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ScienceDirect

Energy Procedia 6 (2011) 236–240

Energy Procedia

MEDGREEN 2011-LB

Using Mud Bricks as a Temporary Solution for Gaza Reconstruction

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Abstract

On Tuesday April 28, 2009 a report for BBC displayed an interview with a Palestinian citizen rebuilt his destroyed house with mud brick and mentioned that, it is a shame to live in a mud house at this age. The researcher was struck by this interview which led to work on this research. Due to the siege, the Palestinians lost the hope to reconstruct their destroyed homes, public buildings and infrastructure. Building with mud bricks as a thermal insulation and environmentally friendly method, works as a fire resistant, sound proof and can be entirely chemical free. It is cheaper; 80 m2 house made of cement would cost around 16,000 dollars at least, but a mud one with local materials cost just 3,000 dollars. Best of all, it can be made on site in any shape, color or size, made of a mixture of clay, mud, sand, and water mixed with a binding material such as rice husks or straw.

Mud bricks fulfill the compressive strength and heat conductivity requirements. It also keeps indoor temperatures stationary during the summer and winter as a thermal insulation method. It is a traditional building material in much of the Middle East, India, North Africa and the majority of the Islamic cities buildings.

Recently, there have been attempts to revive the use of mud brick through special projects such as those instigated by Hassan Fathy in Egypt, the beautiful Cob House on Mayne Island, Canada, etc.

The mud bricks aim to save energy. The energy crisis experienced in the past have shifted the focus of the economical gain to energy saving.

The research will display all the successful methods of building with mud bricks in order to extract different recommendations from it .this will be a guide for anyone who want to build his own house in a wonderful form, shape, style and colors. Besides different recommendations for the governmental institutions to encourage the citizens to reconstruct their homes by this method and construct models of mud houses to teach the citizens how to build their own homes?

Finally, earthen structures are cheap, environmentally friendly and it is not a shame to live in a mud house but it is a global trend to preserve and to protect the environment.

Mud Brick, Thermal Insulation, Rammed Earth

1. Introduction

Earth as mud bricks, has been used in the construction of shelters for thousands of years, and approximately 30% of the world's present population still live in earthen structures [1]. Earth is a cheap, environmentally friendly and abundantly available building material. It has been used extensively for wall construction around the world, particularly in developing countries [2].Unfortunately these days so many of people think that only building "properly" and "satisfactorily" by using such items as reinforced concrete, cement blocks, burnt bricks, etc. But equally unfortunately the manufacture of steel and cement for reinforced concrete is now called "energy intensive'. An enormous amount of energy that is some sort of fuel-is used to manufacture these so-called essential materials. [3] Mud may be old fashioned whereas concrete has been in circulation for less than hundred years, despite this, mud could be successfully used even for the best houses." this research will prove that it still fashionable".

doi:10.1016/j.egypro.2011.05.027

2. The siege

The continuing Israeli blockade of the Gaza Strip is putting the Palestinians in a continuous challenge to overcome their difficulties especially in their daily life demands. The Palestinians lost the hope to reconstruct their destroyed homes, public buildings and infrastructure. So, as "**Necessity is the mother of invention"**, Palestinians decided to use both of sand bags and mud bricks to reconstruct their destroyed homes.

Figure 1: shows the process of manufacturing the mud bricks in Gaza [4]

3. Mud Bricks

A mud brick is a fire free brick, made of a mixture of clay, mud, sand, and water mixed with a binding material such as rice husks or straw. They use a stiff mixture and let them dry in the sun for 25 days. Adobe is a type of mud brick also used today to save energy and is an environmentally safe way to insulate a house. This type of house tends to stay cool in the summer and warm in the winter. Whether it is known as adobe, cob, loam or banco, mud is one of the commonest and most beautiful building materials on the planet. The bricks are then used to construct walls, sometimes on stone foundations, while roofs are made from timber. The whole lot then gets coated in layers of banco, a mixture of mud and rice husks, giving the architecture of the region its organic, sculpted feel. Larger buildings, such as mosques, also have projecting timber struts, which add support and double up as ready-made scaffolding. [5]

3.1 The Advantages of Mud Brick Constructions

There are several major attractions associated with earth buildings:

