Abstract

The Superadobe is an economical, time efficient, energy efficient and ecologically friendly system which was created by Nader Khalili, an Iranian-born architect. Superadobe system connects the natural materials and rural traditions to create a new way to use natural materials such as mud, water, air and fire, which can be finished in a short time without any large construction equipment. It is a very convenient building option for disaster regions as well as low-income areas. It has great social and environmental value. The goal of this study is to introduce the building system, analyze the ventilation, lighting and insulation of the prototype of Superadobe system. Meanwhile talk about why it has Local characteristics and discuss the possible scope of its application.

1. Introduction

Superadobe is a form of earthbag construction that was developed by Iranian architect Nader Khalili(Lambert M Surhone et al. 2010). The technique uses layered long fabric tubes or bags filled with clay to form a compression structure. (Katauskas, Ted.2007)The system connects traditional and natural resources such as mud, water, air and fire to create energy efficient houses. It supplies an effective way for an individual to build residence in a very short period of time without assistance. Due to the self-supporting arched roof structure, it can be one single space, or form more spaces through merging multiple arch systems (Fig.1). This allows for flexibility and variability of the
Due to its materials are native and recyclable as well as its structure needs no construction equipment, and its prototype has good ventilation, lighting and insulation. Superadobe is a kind of ecological and sustainable building system.

The inspiration and concept for the Superadobe system originates not from the modern architecture design experience, but from the influence of traditional rural buildings and landscape, together with a 13th century Persian poet named Rumi. Born in Iran, Nader Khalili earned his architectural design certification in California in 1970. Like many other architects, Khalili had designed many skyscrapers and then realized that he should do something meaningful for those in need. Khalili gave up his work as a modernism architect in the USA and traveled to the desert area in Iran for five years. When viewing all that with a new perspective, Khalili saw wonderful, pure and valuable traditional rural architecture and affected and moved by tens of thousands of rural mud rooms. Rumi conceived that elements such as water, air and fire in the land have a great power which can cycle inside and outside of the life. If these elements can be well balanced, the environment and all life in the world would have good status.
Rumi had said “The earth will become the gold of the wise”. Affected by Rumi, Khalili realized the value of the earth and formed his design concept using clay to build (Fig.2) and fire to burn (Ceramic House).

Nader Khalili began to research how to use natural resources as much as possible and to study the possibility of no use of high technology to build house in modern world. The Superadobe system could satisfy above request and it has good seismic performance. It is a good option for the poor and is also suitable for the moon. In 1986, Khalili founded a research organization called Cal-Earth which began practice in the California Hysperia area of the Mojave Desert. His main studies are about earth art and the technical problems of clay construction. The scope of his research includes building a house on the moon with technical innovations for NASA (National Aeronautics and Space Administration) as well as building housing for homeless people in the United States. The building philosophy seeks harmony between art and nature. The sandbag engineer prototype won the Aga Khan Award in 2004[8]. Cal-Earth has posted their concepts and methods on the Internet. The works and practices of Cal-earth have been studied by other research institutions as a model.

2. Material and methods

Mud, water, air and fire are the main materials of the Superadobe System. The building process is easy and time efficient, but a lot of patience is necessary. (Fig.3)

Firstly, collect some tools such as scissors, a rod, a shovel, a roll of woven sacks, short tubes, kegs or coffee tank, a roll of metal wire with barbed and a pair of pliers. Then dig mud from the base of the ground and mix some cement and water together, add cement or lime or an asphalt emulsion for reinforcement. Add enough water and squeeze it into a ball until it does not stick to your hand. The location of the entrance should be chosen to avoid the rain and the winds. Dig a 30cm deep trench in the base, and flatten the soil to compact it. Then, lay a bag along with the ditch. Fold the tail section to make it closed, and then it will be like a short rising column. Pour the soil into the bag and constantly shake it into the bottom. A good method inclining the bag to your feet in the helping of the gravity could be used to prevent the bags twisted, and withdraw your foot after the bag is well filled. Then correct its position by a compass. Make sure the tail section of the bag is well folded to close. A tamping is used to make the
sandbag compacted. To make it smooth, fixed and uniform sealing good until they become strong enough. In order to make them stable, barbed wire is tied between the different layers of sandbags. First wire is 4 meters long, the next need more 65cm longer to make sure overlapping part when fracture occurred. When build it in certain height using two compass to ensure the shape of the roof. The one is central compass formed with a wire rope or other chain unable to stretch and the ground center. The other is a height compass that can be increased according to the layer. And the sandbag should be rearranged if it’s not matches compass trajectory.

