

See discussions, stats, and author profiles for this publication at: <https://www.researchgate.net/publication/323446104>

# The mud architecture of the Sudan and Saudi Arabia

Research · February 2018

DOI: 10.13140/RG.2.2.25416.01287

---

CITATIONS

0

---

READS

1,623

1 author:



Ahmed Ibrahim  
University of Hail

16 PUBLICATIONS 0 CITATIONS

SEE PROFILE

Some of the authors of this publication are also working on these related projects:



Hail Vestiges and Heritage- Boasting the booming tourism of Saudi Arabia [View project](#)

# The mud traditional architecture of the Sudan and Saudi Arabia: The difference in employment techniques

1- Dr Ahmed Osman Ibrahim

## **Abstract**

*Mud is made of mixing water and any combination of soil, silt, and clay. Soil to be used for mud should be devoid of organic matter. When water is mixed with soil it forms mud, which is the preferable combination necessarily used as a building material. As a building material mud has two main forms; cob and adobe or sun dried bricks, which are of much concern in this research. In this research just the term "Mud" will be used referring to the "soil mud". The same mixer of mud could be used before drying off as a plastering material on walls and roofs for protection from rain or as a decorative material and sometimes its employed in floors inner surfaces as a decorative material. Even though there are many forms of mud as a building material as; earth bricks, soil bricks, adobe, sun dried bricks, clay brick, stabilized bricks, rammed earth or cob. Fired bricks are excluded in this research since when burned; they will be losing their natural characteristics.*

*The method adopted in coming out with this research is analytical in which a comparison between the method of employing mud as an architectural building material in the Sudan and Saudi Arabia emphasizing the difference in need in the two countries. It is employed in the Sudan for buildings for people of almost all social classes in mainly two types of buildings; residential and commercial, whereas in Saudi Arabia employing mud as an architectural building material is merely for cultural purposes more precisely in the rehabilitation and development of Urban Heritage buildings. What the research is trying to investigate is whether there are any differences in the techniques and methods of employing mud in all construction stages from the stage of bringing the most suitable soil used in making bricks until the stage of its employment as plastering and decorative material.*

**Keywords:** Mud, mud construction techniques, mud traditional architecture

## **1- Introduction**

Mud being one of the oldest building materials used in construction in certain climatic conditions in which the availability of peculiar quality of soil is required necessitating outstanding building artisans affirmed by Mardith-Schuetz-Miller (2011). The economical difficulties many people face in the Sudan and the cultural values everybody demands in Saudi Arabia. Besides the main reasons mentioned earlier the employment of mud as a building material, energy and pollution problems in the industrialized world and unemployment hurdles in the developing world are other reasons that could make the use of mud as a building material a amore pressing issue.

Mud has been used for construction in many countries of the world, especially in the various urban settlements located near the valleys and rivers, in mountains foothills and oases. Since the human race settled in rural settlements where soil available around 10,000 years back mud deployed as a leading building material in the construction of their shelters protecting them from the various environmental hazards, predators, and enemies attacks.

In the Mesopotamian and the Egyptian civilizations mud has been widely used, and later on used by the Romans, the peoples of the Middle East, India, and China. In the middle Ages, the construction of mud was practiced in Europe, North America, Mexico, and Latin America. It was as well practiced by various African cultures, such as the Berbers and the Hausa, figure (1), (2) and (3).

Exemplars of traditional mud buildings of the African cultures are; the fortified buildings made of karsheef, a local type of mud, make up the desert oasis of Siwa. Karsheef made from the unique sand from the lakeshore, high in salt content. The Great Mosque of Djenne, Mali built in adobe, the struts projecting from the wall serve as decoration, as well as supports for scaffolding during maintenance, as Marchand (2009) described.

According to Dethier, J. (1982). Shown below are exemplars of Mesopotamian mud buildings as the Mud Brick Walls at Tell Brak located in northeastern Syria, the Peruvian Incan civilization's City of Chan Chan, Peru, the Largest Mud Brick Complex in the World located in South America Pre-Columbian ancient architecture, and the Islamic old adobe minaret in Kharanagh village, Iran, figure (4), (5) and (6).

