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The Cosmic House: (A Case study of a Sustainable Earthbag House) in Jordan

Samara Abdel-Sada Mutlaq Al-Saleem ¹
Rasha Mahmoud Ali Al Zaini², Mohamed Saber³

¹ PhD candidate –faculty of Fine arts - Minia University

²Professor at the University of MSA, ³Associate Professor - faculty of Fine arts - Minia University

Email address: samara_abdulsada@yahoo.com

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Abstract

This research is based on the analytical study of a sustainable house that exists on the ground, which is the Earthbag house of engineer Hanna Al-Khalili in the Jordanian capital, Amman. The building method has been documented with a group of advantages that was provided to its users and the negatives they faced inside the house, and the analytical method was followed in the case study.

It has been noted that this house is adaptable to the surrounding climate and the environment in which it is built; It is considered a strong competitor to the well-known and highly rated sustainable houses such as Earth ship, Straw bale, and Earthbag House is classified as a mud house, but it is not classified as a poor house, as it is known for traditional mud houses, as it is considered one of the high-cost houses in construction and internal and external cladding, and it needs A great effort and a large number of workers to complete it, this type of high-cost sustainable house has been called the creature, due to its ability to grow, develop and adapt to the environment and surrounding conditions.

Keywords

Earthbag - Cosmic Home - sustainable

1. Introduction

Man has used clay as a basic material for building, more than ten thousand years ago in different places of the world, such as the basin of the Tigris and Euphrates rivers, and clay terraces in Upper Egypt, in the ancient Levant, as well as the right and its historical mud towers that are still present until now hundreds of years ago. According to (Al-Kassibi, 2010), in Europe, mud structures flourished from the eighteenth century to the end of the nineteenth century, and mud buildings were reused after the World War, where more than ten thousand mud dwellings in Germany testify to this (Norton, 1997).

Clay is one of the most important materials that can be exploited in environmentally-friendly sustainable buildings, due to its availability in nature, the possibility of recycling without causing pollution, and its possession of good physical properties, in terms of thermal conductivity, thermal resistance and light reflectivity, in addition to the exchange property Thermal heating provides comfortable buildings for humans without the need for heating and mechanical cooling, and the Arab architect Hassan Fathi took advantage of these properties in his famous architecture, in Upper Egypt, with hot weather during the day and cold at night, using the local Nubian expertise, in uniquely building domes and vaults without the need for Use any of the topping systems (fathi, 1988).

Earth-cup houses that were built to help victims of floods in Africa, earthquake victims in South America, and victims of wars in Gaza and Sudan have proven their worth in resisting disasters, but

are these houses the ability to survive in crowded capitals? Is it possible to build and live inside cities and be inhabited by people? Can it meet the needs of the contemporary family?

significance

The success of traditional mud architecture in the world, and its steadfastness despite the many dilemmas it suffers from, such as the weak resistance of mud to the forces on it, and its sensitivity to moisture due to traditional skills acquired from trial and error, and with time the use of mud decreased, but in the last two decades the importance of building with mud has been realized, and that Because of its sustainable properties, on the environmental, economic and social levels, many attempts have been made to revive the mud architecture in large parts of the world (Correia & Neves, 2008).

stated that technological development has added the ability of several scientists and architects in the world, to develop techniques for building with mud, and to reduce its defects as a building material (Abda & Abdel Hafeez, 2012), in different ways, such as the construction technique (Earthbag). Thus, making mud buildings more suitable for different weather conditions, and resistance to natural disasters, like several countries, have witnessed modern and advanced techniques of mud architecture, so its use is no longer limited to dry areas only (Al-Kassibi, 2010).

methodology

The researcher seeks to study the Earthbag house as it is a sustainable and modern mud house in the field of sustainable houses in hot areas, and this is

done through the methodology of a documentary and analytical case study of the building elements, and because this house is implemented on the ground and in the middle of a crowded capital such as the Jordanian capital Amman, where we can monitor The advantages of this house and to identify its negatives more broadly and accurately, as it exists and is easily accessible.

