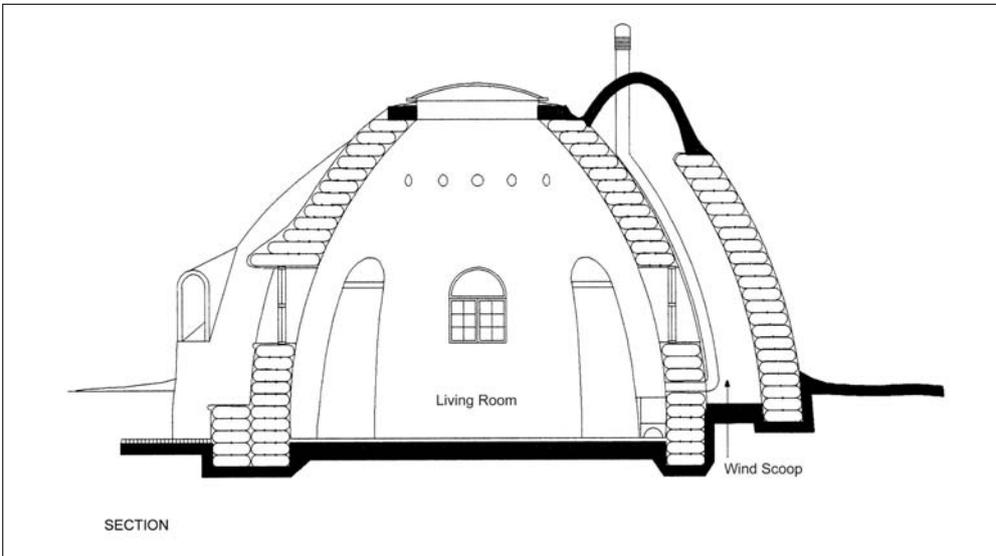
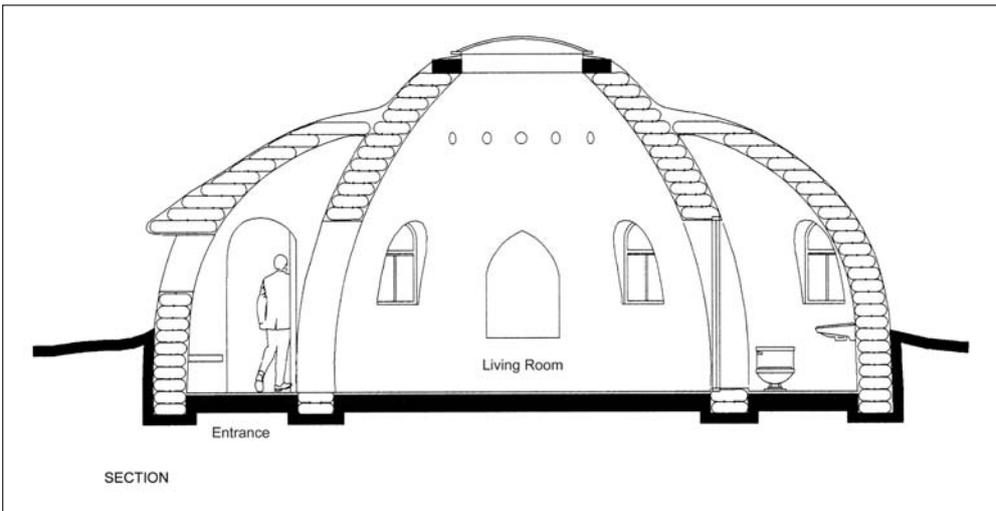
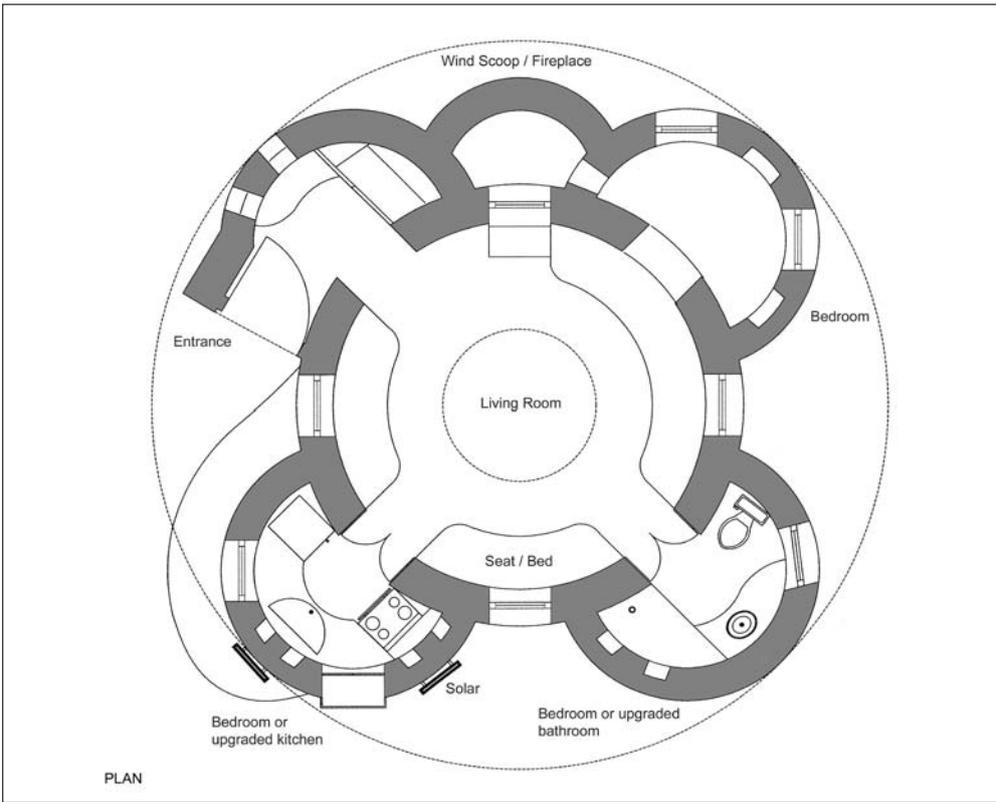
Consultants: P. J. Vittore Ltd, US, and C. W. Howe Associates, US, structural engineers.