---

1- Head of Visual Communication Department, Faculty of Architecture and Planning, Qassim University, Buraydah, Qassim, Saudi Arabia. (e-mail; [ahmedosmanibrahim@yahoo.com](mailto:ahmedosmanibrahim@yahoo.com))



Figure (1) Fortified buildings made of karsheef mud buildings built by Siwan Berbers



Figure (2) The Great Mosque of Djenne, Mali was built in adobe

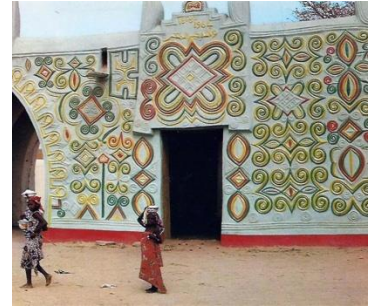


Figure (3) Hausa traditional mud buildings



Figure (4) Mud Brick Walls at Tell Brak, Syria



Figure (5) The Incan civilization's City of Chan Chan, Peru



Figure (6) Old adobe minaret in Kharanagh village, Iran

There are many historic mud buildings in the Arab countries as Al-Jadeed, M. A. (1994) explained. Perhaps the most famous exemplars in this regard are the magnificent mud buildings of Shibam in Yemen, the Kasbah at Ait Benhadou of Marrakech in Morocco and Oasis de Ouled Saïd at Adrar in Algeria, figure (7), (8) and (9) are showing such exemplars.

In the other Arab's countries, there are abundant historic mud buildings, exemplars of such buildings are Ghadames oasis old city in Libya and Aleppo's citadel in Syria shown in Figure (10), (11) and (12) shown below.

Historic mud buildings availability is not restricted to the countries mention before; almost all Arab countries have such kind of buildings, as those mentioned are just exemplars.



Figure (7) Shibam in Yemen



Figure (8) The Kasbah at Ait Benhadou of Marrakech in Morocco



Figure (9) Oasis de Ouled Saïd at Adrar in Algeria



Figure (10) Ghadames oasis old city in Libya



Figure (11) Aleppo's citadel in Syria



Figure (12) A side view of Aleppo's citadel in Syria

There are as well many historic mud buildings in the Sudan such as those in Deffufa, once the centre of the city of Kerma, Figure (13). Deffufa is a Nubian term meaning mud-brick building. Kerma was the seat of the first independent kingdom of Kush. Deffufa is the largest and possibly oldest structure in sub-Saharan Africa. The ancient kingdom of Kush emerged around 2000 BC in the land of Nubia, what is today northern Sudan. The Nubians ruled over ancient Egypt as the 25th Dynasty between 720 BC and 664 BC known as the Black Pharaohs and their borders reached Libya and Palestine. Dome shaped houses in Old Dongola, Sudan, are other exemplars of historic mud buildings, Figure (14).

At that time, the use of mud in buildings was common as it was the best and most advanced technology of the time. It used in almost all buildings including castles and residence of political leaders.



Figure (13) The historic mud buildings, Deffufa, Kerma, the Sudan



Figure (14) Mud dome shaped houses in Old Dongola, the Sudan

So many historic mud buildings also found in Saudi Arabia as the wattle and daub or mud and straw adobe in Amarah Palace, Najran, Aba Al Saud, in the heart of Hofuf as the Old Kout neighborhood and in Dir'iya's mud buildings, figure (15), (16) and (17).



Figure (15) Amarah Palace, Najran, Aba Al Saud Historical Area, Saudi Arabia

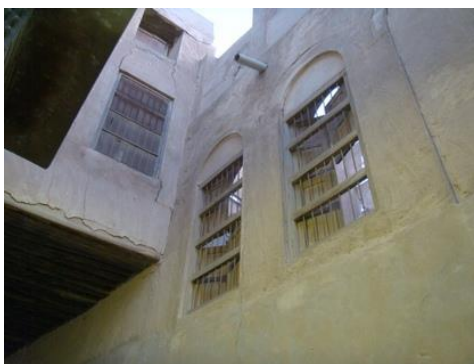


Figure (16) the heart of Hofuf, the Old Kout neighborhood



Figure (17) Dir'iya's mud buildings

The main two methods of mud construction; the cob and adobe or sun dried bricks are the most ancient as well as the most employed building materials by almost all people of the long lasting previous

civilizations. However, since the fifties of the last century buildings with mud in the Arab countries are no more much employed as people's economical states have been considerably booming like all other countries of the developing world. It was a natural result of what the world has witnessed during the past few decades in regards to buildings with mud as a result of the drastical changes in the political, economic, cultural and social conditions.