The next step is making the door and windows. Cutting parts of the sand bags to form openings. Excision and then tamping to make ensure that cutting soil not to stick in original sandbags. The door could be pushed when at least 5 layer sandbags is masonry. Insert the pipe into the sandbag as a window. In order to prevent the rain inflow to inner, the pipe should be inclined to external. Keep the bag indentation in the top and form an adobe. Add the arched doorway to support and protect the entrance. The door way could be arched or sloped, higher or lower (Fig.4).

Finally step is protecting work. Cover the surface with concrete before the bag is weathering. And cover waterproof material to let it to be moisture proof and anticorrosive. In the basic of the works above, it can be end up with a smooth or a lime surface.

3. Results

In order to discuss the system’s energy sufficient characters, it can be analyzed from aspects of ventilation, lighting and insulation. The prototype be chosen is a single adobe.

First of all, the dome roof has better ventilation effect than the flat one when they share the same inner wall length. (Fig.5) when the model has been overlap together, the height from roof windows to the floor certifies that dome roof has accelerated the air fluent better because it forms a Stack effect. In order to analyze the ventilation of the prototype of Superadobe, the author use PHOENICS to simulate and gets a conclusion which can be seen in the Figure 6-7.

Then, saw the material choice. The natural material mud has good thermal inertia, and it has better insulation than brick and concrete. The openings of Superadobe are all not very big. This practice can reduce the heat bridge and make the maintenance structure has good integrity. Moreover, dome roof increases the heat radiating area. The system can use skylight to save artificial lighting. It creates the diffuse reflection of light by using white plaster inner house. Because of the thick wall, windows get a shade space which can decrease the solar radiation. All above show that Superadobe has a good physical property.

Due to its advantages, it had been introduced in the discussion meeting of NASA. Its design can also serve the low income areas and reconstruction areas after disasters. The Superadobe with its natural materials and traditional characteristic is a good answer for how to build rural architectures.
The Superadobe system has been studied and developed by many other professors or institutions. In Bahamas, Steve Kemble and Carol Escort tried to use a canvas polystyrene bag full of sand and crushed coral to build a house. Because crushed coral of lime is just as natural as sand adhesive, and can form similar cement composites (Elizabeth, L. 2005). These learners created their houses on the basis of the Superadobe system, meanwhile coordinating with its local environment. In addition, European Teslik, Jiri Zdrazilová, Nada Vodicková, Martina has researched the air-tightness and acoustic properties of Superadobe system. It is conducted in Faculty of Civil Engineer in VSB-technical university of Ostrava. Their measurements show sufficient air-tightness of system Superadobe. (Teslik, J et al. 2014)
4. Discussion

On the basis of the interpretation of the materials, the construction method and the achievements of the Cal-earth, the system can be analyzed from four aspects.

First of all is material choice. The materials of Superadobe are almost all natural, such as mud, water, air and fire that can be easily gained. They are from nature and return to nature after construction when they must be abandoned. It can be circled in the ecosphere. That is sustainable. Besides, the thermal inertia of the earth makes the inner house to have good insulation as well as the material using make it have good air-tightness.

Then pay attention to its construction method. No large construction equipment be needed in building and it can be finished just by several men in a short time. No noise, non-pollution and little impact on the surrounding environment. On the other side, The Superadobe system provides a possibility for those who need temporary housing in case of emergency because it can be easily assembled and disassembled.

Moreover, Go to its appearance, Superadobe follows the Islamic traditional building method which was using dome. And its construction method is also drawing lessons from the Persian Sassanid Dynasty (AD226-651) when the brick corbel method was popular. (Fig.8) The difference is he uses sandbags to corbel and each cross section is a circle. The advantages of the dome space they choose have been talked about in the front text from the angle of technology. Another explanation of the dome used by Khalili is that building just as smooth as human’s body without edges and corner just like the nature itself. Its smooth surface gives a special view outside and a safe space to play for children inside (Fig.9).

Finally, the scope of application of Superadobe system should be discussed. For signal building, its flexibility of space organization provides choice for different number of population. One family and more together (parent living with their children who are married) are both possible. It can expand space according to different situation.

For building group, another question is if it suit to all cities or countries? This should be carefully discussed. First of all, the main materials of Superadobe system are clay. Not enough clay could be built in the density cities. For another the system itself can not satisfy the high-rise building requirement. But it really suitable for the low density rural area because of low cost, environment friendly and time efficiently. Meanwhile, Due to water permeability of the soil, Superadobe is more adapt to dry areas than wet regions, especially for desert districts.

In conclusion, Superadobe system is an economical, ecological and energy efficient system. The scope of its application is dry and low density rural areas. Superadobe connects the nature and tradition. It can provide a very effective point of reference for our country construction in west China.

Acknowledgements

Supported by

- Scientific Research Fund of Hunan Provincial Education Department 14C0969
- NSFC 51278194
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