ADOBE DOME HOUSE

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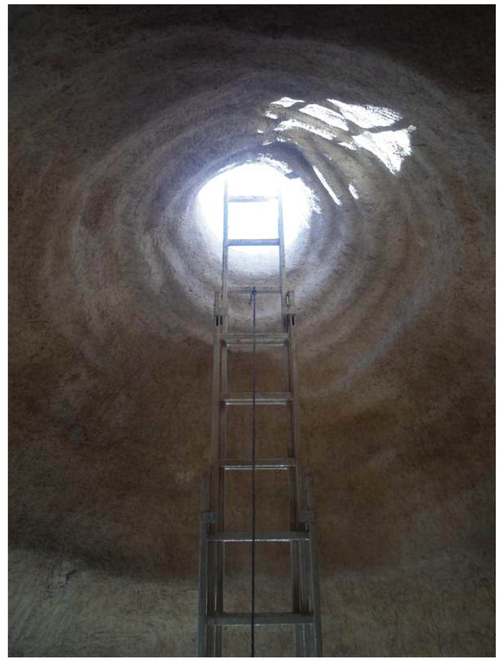
INTRODUCTION

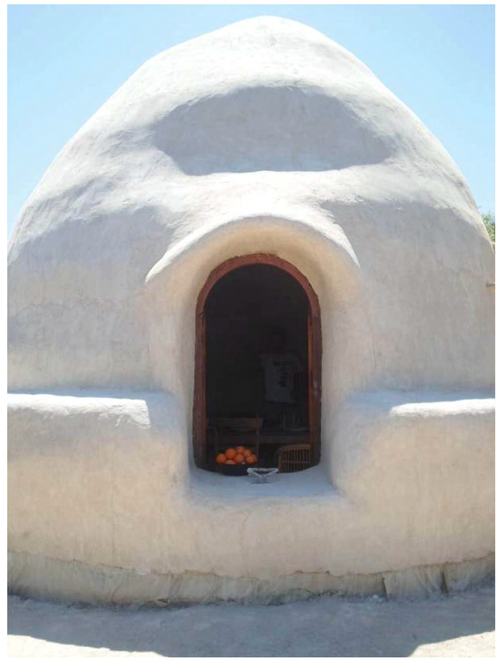
SUPERADOBE HOME. FRESNEDILLA, SPAIN

Buildings account for thirty-nine percent of the carbon dioxide emissions in the United States. This is why I wanted to help construct an off-grid superadobe home. Superadobe is a construction technique developed by the Iranian-American architect Nader Khalili. The technique involves layering long fabric tubes filled with adobe to create dome-shaped structures of compressed earth. It was developed for NASA as a housing prototype for future settlements on other planets. For this reason the technique involves minimal off-site materials, simple repeatable geometries, and a reliance on thermal mass in order to conserve energy. Superadobe has never been implemented on other planets, but on earth it is being used as a sustainable construction technique and a possible solution for emergency housing for disaster relief.

One of the greatest strengths of superadobe construction is its ability to adapt to different climates. By using a mixture of the local earth, substrate, and lime, the building relates to the surrounding landscape and will eventually, with time and maintenance, become a form of limestone. This method creates thick walls that act as great thermal insulators while also acting as a breathable skin for moisture to pass through. This prevents the structure from cracking from frost and thaw and ensures a greater lifespan of the structure.

The pictures to the right show the process of building the living-room dome structure. The form is composed of concentric circles that are made smaller as they rise, creating the dome shape. These layers add about 8cm of height to the dome with each bag, a team of three being able to lay approximately three bags a day. The process creates a structure reminiscent of a clay coil pot. Layering the earthbag coils taught me about material assembly, force loads, and adobe curing. More importantly, the slow process of building the walls gave me a greater understanding of scale and enclosure. It was remarkable how the space changed with each additional 8cm bag. This experience gave me a more precise





CHICKEN HOUSE

The adobe walls of the chicken coop are composed of a failed wall previously used around the windows in the living room. We then collected branches, striped them of their bark, and used them as roof supports. A salvaged plastic tarp was then draped over and held in place by a layer of river stones left over from the foundation work. The straight wall is made up of recycled palettes and acts as a large door to accommodate cleaning and letting the chickens out.