1- **Earthbag Construction Definition:**

It is a natural building that is not financially expensive, easy and quick to prepare, strong and withstands all weather conditions such as rain, storms and earthquakes, very healthy and does not contain iron and cement except in a very small amount and its shape preserves the energy of the human aura, and it is also an environmental building material because most of its materials are natural or decompose and return Nature without traces or pollution (Aba Al-Khail, 2017).

Despite the simplicity of natural construction using earthbags, this requires courage and bravery, as it is an unconventional way of building and very different from what the "modern man" is accustomed to, who grows up in houses that resemble chickens, and the individual can start the ages after learning the construction method directly. One of the most prominent features is that the materials and tools used in construction are primitive and available materials, which are simple filling, and the filling means that the basic unit of construction here is similar in shape and composition to our guts or intestines, and the principle of the construction process is to fill those bags.

2-**Earthbag construction date:**

The idea began when military trenchers used sandbags in World War II to stop the flow of floodwater on soldiers, so they built high walls of bags to trap water behind them... Then an expert in architectural techniques "Gernot Minke", a professor at the University of Kassel in Germany He is considered one of the most famous people interested in developing sustainable buildings, collecting his experience in the book "Building With Earth" and starting to introduce the technology of using earthbags to build house walls in 1960 and this continued until 1970, when Iranian engineer Nader Khalili and his colleague Elora Outram "Nader Khalili" with "Illiora Outram". From the California Institute of Art and Architecture "California Earth Art" in partnership with the "Architectural Institute" in Asperia to construct domes based on single earthbags, and then developed that where they also discovered the possibility of using a single roll or roll without interruption instead of using Single bags, so they created one long roll that they could fill with dirt and roll it up as much as they needed and control its length so that the walls would become impartial and therefore more cohesive, and no Softness, stability and strength (Khalili, 1996).

And architect Nader Khalili, devised the domed construction method in 1984, in response to a request by the US Space Agency "NASA", for designs for human settlements on the moon and Mars, where he signed a partnership with the United Nations Development Program and the

United Nations High Commissioner for Refugees, to apply his research to emergency shelters.

Khalili's idea of building a dome developed at the end of the seventies of the last century after he visited an Iranian village that was exposed to an earthquake and found that the most resilient houses in the face of the disaster are the mud houses in the form of arches and domes, which prompted him to develop the idea between 1984 and 1986, and it was later adopted in 1991 Foundation for Art and Reconstruction of California Soil Teaching its methods of construction and reconstruction (Hunter & Kiffmeyer, 2004).

Cosmic Home

The house is in the west of the Jordanian capital, Amman, in the Bayader area, Wadi Al-Seer district; This house was designed by the architect Hanna Al-Khalili on an area of 50 square meters, and was designed to serve a family of 4 people; The idea of the earthen or cosmic house appeared in 1993, but it was implemented in 2006, and the construction of the house continued for nearly two months.

It was called the cosmic house because it was built instinctively before the presence of cement and iron, and it was always built in a circular shape (Figure 1), which is the areal shape that guarantees safety for humans against earthquakes and hurricanes, and in the case of its construction,



Figure 1 : the circular foundations of the house are made of plastic bafs filled with sand , source : by researcher

concrete is not poured from the surface because it is circular.

Every building has a geometric shape that affects those around it. The triangle comes with negative energy, and the ancient Egyptians used it to protect their properties, and because it is a pyramid, viruses remain in it and infect those who enter it with diseases, so it was called the curse of the pharaohs; In contrast to the circular shape, it comes with positive energy (interview, 24/March/2020) .

The idea of Earthbag houses is that they are based on a scientific base of science called "Bio-Geometry", a special engineering science that works on the energy balance within the human body in the surrounding environment. It can be considered a comprehensive science related to many other sciences, the most important of which is engineering. It is based on reaching the best forms of the paths of energies surrounding us in this universe and thus can restore balance and harmony for vital functions. Therefore, they are considered complementary sciences to medicine. Bio geometry is concerned with the energy pathways present in the earth, which would affect the human being and related diseases resulting from an imbalance in his vital system.

This science works to protect humans from environmental pollution, whether visible or invisible. An example of this is electromagnetic fields and cancer radiation (Qmada., 2017) .