- **Cost Savings**, Earth building can be a very cheap way of building. This is not necessarily always the case however. you become too ambitious in your plans and design a building full of cathedral ceilings and stained glass, you are likely to find that any savings you might make by using mud are offset in the added expense of these features).
- **Thermal Mass & ECO Friendliness**, Thermal mass is a term used to describe the ability of building materials to store heat (thermal storage capacity). The basic characteristic of materials with thermal mass is their ability to absorb heat, store it, and at a later time release it. Mud brick is a natural material that can create a more environmentally friendly building. It has been used since very long time in building techniques. The mixture of mud brick is available in abundance and the only source of energy needed is solar energy. If it is maintained properly, it is durable and many old buildings have been standing perfectly even after many years. If done properly it can place less demand on planetary resources than other types of construction both in the actual building and in the running costs .it also reduces the heating and cooling costs. A mud brick wall performs similarly to a brick veneer wall in terms of heat insulation. [6] It does, however, have better noise insulation qualities and higher thermal mass. (This is because mud bricks are solid and dense. Their density blocks noise and absorbs heat. Effective heat insulation, on the other hand, is largely provided by pockets of air in a material, which trap heat and stop it moving through the material.
- **Self Satisfaction**, Earth building can be so very simple that (with adobe at least) a beginner can attempt and successfully build his own home.
- **Aesthetics,** Earth buildings have an appearance which is very unique. Many people build out of mud simply because they like the look of it. Figures (2, 3, 4, 5, and 6) display different examples for unique successful projects all over the world take into consideration the aesthetics factor.

3.2 Examples for Different Projects Constructed from Mud Bricks.

3.2.1 Yemen Towers.

Indeed Yemen is famous for its high rise towers constructed from mud brick as shown in figure 2, Here the height of their homes was an indication of the owner's wealth and power. Land there is also scarce and expensive. Besides the towers served a defensive purpose in troubled times. Each houses a family. In this typical example, the ground floor is for the animals and storage; the first floor for the living rooms and bedrooms; above that would be the kitchen. [7]The top floor contains the mafrai: This is the large room where the owner of the house meets his friends, and it is usually the only decorated room in the house.

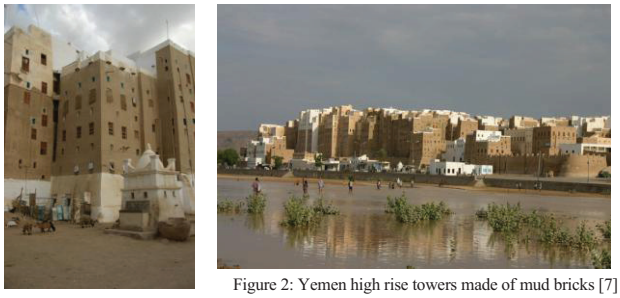

Figure 2: Yemen high rise towers made of mud bricks [7]

Construction workers dig deep into the ground to find firm soil and, at the bottom of the trench, place a layer of animal droppings covered by a layer of salt. On this course they place timbers parallel to the walls, with stones packed in the interstices. In this manner, the builders construct a masonry wall of stone and lime up to street level. [7]Then they pile sun-dried mud bricks up to the sixth floor, reducing the thickness of the walls as the building rises so that the internal dimensions seem to be constant and the external profile tapers slightly from ground to roof. The houses are topped by flat roofs surrounded by parapets to form terraces. These terraces are waterproofed with an application of ramad - a plaster of lime, wood ashes and sand as will be seen below.

3.2.2 The New Gourna Village in Upper Egypt…Hassan Fathy

In 1946, architect Hassan Fathy was commissioned by the Egyptian government to plan and build a new village for the inhabitants of Old Gourna, who for generations had lived directly above the rock-hewn tombs in the cemetery of Thebes on the western mountain side of the Nile, near Luxor. [8] Fathy made an extraordinary design sensitive to climatic problems, local Materials and traditional Islamic architecture. At this project Fathy demonstrated how elements from vernacular Arab urban architecture, such as the Malkaf (wind catch), Shukshaykha (lantern dome) and Mashrabiya (wooden lattice screen), could be combined with the mud-brick construction traditionally practiced in Nubia in Upper Egypt to form a distinctive, environmentally and socially conscious building style that linked the use of appropriate technologies with co-operative construction techniques and the guiding thread of tradition.