PROCESS

Superadobe construction can be broken down into six stages : site analysis, design development, foundation work, earthen wall construction, plastering, and lime washing. These homes are inherently well insulated and well adapted to virtually all climates. Although solar orientation is important and can be beneficial, the thermal mass of the earth walls provides enough protection from the elements in all seasons. Because of this, the home in Fresnedilla, Spain was designed to privilege views of the Sierra de Gredos mountains to the north, not focusing on passive solar heating in the winter. The soil of the acre plot of land was then analyzed and measured in salinity and clay composition. A one thousand meter deep well was also dug on site to supply water for construction. The only purchased construction materials were foundation aggregate, liquid and powder lime, polypropylene bags, and barbed wire.

The site was prepared by renting a bulldozer to extrude a portion off hillside on the land measuring five by ten meters, supplying the earth that composes the majority of the home. The plan of the house was then drawn on the ground using a compass attached to stakes set in the center of each dome. These stakes remained in the center of the domes throughout the construction process to measure the geometry and ensure a circular dome. During the site analysis, it was calculated that the earth mixture formula should be composed of seven parts earth to one part water, one part liquid lime, and one fourteenth part powdered lime. First, a trench was dug 20cm along the home's outline on the ground. The trench was 46cm wide; large enough for two compacted earth-filled polypropylene bags to fit inside.

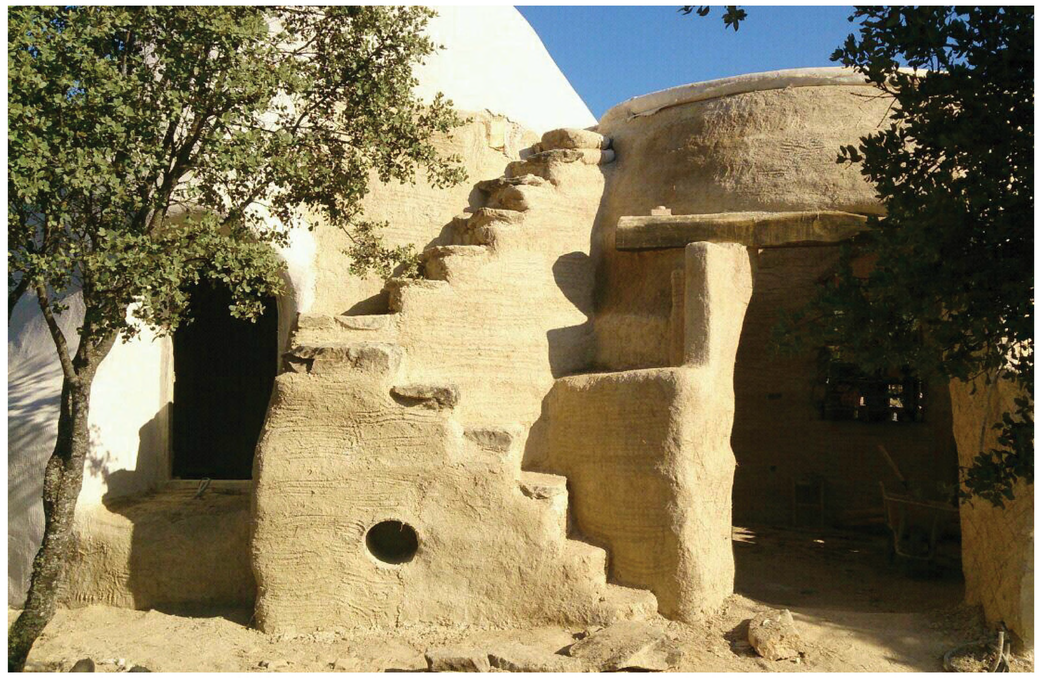
The trench is first filled 5cm deep with river stones, providing easy drainage around the foundation. After the foundation of river stones, the first layer of earth bag is ready to be laid. First, you walk along the outline of the circular foundation, counting each step and walking heel to toe. You then walk along an unrolled polypropylene bag until you reach that number plus an additional six feet. This addition six feet allows for extra length in the bag for the sealing process. The earth, water, and lime are placed in a mixer then carted over to the foundation site using two wheelbarrows. Folding the bag under one foot, one person holds the bag up while another fills it with the Adobe mixture using a half-gallon bucket. The bag is filled vertically for a few feet in order to allow gravity to compact the mixture and ensure it is at a consistent volume. The bag is slowly filled inside the foundation trench and then folded under itself with the remaining sack once it reaches the other end of the bag. The bag is then compacted using a manual, weighted compacting pole until the entire surface is even and flat. Barbed wire is then attached to the top of the bag by puncturing the bag with every fifth barb; twisting the wire after the placement of each barb. The barbed wire keeps the bags from slipping out of place.