The main material in the construction of this type of house or building is the soil material, with the incorporation of straw with it, and a lime material treated specially and packed inside plastic bags

that built in a circular shape. The earth and the white and red blood cells are spherical, and everything in the universe is based on the principle of the circle or its derivatives such as the arc.

The process of building Earthbag houses is also practical and inexpensive for the infrastructure, as construction is done using a sandy material of a certain type and plastic bags for fixation instead of the foundations (Figure 2), in addition to using barbed wire to hold the successive layers of sandbags together, which is expensive in the construction process. It is the "house plasterer", which requires four faces compared to a cement house that needs one or two faces, in addition to the high-priced packing material. (interview, 24/March/2020)



Figure 2 : The construction process by filling the bags .with soil immediately, that is, during construction
Source: by researcher

4-Analytical study of the construction process

Then the bags filled with dirt are stacked on top of each other in the form of courses (Hunter & Kiffmeyer, 2004). A barbed metal wire is stretched over each course. The bags are also tied together with those wires. To increase the wall's resistance to tensile forces (Figure3), the bags are also compressed; To maintain the level of the courses, it is also sometimes resorted to inserting a metal or

wooden bars in the bags vertically to increase their resistance, especially in the corners of the building and around the openings to obtain a more robust building.



Figure 3: The courses of sandbags are arranged on top of each other and around the openings

Source: by researcher

The construction steps are as follows:

1. The necessary tools are prepared (barbed wire and cutter, scissors, tamping or compacting tool, shovel, sandbag roll, pipe, small bucket).
2. The materials that make up the filling of the bags are mixed and water, asphalt emulsion, cement or lime (glutinous) are added to it. If there are no fixing materials, the soil is only suitable for building a temporary house (Khalili, 1996).
3. The quality of the mixture is known by a simple examination, by holding a ball of the mixture and squeezing it without leaving the hand wet when pressed (Figure 4).



Figure 4: shows the tools used in building Earthbag houses and the method of mixing the materials that make up the filler and checking the quality of the soil before placing it in the bags

Source: <https://syrianchange.wordpress.com>

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4. The location of the door shall be designed away from the place of gusts of wind or the prevailing wind direction in the area and away from the watercourse.

5. The first step in the construction process is to dig a trench 30 cm deep as the foundation; Then the soil is compacted tightly and settled in preparation for filling it with bags later.

6. The bags are partially filled inside the trench, where one side of the bag is folded down to hang it, and the other side is filled through it (Figure 5).



Figure 5: The picture represents the location of the door in the plan in relation to the direction of the wind, the foundations and the method of stacking and packing
Source: <https://syrianchange.wordpress.com>

7. When filling the bag, the mixture is in the ratio of 1/3, i.e. one-third of the size of the bag, and the worker moves the bag to adjust its tilt manually or using his foot, and the worker's place during packing is opposite to the direction of the bag.

8. When a filling is completed, the filling opening is closed by twisting it and placing it under the bag itself (Figure6).



Figure 6: This picture shows how to fill and arrange the bags.
Source: <https://syrianchange.wordpress.com>

9. The bag must be full and stacked, tamped and tightly closed to pave and make the bag in the same pattern.

10. The barbed wire is interrupted as a single wire for domes with a height of four meters and the reinforcement with two wires for the domes higher than that.

11. Continuing with the other rows, taking into account the previous steps, such as the paving and



the barbed wire between each row (Figure 7) .

Figure 7: This group shows the process of reinforcing with wires between the layers of the bags
Source: <https://syrianchange.wordpress.com>.

12. To make the dome evenly and uniformly, compasses must be used. This is done by using two pieces of rope, chain or wire, provided that they are not elastic. The end of the first rope is fixed in the middle of the ground, and the second end is used to adjust the distance and distance of each row, and use the second rope (which is a diameter to consider the height; Reconstructed (Figure 8).

