A STUDY ON FEASIBILITY OF EMERGENCY SHELTER THROUGH SUPERADOBE TECHNOLOGY

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ABSTRACT

Superadobe is a form of earth bag construction that was developed by Iranian architect "Nader Khalili". The technology uses layered long fabric tubes or bags filled with adobe to form a compression structure. The resulting beehive shaped structures employs corbelled arches, corbelled domes, and vaults to create single and double-curved shells that are strong and aesthetically pleasing. It has received growing interest for the past few years in the natural building and sustainability movements. In the last century earth bag buildings have undergone extensive research and are slowly gaining worldwide recognition as an optimum solution to the global epidemic of housing shortages. The technique's current pioneer is Nader Khalili who originally developed the superadobe system in 1984 in response to a NASA call for housing designs for future human settlements on the Moon and Mars. His proposal was to use moon dust to fill the plastic Superadobe tubes in layer. The Super Adobe Method is now use in Canada, Mexico, Brazil, Chile, Iran, India, Siberia, Thailand, as well as in the U.S.

Keywords: Superadobe Construction; Earthen Housing; Corbelled Structure; Emergency Shelter; Eco Dome; Layered Construction.

1. INTRODUCTION

1.1. General Analysis

Superadobe (sandbag and barbed wire) technology is a large, long adobe. It is a simple adobe, an instant and flexible line generator. It uses the materials of war for peaceful ends, integrating traditional earth architecture with contemporary global safety requirements. Long or short sandbags are filled with on-site earth and arranged in layers or long coils (compression) with strands of barbed wire placed between them to act as both mortar and reinforcement (tension). Stabilizers such as cement, lime, or asphalt emulsion may be added. This patented and trademarked (U.S. patent #5,934,027, #3,195,445) technology is offered free to the needy of the world, and licensed for commercial use. This concept was originally presented by architect Nader Khalili to NASA for building habitats on the moon and Mars, as "Velcro-adobe". It comes from years of hands-on research and development, and searching for simple answers to build with earth. It comes from the concerned heart of someone who did not want to be bound to any one system of construction and looked for only one answer in human shelter, to simplify.

1.2 The Structural Principles

The structural principles of the timeless forms of arches, domes, vaults are built with the materials of earth, sandbags and barbed wire using the engineering of single and double curvature compression shell structures, to reach the ultimate in strength and aesthetics. In Superadobe, the ancient earth architecture of the Middle East using sun-dried mud bricks is fused with its portable nomadic culture of fabrics and tensile elements, not just through design and pattern, but through the structure itself. Structural design uses modern engineering concepts like base-isolation and post-tensioning. The innovation of barbed wire adds the tensile element to the traditional earthen structures, creating earthquake resistance despite the earth's low shear strength. The aerodynamic forms resist hurricanes. The innovation of sandbags adds flood resistance, and easy construction, while the earth itself provides insulation and fire-proofing.

The Superadobe can be coiled into vaults and domes, the way a potter coils a pot, with barbed wire reinforcement, to build structures which pass international earthquake codes. These structures can last for one season before returning to earth, or they can be stabilized, waterproofed, and finished as permanent houses. The system can be used for structural arches, domes and vaults, or conventional rectilinear shapes. The same method can build silos, clinics, schools, landscaping elements, or infrastructure like dams, cisterns, roads, bridges, and for stabilizing shorelines and watercourses. The whole family can build together, men and women, from grandma to the youngest child. As such, many years have been spent researching hands-on how to make the process simpler and easier. There is no heavy lifting or backaches, no expensive equipment, and is a flexible and fast construction. The bags are filled in place on the wall using small pots like coffee cans, or even kitchen utensils. It can be build alone or as a group.