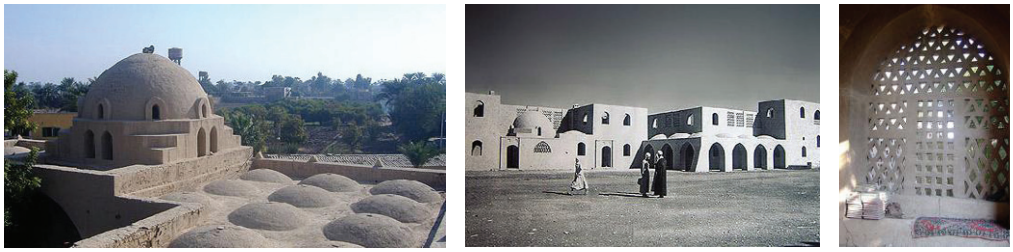

Figure 3: New Gourna Village in Upper Egypt [8]

On the functional level, Fathy tops all the village houses with domes as a means of regulating the temperature and ventilating the houses of the New Gourna village, in combination with traditional ventilation methods such as the claustrum, the *malqaf,* and the mashrabiyya. In this way, he attempts to solve problems pertaining to the flow of hot and cold air; shading of sun-drenched roofs; calculation of the amount of radiation on a given convex surface, air holes, and so forth.
On the aesthetic level, to avoid a monotonous, standardized appearance, Fathy joins to the domes and vaults on the roof a square, gallery-like space which casts shade on the opposite dome. Here the architect juxtaposes rows of simple circles and squares, creating an attractive silhouette of forms carrying on a "dialogue" and emphasizing the undulating skyline of the dwelling houses rather than the uniform building materials. He uses the dome for illumination, especially in the mosque where windows inserted along the sides of the dome as well as on the drum and between the squinches, as in the Mamluk domes of Cairo, focus the penetrating rays of light on elements. [9]

4. Rammed Earth

A technique used in the building of walls using the raw materials of earth, chalk, lime and gravel. It is an ancient building method that has seen a revival in recent years as people seek more sustainable building materials and natural building methods. Rammed earth walls are simple to construct, incombustible, thermally massive, very strong and durable. Conversely they can be labour-intensive to construct without machinery (powered rammers), and if improperly protected or maintained they are susceptible to water damage. Traditionally, rammed earth buildings are found on every continent (Antarctica accepted), from the temperate and wet regions of northern Europe to semi-dry deserts, mountain areas and the tropics. [10] The availability of useful soil and a building design appropriate for local climatic conditions are the factors which favour its use.

When cement is used in the earth mixture, sustainable benefits such as low embodied energy and humidity control will not be realized. Manufacture of the cement itself adds to the global carbon dioxide burden at a rate of 1.25 tonnes per tonne of cement produced. [11]Partial substitution of cement with alternatives such as ground granulated blast furnace slag has not been shown to be effective and brings other sustainability questions with it.

Rammed earth can contribute to the overall energy-efficiency of buildings. The density, thickness and thermal conductivity of rammed earth makes it a particularly suitable material for passive solar heating. Warmth takes almost 12 hours to work its way through a 35-centimetre (14 in) thick wall.[12]

4.1 The Advantages of Using the Rammed Earth

The rammed earth building has several advantages summarized as follows:

1- Perfect choice for any weather: Due to the thickness of the wall and the characteristics of rammed earth, it provides protection to extreme weathers. It stays cool in summer and warm in winters.
2-Proof against flames of fire: The materials in rammed earth are completely fir proof.
3-Soundproofing: The qualities or rammed earth cut out all the noises that come un-invited into a pace.
4- Provides strength: It is strong, which explains why some parts of Great Wall of China were built in rammed earth.
5-Requires less maintenance: There is never a need to re-do the rammed earth walls in any way, as it has the inherent quality of water resistance.
6-It is programmed to bear load: It is capable of bearing load and you can envision number of features and floors when you are planning on a rammed earth house.
7-Humidity Controller: It controls humidity where walls contain clay exposed to internal space. It is successful in controlling humidity till 40%-60%.
8-Economically feasible: The material is naturally available and does not also involve the cost of plastering, tiling etc.
9-Variety: It provides for variety in the look and the fell of the house, due to the usage of a different material. [13]