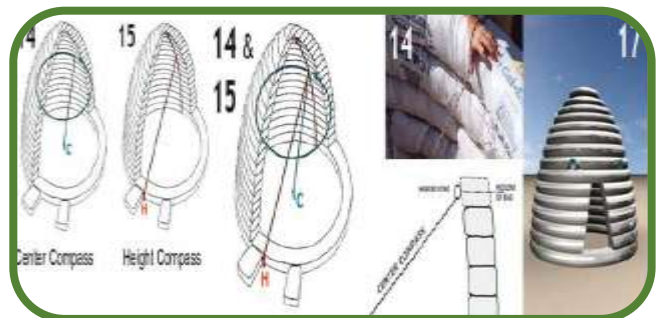


Figure 8: Masonry Calipers for the Earthbag Coordination Assist Dome on Site
Source: <https://syrianchange.wordpress.com>

13. The doors and windows in Earthbag houses are opened by spreading the bags each row separately before the next row. The openings are made after at least five rows.

14. To make ventilation windows in the outer walls, plastic cylinders are placed diagonally outward to prevent rainwater from entering the house (Fig.9).



Picture 9: The picture shows the steps of sawing the openings, and placing the ventilation windows in a diagonal way in the outer walls

Source: <https://syrianchange.wordpress.com>

15. When the construction of the dome is completed, the bags are tilted outward so that water does not collect on the surface of the dome.

16. An arched door is being built at the entrance to the Earthbag house to protect the entrance to the house from rain and wind. (Figure 10).



Figure 10: The picture shows the last layer of the dome building (the ceiling of the room in Earthbag houses) and the entrance to the house with the arch

Source: <https://syrianchange.wordpress.com>

17. The house is painted from the outside with a clay material to prevent the bags from interacting with the environmental factors of the area and damaging the environment.

18. The clay layer is coated with a traditional insulating material that suits the local environment.

19. The previous point can be replaced by adding matrix balls of lime sludge or cement, or it can be finished with fine cement or lime sludge. (Fig. 11)



Figure 11: The pictures show a group of ways of exterior cladding for the house

Source: <https://syrianchange.wordpress.com>

5- Earthbag interior space:

The internal environment that makes up the house is a natural extension of the human being, and the thermal comfort inside the house is due to the basic building material, which is the soil, which is the same material from which man was created.

The optimal solution for lighting in sustainable environmental homes, especially in the geographical area in which the house is located, is due to the sunny environment in the area, as there are 333 sunny days out of 365 days in a year, so the Skylight method is used in the interior lighting, so the sun supplies the house powered by "lighting and igniting"; In addition to the use of modern technologies in Skylight, such as Double glass (Figure 12-13)



Figure 12: Skylight vents from the top of the house from the outside

Source: by researcher

Skylight helps activate the biological clock inside the human body by activating it with the sunrise that is not obscured inside the house.

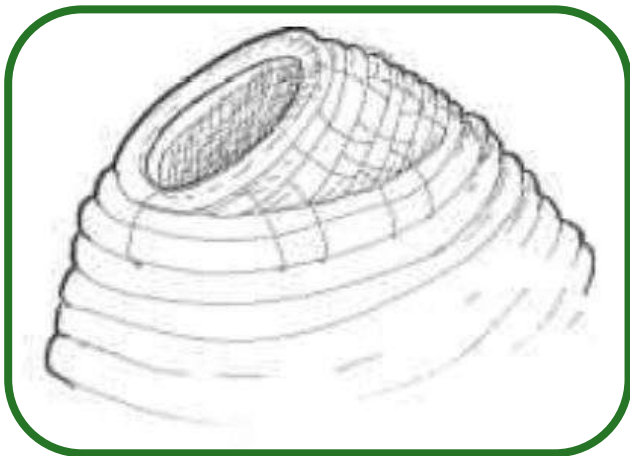


Figure 13: Earthbag dome with a compression ring and skylight

Source: <https://docplayer.net/44368926-Soil-and-health-library.html>

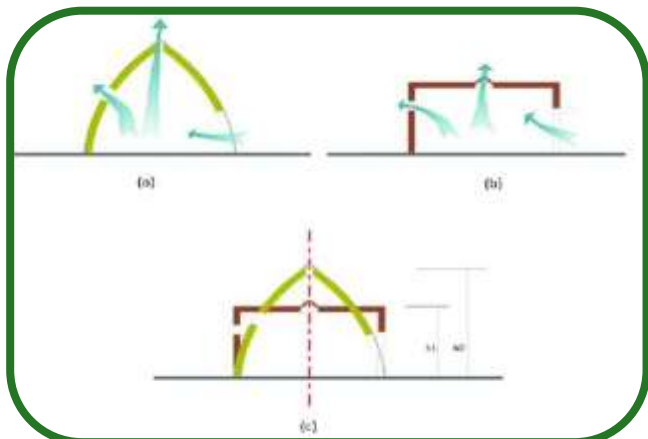


Figure 14: (a) Dome roof ventilation. (b) Flat roof ventilation (c) The different height from roof windows to floor with the same inner wall length