Sponsors and clients: National Endowment for the Arts, US; Southern California Institute of Architecture (Sci Arc), US; the Ted Turner Foundation, US; United Nations Development Programme (UNDP), US and Switzerland; United Nations High Commissioner for Refugees (UNHCR), Iran offices; the Bureau for Alien and Foreign Immigrant Affairs (BAFIA), Iran; Laura Huxley's Our Ultimate Investment Foundation, US; the Rex Foundation, US; Kit Tremaine, US; the Leventis Foundation, Cyprus; the Flora Family Foundation, US.

Prototypes built to date by: Hamid Irani and Iraqi refugees at Baninajar Camp, Iran; Eric Hansen, Mexico; Djalal and Shahla Sherafat, Canada; Michelle Queyroy and orphans at the MEG Foundation, India; Dada Krpasundarananda, India, Thailand and Siberia; Mara Cranic, Baja, Mexico; Virginia Sanchis, Brasil; Patricio Calderon, Chile; Jim Guerra and Mexican farmworkers, US; Don Graber, Craig Cranic, Giovanni Panza and Yacqui People of Sarmiento, Mexico.

Timetable: Sandbag Shelters (Superadobe): first development, 1992.

Nader Khalili (b. 1937, Iran) trained as an architect in Iran, Turkey and the United States. From 1970 to 1975, he practised architecture in Iran, and has since dedicated himself to research into building with earth. He has served as a consultant to the United Nations (UNIDO) and a contributor to NASA. Mr. Khalili founded the California Institute of Earth Art and Architecture (Cal-Earth) in Hesperia, US, and teaches architectural research at Sci Arc. He has received awards from organizations such as the California chapter of the American Institute of Architects, for 'Excellence in Technology'; the United Nations and HUD (US Department of Housing and Urban Development), for 'Shelter for the Homeless'; and the American Society of Civil Engineers (Aerospace Division), for his work in lunar-base-building technology. He is the author of five published books, including two translations of the work of the thirteenth-century Sufi poet, Jalal-e-Din Mohammad Rumi.





Demonstration of the construction of domes with multiple niches and rooms using the “superadobe” method that meets United Nations standards.

The sandbags can be filled and layed by one person.



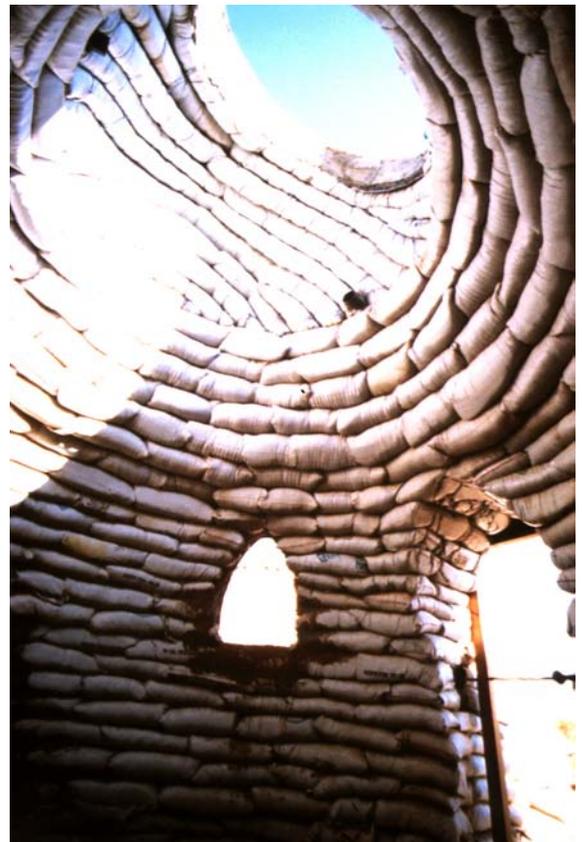


Demonstration image.

Interior of a prototype dome showing corbelled sandbags, and apses using traditional “leaning arches” technique.



Demonstration image.





This is an example of a small house (34 sq. m.) with five rooms formed by a dome with four large apses. The temporary shelter can be upgraded into permanent housing, as seen below.





Cal-Earth Institute variations.

Baninajar Refugee Camp in Iran.



A prototype in Mexico.



Another example from Mexico.





A prototype as constructed in Canada.



An example of the prototype in Chile.





Two different examples from India, above and below.





Prototypes built by the Yacqui People of Sacramento, Mexico.





Brazil.