## **2- The different construction techniques of mud**

According to Ashurst, J. et al. (1988), mud construction mainly found in places, which are relatively dry. The soil, the dry form of mud before water added to it, collected after the depth of about 60cms as the top layer, is full of organic matter; therefore, it is not used for construction. The soil's usability according to its type is as follows; Gravel, which alone is of no use for mud wall building, as the tiny lumps of stone have nothing to bind them together. Sand is similar to gravel and it is of no use for wall making by itself, but if mixed with clay, it becomes an ideal mud wall building soil. Silt by itself is also not good for building walls. It will hold together but is not strong enough. Furthermore, it will not compact so it is also of no use for pressed blocks or rammed earth or cob work. Clay can be rammed or compressed but in drying out it often shrinks. During the monsoon, it gets damp, expands, and cracks because of that. Organic Soil is the most suitable type of soil for mud building.

There are two kinds of soil tests; *field tests*, which are the colour test, touch and smell test, biscuit test, hand wash test, cigar test and adhesion test. There other type of test is either the lab tests, which performed in a sieve test or a sedimentation test. These tests are necessary to determine whether the soil is good for mud building and in which form and part of buildings employed.

In the result of colour test, deep yellow, orange and red, ranging to deep browns soil indicates iron content, which is good for mud building. In the touch and smell test, small quantity of dry soil is rubbed on palm to feel its texture. The soil that feels course when dry but sticky when wet, contains lumps of clay, as the soil that feels course when dry but gritty when wet, contains sand, whereas the soil that feels course when dry but little gritty when wet, contains silt. Usually these various types of soil found mixed, rather than in isolation. Such mixed soil gains its required qualities in its mixed form. They described as mixtures such as sandy clay soil. In the biscuit test, a smooth paste from the soil out of which all gravels removed made. A biscuit of 3cm diameter and 1cm height is molded and Left to dry to observe any shrinkages or cracks. If it breaks easily and crumpled between fingers then it has good sand-clay proportion, but if breaks and reduces to powder then the soil has more sand or silt. In the hand wash test, wet soil is played with until hands are thoroughly got dirty, then hands are washed to see how difficult it is to clean. If hands are cleaned easily and quickly, then soil contains more sand, but if it takes little time to clean and feels like flour then soil contains more silt, and if it feels soapy or slippery and takes time to clean then soil contains more clay. Cigar test in which a smooth paste from the soil out of which all gravels removed. The paste rolled on palm to make a cigar, and then slowly pushed outside the palm. The length at which it breaks is then measured. If the length is below 5cm, it means the soil contains too much sand, but if the length is above 15cm, it means the soil contains too much clay. If the length is between 5cm to 15cm, it means the soil contains good mixture of sand and clay. In The adhesion taste, a ball made out of wet soil in which a knife pierced into it and removed. If little soil sticks on the knife then it has more silt, but if a lot of soil sticks on the knife then it has more clay. If the knife is, clean after removal then the soil has more sand.

The lab tastes are only two; the sieve test in which soil passed from series of standard sieves set on top of each other, with finest sieve at bottom. Silt collected in the lowermost sieve, whereas gravels collected on the topmost sieve. Sand and lumps of clay collected in the intermediate sieves. In the sedimentation, taste a transparent cylindrical bottle or jar of one litter capacity is filled with  $\frac{1}{4}$  soil and  $\frac{3}{4}$  water. The mixer is well shaken and allowed to settle for 30 minutes. Coarse gravels settle at bottom, followed by sand, silt and clay on top. Measuring the layers will give us the approximate proportions of each content.