4.2 Examples for Different Projects Constructed from Rammed Earth.

4.2.1 Rammed Earth Home by Paul Weiner

Figure 4: Rammed Earth Home by Paul Weiner [13]

Preparing the material: The right type of soil is needed. It needs to be sandy between 50%-75%. Too much clay should not be used as the wall can shrink and crack. Sieve the soil selected to separate other impurities like leaves; stones etc. spread a cover on the material, as it will prevent it from precipitation. If the soil will contain more than 10% moisture, it will puddle. To test it, make a ball of the material and drop it, when you do so it should hold its shape. If you have kept your material homogeneous by following the above steps, the turn is to change the material into sandstone with the help of pressure. Build the Foundation: Lay the foundation carefully and properly so that the walls have a strong base to stand on. Then is the turn to ram the earth for the walls: 3-10% of Portland cement is mixed with the material for stabilization. The wall depths will be from 18 to 36 inches. [13] However in two story buildings the first story walls are wider. Walls will definitely include a framework as well.

4.2.2 People's Co-op, Portland, Oregon

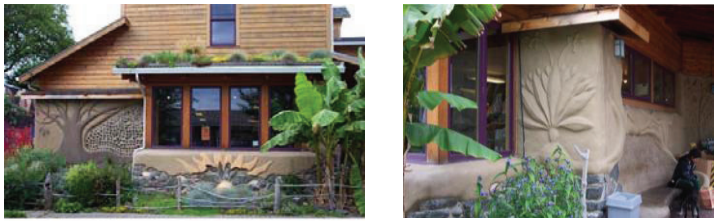

Figure 5: Co-op, Portland, Oregon [13]

This adorable little cob cabin mimics the style often seen in England but is actually located in Mayne Island, Canada. It features the smooth surfaces, curved walls and archways so typical of cob architecture. Some modern elements are included as well, such as the pre-fab windows. One of the advantages of cob is the malleability of the mud as it's drying on the exterior and interior walls – it can be sculpted into beautiful relief designs, as seen here at the People's Co-Op of Portland, Oregon. [13]Cob was used as infill for two walls of the building as well as for the benches inside and outside the store.

5. Discussion

From the previous experiments it appears that using earth materials such as mud bricks and rammed earth are a global trend for saving the energy as they do not require a high energy input, such as is needed in a blast furnace for the production of steel, or in a kiln for the production of cement. And their techniques are simply to learn and easy to implement. An earth wall may have a lower embodied energy than the same wall made in steel or concrete. Therefore in the correct context, earth walls may be a lower carbon alternative to traditional construction.

In addition to the low embodied carbon in earth buildings, earth walls are known for their ability to balance the relative humidity inside buildings and to provide thermal mass, reducing the heating and cooling requirements for the structure.

So by little knowledge of the simply techniques of building construction for mud bricks and rammed earth Palestinians could build their own homes and public buildings.

6. Conclusion

It`s not a shame living in a mud house, as it provides good heat and sound insulation. The main issue is not how to build as how to choose techniques and materials appropriate to a given situation. Making earth bricks eliminate the energy use and greenhouse emissions from transporting the bricks. At the end of the building's life, mud bricks can simply be broken up and turned back into earth.

Palestinians' houses would be good thermal masses, which can be used for effective passive solar design to store heat during the day for slow release at night - good for climates with warm days and cooler nights. Using Mud Bricks doesn`t Contradict with the Ethics or the Luxury Issues as shown in figures [3, 4, 5]

Mud brick and rammed earth homes generally have thick walls (approximately 300 mm) and high thermal mass. When outside temperatures fluctuate above and below comfort temperatures, the high thermal mass of mud bricks considerably reduces heat transfer, performing particularly well in summer. In winter however, outside temperatures are normally lower than comfort temperatures and the low thermal resistance of mud brick leads to poor winter performance as heat is lost through the walls. [14]

7. Recommendations

*There is much research which still needs to be carried out in this field. The final aim of such research is to bring the standard of mud or earth brick building to that of more common modern building materials such as steel and concrete.

*The authorities in palatine should adopt this trend of building and share the designers, planners and researchers in the decision process in order to occur, standards for the construction process such as a palatine ISO for earth building materials.

*With such research, and the development of internationally recognized codes and standards, it becomes much easier for organizations such as Engineers without Borders to present solutions to problems for emergency and permanent shelter provision using mud bricks and other techniques.

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