Source: https://www.researchgate.net/figure/a-Dome-roof-ventilation-b-Flat-roof-ventilation-c-The-different-height-from-roof_fig3

The heat and the air that comes out of the breathing process comes out to the top and then comes out of the house and thus the house becomes healthy and vital, because it brings out the rotten air outside the building of the house like the human body, and that is why the designers consider this type of house as a creature, and if this property is canceled it turns into an oven Closed (Figure 14); The

breathing process of the house takes place through the clamp and it creates circular air currents inside the space by entering the air from the holes in the walls and taking the air out through the clamp and vice versa; A special room was created for the air conditioning process adjacent to the central space, and this room is considered the hidden place for air conditioning extensions inside the house, as it contains an air conditioner that works in the rare severe heat waves in the region, and a gas regulator that served the gas heating unit in the winter, and inside it there is a traditional air envelope(Fig.15).

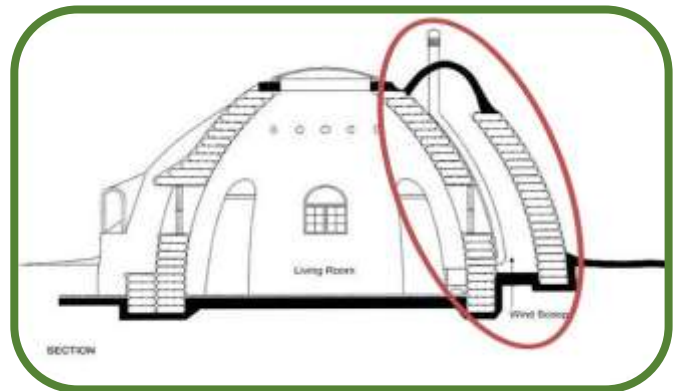


Figure 15: Profile showing the adaptive chamber and posture.

Source: by Hanna Khalili

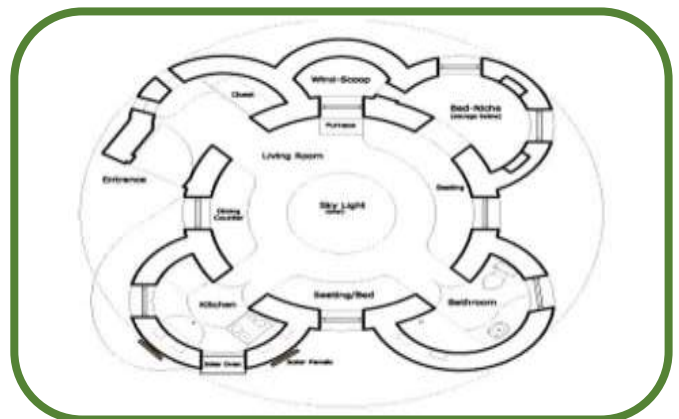


Figure 16: The floor plan of the house.

Source: by Hanna Khalili

The bedroom is a semi-circular space, and its entire floor is covered with a raised mattress on an equipped storage unit because there are no wardrobes in the room, where the area under the

bed was used for storage and is easy to access and use. The room is completely prepared for the purpose of sleeping only, and there is no door to the room separating it from the hall or the central space of the house. Rather, a curtain was placed in the form of a traditional Bedouin cloak, to match its colours with the colours of the house and to provide space for the movement of the door inside the room.

As for the kitchen, it is in the traditional form, which is a shelf of zellij, and below it is shelves built of cooked mud bricks, which are shelves for keeping pots and mortar and covered with white curtains, as was customary in the old houses of the region. The combination of traditional design and modern design, i.e., the introduction of harmless development that facilitates life and this is the true meaning of development, such as the design of gas and shelves under the gas .