Some mud building materials techniques require the addition of some stabilizers. When the available soil not suitable, enough for construction, then the soil used by manipulating its composition by adding suitable stabilizers. Stabilizing enhances the given property of the soil type, increase Tensile and Shear strength, and reduces shrinkage.

The most common and effective stabilizer is Soil itself. Cement, is the best example of a modern contemporary stabilizer. Various other indigenous stabilizers include; straw, plant Juices, gum Arabic, sugar or molasses, cow dung, animal urine, tannic acid and oil.

There are various mud building materials techniques some of which are; cob, pise or rammed earth,

adobe, pressed bricks, enhanced bricks or stabilized earth bricks, and wattle and daub. In regards to this research, only cob and adobe or sun dried bricks or blocks are considered because they are the only most common mud traditional building materials techniques employed in both the Sudan and Saudi Arabia. Cob is good for anything except height. It is particularly good for curved or round walls. Pise or rammed earth is strong and ideal for solid, squat, single storey houses. Adobe or sun dried bricks can easily cope with two storey houses. Pressed bricks are smooth and very strong and can build three storeys. Wattle and daub is elegant and fine for Seismic Zones.

For the employment of Cob as a building material technique, little water added to soil to form a very stiff mud; large blocks of lumps laid neatly side-by-side then roughly molded into the shape of a huge elongated egg. Its usual size is anything between 30 to 40-cm in length and about 15-cm in diameter. Rows of these cobs of mud laid neatly on top of each other preferably somewhat pressed together. Then other rows of cobs lay on top. When three or four courses laid, one above the other, they smoothed over so that the holes and cracks disappear, as affirmed by Davey, N. (1961) figure (18), (19) and (20).

Openings for doors and windows are a problem, which solved by using temporary vertical planks or shuttering. Another very simple shuttering for openings is to use empty tins or similar plastic containers.



Figure (18) A cob wall under construction



Figure (19) Rows of cobs of mud laid neatly on top of each other and pressed together



Figure (20) large blocks of lumps laid neatly side by side

As explained by McHenry, P.G. (1984), the pise or rammed earth building material technique has developed from the cob technique to standardize or regularize the thickness of the wall. It is also an attempt to increase the strength of the wall by ramming it, therefore, known as the Rammed Earth method. Two parallel planks held firmly apart by metal rods and clips or bolts, or by small crosspieces of wood in making the formwork. Stiff mud thrown in between these two planks rammed down with either a wooden or a metal ramrod, modern ramming mechanism employed as well. When one section is completed and hard, the two boards moved along and the process repeated. The two planks then rose up and a second course of rammed earth repeated first in line with the previous one then over it when dries figure (21) and (22). Desert courtyard house rammed earth project designed by Wendell burnette architects, figure (23).



Figure (21) Making the formwork of rammed earth walls



Figure (22) The two planks then raised up and a second course of rammed earth repeated



Figure (23) Desert courtyard house, a modern rammed earth project designed by wendell burnette architects

In the adobe or sun dried bricks building material technique, mud molded inside frames to form blocks directly displayed under the hot sunrays exposed to enough air circulation. To ensure that the blocks are well dry inside, they turned by the side to make sure that the other side as well exposed to hot sunrays for complete dryness before employment. Chopped straw used as stabilizer in some areas as Saudi Arabia.

The equipment used in making mud molds can be either single-framed or multi-framed to produce a large number of blocks in limited time. Mechanization introduced to produce even huge number of blocks in large projects in order to lessen effort exerted and to minimize production time and cost. In this case, metallic frames replaced by timber frames most often used in hand made blocks.

The Multi-framed equipment used in the production of adobe blocks, the displaying of wet adobe blocks under the hot sunrays for drying and building by adobe blocks by experts, figure (24), (25) and (26).