This method for filling the bag is then repeated beside the first ring. This double bag thickness acts as a buttress for the walls of the dome and prevent it from splaying outward under compression. The process is repeated vertically for approximately one meter of double sack thickness. Afterward, wood formwork is placed in the home towards the north; creating voids for the windows. The stake in the center of the dome attached to the chain compass is also a meter in height. The chain compass is used from now on to ensure a consistent inward curve of the dome. Now each sack is laid above the previous and measured by running the chain around the interior rim; making sure each sack is approximately three centimeters closer to the center. As the chain is pulled vertically to meet each additional ring, the circle becomes smaller and creates the dome structure. The last ring's interior dimension is small enough to accommodate a skylight, creating the oculus.

Once all the bags have dried, a flamethrower is used to burn off all of the exposed polypropylene sack. This is done to ensure the interior plaster binds with the Adobe walls. The interior plaster is composed of 3 parts earth, half a part of liquid lime, and a few handfuls of straw to act as a binding agent. The interior and exterior of the dome is coated with this mixture by hand for several layers. Once the exterior has a consistently smooth appearance and the rings of earth are no longer visible, the window formwork is removed and the exterior is coated I in a lime wash several times. The lime wash protects the domes from water damage and creates a hard outer shell. The interior is applied with another type of plaster consisting of clay, earth, and pigment and comes is blues, yellows, reds.

CONSTRUCTION

The construction of the domes is a slow process. These photos were taken two- months apart. The two images above illustrate the transition from a half way constructed dome with exposed bags to the completed North façade of the domes with their first lime-plaster coat.



APPLICATION

At its simplest description, superadobe is the transformation of a mound of earth into a piece of architecture. The resulting structure has a sense of place that is unparalleled. Something about the house being composed of the earth that surrounds it, or the optimism and collaborative effort that resulted in its design. These domes were in rural Spain and were part of the operation of a homestead consisting of a vegetable patch, chicken coop, and a composting system that generated virtually no waste; all on two acres of land. Juxtapose this to the land use and produce yield on the typical suburban lot in the United States and the differences are startling. Superadobe homes have the potential to generate a more sustainable way of life in the United States by maintaining the low-density appeal of the American suburb while introducing a more independent way of living.

ADOBE STAIRS

While working on the home, the client decided to redesign the kitchen dome into a cylinder with a roof terrace on top. A local structural architect and myself designed the stairs to reach the terrace by utilizing the existing buttressing bags to create the first risers in a scissor back stair. Once the bags were laid, the polypropylene was burned off and stones were placed on top to create the stair treads. These stones were cemented in place using a mixture of lime, water, earth, and sand.

PALLET CHAIR

Inspired by the Adirondack chair, it is composed of recycled pallets and was built using a jigsaw, hammer, and recycled nails. The limited tool resources resulted in a frame construction with plank infill. The staggered wood planks are utilized to create geometric shadow-line patterns and a tapered back support.

PLASTERING

These images show the process of painting the polypropylene sacks at the highest part of the dome with a coat of tar for waterproofing. The bag is then covered with the plaster mixture and punctured with finger holes to allow a greater connection to the next layer of plaster by increasing surface area. The first step is to fill the ridges between the sack layers with plaster. This is repeated until the wall becomes a smooth, even surface. This usually takes six separate layers of plaster. Once these are dry, the lime-wash plaster is applied to the exterior for the final exterior shell.