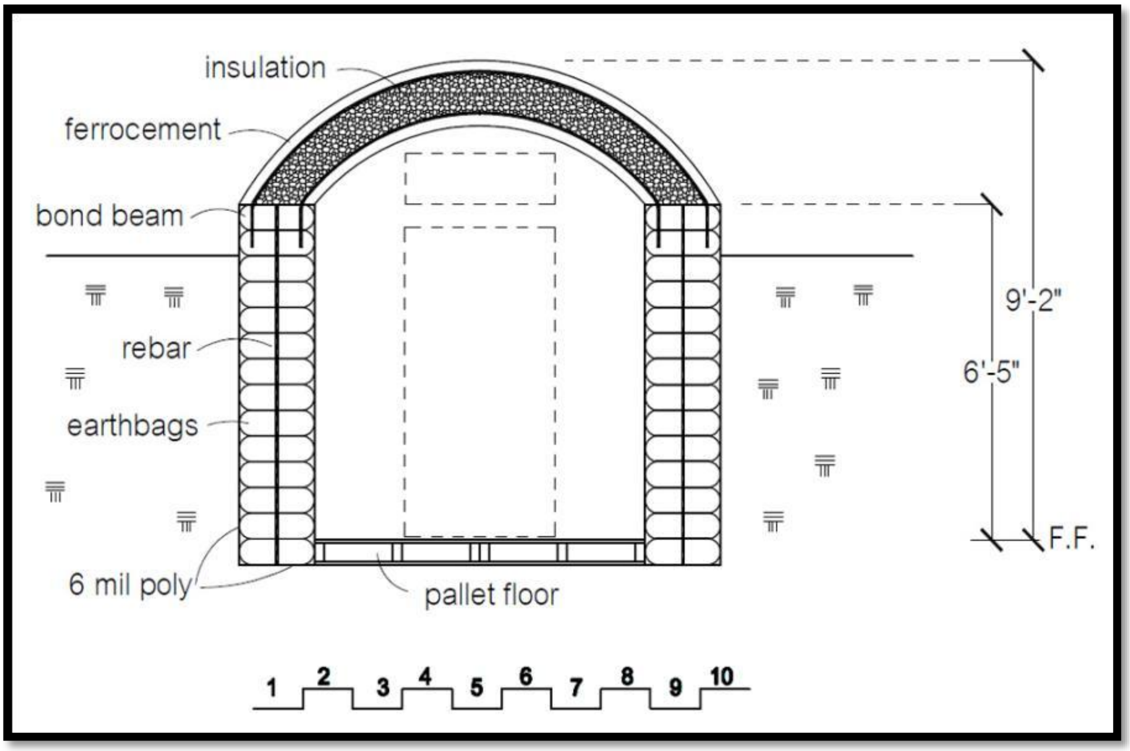

Figure 1: Superadobe structure plan (sample)

1.3 Methodology

Superadobe Materials

Many different materials can be used to construct Superadobe. Normally earth or sand, cement or lime, and Superadobe polypropylene tubing; bags can be polypropylene, or burlap. What is important is that they are UV resistant or else quickly covered in plaster. Virtually any fill material will actually work including un-stabilized sand, earth, gravel, crushed volcanic rock, rice hulls, etc. If the fill material is weak the bags have to be really strong and UV resistant, or else plastered right away.

The material can be either wet or dry, but the structure is more stable when the tube's contents have been moistened. Other materials needed include water, shovels, tampers, wheel barrow, mechanical pumps, scissors, compass, large plugs or pipes (for windows), and small buckets or coffee cans for filling the sacks. If you decide to go the quicker way, then electric or pneumatic tampers can make the tamping easier, electric or gas powered bucket chain that can reach 7 meters or higher would eliminate the need of manual filling of sacks or tubing using coffee cans or small pails.

Construction Process

The foundation for the structure is formed by digging a 30 cm deep circular trench with 2 to 4m diameter. Two or three layers of the filled polypropylene sand tubes (superadobe tubing) are set below the ground level in the foundation trench. A chain is anchored to the ground in the center of the circle and used like a compass to trace the shape of the base. Another chain is fastened just outside the dome wall: this is the fixed or height compass and gives you the interior measurement for every single layer of superadobe bags as they corbel ever higher. The height compass is exactly the diameter of the dome. The center chain/compass is used to ensure the accuracy of each new superadobe layer as it is laid and tamped. The compasses must be made of non-stretchy material to ensure an accurate geometry.

On top of each layer of tamped, filled tubes, a tensile loop of barbed wire is placed to help stabilize the location of each consecutive layer: it plays a crucial role in the tensile strength of the dome - it is the 'mortar'. Window voids can be placed in several ways: either by rolling the filled tube back on itself around a circular plug (forming an arched header) or by waiting for the earth mixture to set and sawing out a pointed arch void. A round skylight can even be the top of the dome.

It is recommended to not exceed the 4m diameter design in size, but many larger structures have been created by grouping several "beehives" together to form a sort of connected village of domes. Naturally this lends itself to residential applications, some rooms being for sleeping and some for living.

Exterior Treatment

Once the corbelled dome is complete, it can be covered in several different kinds of exterior treatments, usually plaster. Khalili developed a system that used 85% earth and 15% cement plaster and which is then covered by “reptile”, a veneer of grapefruit sized balls of cement and earth. Reptile is easy to install and because the balls create easy paths for stress, it doesn't crack with time. There are many different possibilities. Some Superadobe buildings have even been covered by living grass, a kind of green roof but covering the entire structure. Any exterior treatment and building details would need to be adapted to a region’s specific climatic needs.

Figure 2: A typical superadobe structure

Figure 3: Superadobe structure with finishing

1.4 Advantages of Superadobe Domes

- Natural, reversible and recyclable building materials are used causing no harm to health and environment.
- Good thermal mass material: perfect heat storage capacity, regulation of temperature and humidity resulting comfortable interior microclimate.
- Good acoustic parameters.
- Statically strong, durable and resistant even to extreme weather conditions and natural catastrophes like flood, windstorm, fire, hurricane and earthquake.
- Wide range of use.
- Harmonic and diverse – traditional or modern forms and styles.
- Economic and environment friendly, easy and quick building with locally available materials, small waste production, minimal need for industrial background and use of machines, low shipping costs, low energy input and environmental pollution.
- Low housekeeping costs.
- Anyone can learn this building technology, the whole community from young to old.
- With building vaults and domes one can omit and minimize the use of wood, iron or reinforced concrete bond, beam system and roofs.
- Ideal for humanitarian purpose, strengthen communities and equal opportunities.