And about the idea of the oval shape of the building, it is considered a natural development. When the building began, the shape was circular, and when the ceiling was closed, it turned into an oval shape, as the ground was circular and oval, confirming this idea, and it appeared clearly in the ceiling, as the circular shape gradually increased until it reached the Skylight opening.

As for the bathroom, it was built with high technology to be a typical house and can be easily implemented by resorts and eco-villages. As for the shape that was supposed to be implemented, it is the traditional form of ancient bathrooms, such as the bathroom known today as the Moroccan

bath and the Turkish bath. As for the existing bathroom, it contains a Shore Box.

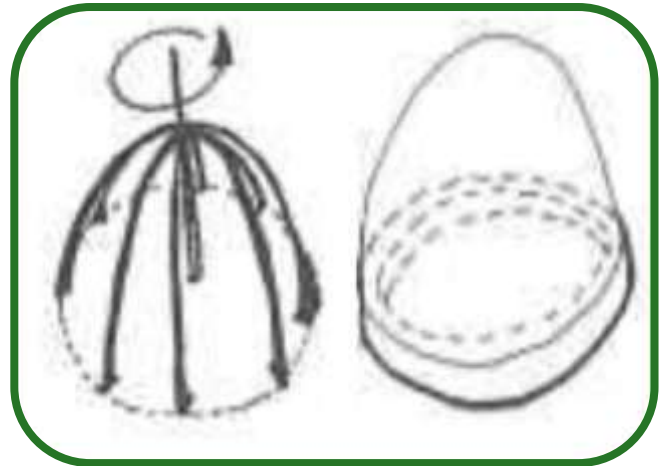


Figure 17: A rotated arch is a dom .

Source: <https://docplayer.net/44368926-Soil-and-health-library.html>

The central hall or the central space, and it serves several functions inside this house. It is, in the main or basic degree, a distributor of the spaces surrounding it, and it is the focus of movement for the kitchen, bathroom and bedroom. It also performs the function of the programmer for the heat and the air conditioner for thermal comfort inside the house. Through him, his real function is the living or living room in the house; The pieces of furniture are functional only, and all of them are designed from natural and sustainable environmental materials. The seating units are made of bamboo braided over the room's area and topped with a mattress of natural cotton, and the floor is covered with handmade carpets from the remnants of fabrics and clothes, which has overlapping colours. The type of handmade carpet is the oldest method of home recycling; There is a small office unit to store books, and we notice the coordination in the colours between the furniture and the colours of the interior and exterior paints of the house. The designer relied on a three-colour

scheme (white, earthy beige, and blue) and this is due to a quote that is done in Country Style. This type of house emphasizes the idea of the least expensive house close to nature as a basic idea for its construction (interview, 24/March/2020) .

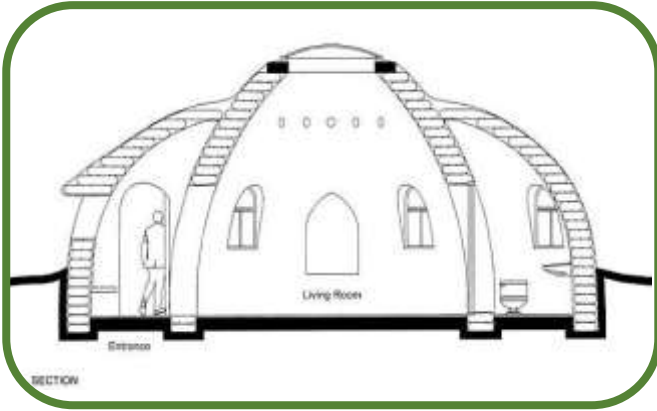


Figure 18: longitudinal section of the living room (main space).

Source: by Hanna Khalili



- Figure 19 of the reality of the situation .

6- Advantages and disadvantages of Earthbag houses:

First the features:

One of the advantages of this type of house is that it is sustainable, as it can be added, modified and developed without depleting natural resources or causing serious environmental damage (Croft & Heath, 2011). Earthbag construction is not a competitor to other natural building methods, but rather a science that offers us more options. One of the important uses of sandbags throughout history is protection from floods, and the bags not only retain excess water, but become more durable and solid when exposed to water, and high strength for construction thanks to the coils of earthbags and the barbed metal wire between them. When exposed to any strong factor of nature or extreme pressure.