1.5 Disadvantages of Superadobe Domes

- It does take a lot of people to build a house by hands only.
- It gets difficult after several hours of lifting the heavy bags.
- It isn’t easy to understand at first when you look at the way it is being built.
- It takes strength to lift and carry each bucket.
- No mention of them in building codes.
- High moisture content and dampness cause serious problems.

2. EMERGENCY AND TEMPORARY SHELTER

An emergency shelter is a place for people to live temporarily when they cannot live in their previous residence, similar to homeless shelters. The main difference is that an emergency shelter typically specializes in people fleeing a specific type of situation, such as natural or man-made disasters, domestic violence, or victims of sexual abuse A more minor difference is that people staying in emergency shelters are more likely to stay all day, except for work, school, or errands, while homeless shelters usually expect people to stay elsewhere during the day, returning only to sleep or eat. Emergency shelters sometimes facilitate support groups According to Khalili's, emergency, impermanent shelters can be built using only dirt with no cement or lime, and for the sake of speed of construction windows can be punched out later due to the strength of the compressive nature of the dome/beehive. Ordinary sand bags can also be used to form the dome if no Superadobe tubes can be procured; this in fact was how the original design was developed. There is a great potential for long-term emergency shelters with Superadobe because of the simplicity of construction. Labor can be unskilled and high physical strength or formal training is unnecessary for the workers, so women and children are able to substantially contribute to the construction process. Local resources can be used with ease. Superadobe is not an exact art and similar materials may be substituted if the most ideal ones are not readily available.

A 400-square-foot (37 m^2) house, with bedroom, bathroom, kitchen, and entry can be put up in about four weeks, by one skilled and four unskilled people. Emergency shelters can go up much more quickly. During the gulf war every five incoming refugees put up a simple structure in five days. It's emergency shelter, but if you cover it with waterproofing and stucco, it will last for 30 or more years.

2.1 Serviceability Considerations of Superadobe Structure

1) Floor of a Superadobe building is usually finished last.
2) Plumbing and electrical lines are run underneath.
3) Plumbing pipes are placed on, in, or under the lower Superadobe layers and run vertically through small channels cut in to the walls.
4) Electrical lines are run through flexible conduit that follows the contours of the bags.

2.2 Structural Considerations of Superadobe Structure

Transfer their stresses along the surface of the structure and not from element to element like column- and beam-type building. Excessive loads on their surface will first cause a puncture failure but will cause only localized damage. Differential settlement and frost heaving do not pose severe problems. DL and LL stresses are transferred to the supporting ground, spreading uniformly along the perimeter of a dome or bearing wall.

A dome or bearing wall built on a floating foundation, the base isolated by a layer of gravel or sand, provides the ideal earthquake-resistant structure. The continuous or ring foundation can slide across the moving ground, while the upper structure, which diminishes exponentially in mass toward the apex, it performs as a unified monolithic piece thus eliminating local failure higher up the building.

2.3 Sustainability of Superadobe Structure

It is realized as a green building technique, the system is extremely cheap and easy to build. Soil can be taken right from the site, and the bags can be obtained for free or for a low cost, this technique demands few skills and is accessible to low income communities.

Building can be erected very quickly and the system is very flexible, allowing for alterations in design and construction.

Major ingredient is earth, which is nontoxic and readily available, in terms of energy conservation, the walls are very thick and have significant thermal mass, which reduces heating and cooling costs, it provides good sound insulation, structural integrity, fire resistance, and protection against pests.

2.4 Thermal Performance

Earthen walls function as an absorbent mass that is able to store warmth and re-radiate it back, this temperature fluctuation is known as the “thermal flywheel effect". Effect of flywheel is a 12 hour delay in energy transfer from exterior to interior, at hottest time of the day the inside of earth bag structure is at its coolest, while at the coolest time of the day the interior is at its warmest.

Thermal performance is regulated by placement and condition of windows and doors, climatic zone, wall color, wall orientation, wall thickness.

CONCLUSIONS

Here are some conclusions for superadobe technology:

- It is inexpensive technology.
- Natural, reversible, recyclable building materials are used which are not harmful to our health and the environment.
- It has low energy input and causes very less environmental pollution.
- Small waste production is there.
- It is economic and environmentally friendly.
- It is statically strong, durable, and resistant even to extreme weather conditions and natural catastrophes like flood, windstorm, hurricane, fire, and earthquake.
- Reduces global warming.
- Speedy in construction.

Hence, it is a feasible technology and can be used in future to promote sustainable development.

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