Dome or vaulted natural construction is the oldest method in natural construction, it is the best example of durability and is known for its long life, and the earthbag construction system gives you the ability to "do it yourself" compared to other methods when this construction was put to the test for some time. Scientifically determined to know the durability of the building and its life (Hunter & Kiffmeyer, 2004), the specified test period expired before any damage occurred to the building and we did not know the age, and since the building has exceeded even the test period, the evidence is its survival, which is characterized by a long life.

As the shape that is still used so far all over the world, especially in dry places, it was also seen in the most humid areas in the world in the Costa

Rica coast, where rain rates reach 500 cm per year, and this is evidence of the solidity of this building, its durability and resistance to factors Different weather, and this design in the building is resistant to floods, hurricanes, and moisture, and it can maintain thermal balance and insulation and is resistant to the principle of heat loss, that is, the building is not affected by the external temperature. And cold in summer, in addition to other factors that play an important role, such as doors and windows.

Second, the negatives

The downside of Earthbag House is the huge amount of hard work required to build a single unit of this type of house, the more people build the house, the more expensive it is. Sustainable houses, due to the number of workers and some of the raw materials used in its construction, and this type of house is not considered a separate house because people do not accept the idea of living in houses made of plastic bags and dirt only.

Thermal comfort requires correct air currents, and for the internal air currents to work properly and implement thermal comfort, the house must be directed correctly, and this requires a long experience in building Earthbag houses for the house to be oriented towards the south and the ventilation inside it is correct

In most climates around the world, a habitable building shell is best insulated from the extremes of ambient temperatures to have comfortable and energy-efficient housing. Unfortunately, most types of soil are poor insulators, so filling soil bags with soil is of limited benefit, and the insulation

materials used in Earthbag homes are not available in all countries of the world and sometimes are expensive.

The thickness and weight of Earthbag walls limit its uses, as it is not the best choice as interior walls, as it reduces the space for the interior space. The Earthbag house is one of the homes that are difficult to carry out plumbing and electrical work through its walls and floors, as its weight and thickness do not allow it, and its foundations are not suitable to bear high weights on construction and heavy.

Results:

It can be clearly noted that the EARTHBAG sustainable house can adapt to all types of climates around the world (hot, cold, humid, rainy, dry...etc) and the reason behind this is due to the quality of the sustainable materials used in its internal and external (earth) construction. The materials are designed to automatically adapt to the environment, and one of the most important features of sustainable materials is that they are part of the surrounding environment, as they are not considered alien to the surrounding environment but adapt to it to serve the interior space of the house.

The Earthbag house is one of the latest sustainable home systems, and it is a real and strong competitor to the traditional sustainable homes or those that have already been implemented on a large scale and have proven their worth in many countries such as (Earthship, Strawbale), as they are distinguished from them by being easy to build, few tools, and flexible. Forming, and with a very

high resistance than any type of sustainable house, and it is capable of growth and development in all directions and does not require highly experienced technicians to build it.

Earthbag houses cannot be classified as the rest of the environmental houses that are built with mud and mud. The mud houses are classified as a type of architecture for the poor, due to the low cost of construction, and they have weak resistance, and their life is short, and this is completely opposite to the idea of Earthbag house, as it is very expensive; But it can be the model house, approved by the humanitarian relief organizations, as it is the best and fastest solution, due to its high resistance to all weather conditions, natural and abnormal, and its high resistance to disasters, such as floods and earthquakes, and its high ability to perpetuate, and it can be implemented in villages Sustainable Dedicated to the study and development of this type of unique building.

Conclusion:

In conclusion, we note that the Earthbag house is unique, easy to build, feasible and requires no experience, despite the great effort that is required to build it, and you can, in simple steps, get a house that does not harm the environment, is sustainable, energy-saving and comfortable, but a greater number of studies related to interior cladding should be available. This type of housing become a real competitor to traditional homes, and this may lead to the vision of an entire residential community of Earthbag homes.

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