Figure (24) Multi-framed to produce a large number of adobe blocks



Figure (25) Chopped straw used as stabilizer in some areas as Saudi Arabia



Figure (26) Adobe blocks in use by an expert

In the wattle and daub building material technique, tree branches, bamboo, timber and cane frame structure made as roof supports, roofs or walls. Straw or chopped straw sometimes added to the frame structure to make the mud easily and firmly stick. Mud then plastered over this mesh of these different materials. Due to excessive rainfall, the Wattle and Daub structures washed off. However, the mesh remains intact and after the heavy rain is over the mud plastered on again, figure (27), (28), (29) and (30) show different techniques of working on a wattle and daub wall and a wattle and daub wall washed away by rainwater.



Figure (27), (28) and (29) showing different techniques of working on a wattle and daub walls



Figure (30) A wattle and daub wall washed away by rainwater

### 3- Worldwide construction techniques of employing mud in buildings

Presently, more than one third of the world's population lives in mud houses. Referring to Al-Jadeed, M. A. (1994) explanations, there are several construction techniques of employing mud in buildings in the past and the present time. These construction techniques vary in the different countries of the world; they are, therefore, mounts to more than 15 techniques. Exemplars of these techniques are the full use of soil in all elements of the building, as is the case of carving out the entire project within the soil as in some of the settlements in North Africa. As well as the use of mud bricks in the construction of the entire building including its walls and ceiling in form of domes and vaults, as in Egypt. Besides these two techniques, there are many others in different regions of the world.

The idea of mud construction techniques generally depends on the choice of suitable soil, which mixed with the right amount of water. If this mixture formed in the required manner and method of construction, it gives a solid and strong entity. The necessary bonding of the mixture of soil obtained; either by natural drought of water from the mixture, as is the case of adobe or *labin* as is termed in Arabic, out of which water dried off when kept directly under the sunrays before employed in the construction of buildings. On the other hand, the mixture could directly apply in walls, as in the cob method or *madamik* as is termed in Arabic, figure (31).

This adhesiveness obtained by applying external pressure to the wet mixture of soil that kept in custom

templates as is the case of Rammed Earth, and most types of improved brick as the stabilized earth blocks according to McHenry, P.G. (1984).

Adobe as a mud construction technique generally found in the Arab world, in Egypt, Iraq, the Levant, Yemen, and the regions of Najd and Al-Ahsa in Saudi Arabia. Construction is cob is dominant in the United States, especially southwestern states, including California, Texas, New Mexico, and Arizona as well as in the eastern parts of Britain, especially the central and southern region.

In the past adobe was being prepared by mixing the soil, which often contains a high percentage of silt or clay with water with the addition of hay or chopped straw or other plant fibers. It was then well mixed by foot or using the bulls or cows, figure (32) and (33).

Hands full of the mixture then taken into a wooden mold without bottom, which is necessarily kept on ground. The mold contains a space or more in which the mixture is well compacted to ensure gaps filling to shape the adobe bricks and to ensure homogeneity of mixture when taken away. This template is different in size and the number of similar spaces it contains from one area to another. These similar spaces determine the shapes and sizes of the bricks. Molds continuously cleaned from mud that stuck on them by hands or by using wooden tools, to prevent the adhesion of mud dirt on molds when repeating bricks making process. Bricks kept in continuous lines, separated by small distances and left to dry in the sun. To ensure bricks complete drying after leaving for a few days to dry, they laid on their sides, to



Figure (31) Mixture of soil, water and hay or chopped straw directly apply in walls, as in the cob method or *madamik*



Figure (32) Molds of adobe blocks containing hay or chopped straw



Figure (33) Adobe preparation by mixing the soil with water in the addition of hay or chopped straw well mixed by foot

assure the passage of air currents around them before used in construction.

This technique of adobe bricks manufacturing continues to prevail in most countries of the world. In some countries of the developed world and the United States in particular, mechanization in bricks manufacturing process in commercial quantities introduced, due to the growing request, especially in the United State, more precisely in New Mexico. Large commercial quantities mechanization now found in many developing countries as well, figure (34).

Cob as a mud construction technique, commonly found in the Arab world, in parts of Yemen; as the region of Sa'ada as well as in Hail and in Asir in Saudi Arabia. Different parts of the Arab world, employ it especially in the construction of walls, castles and forts, while in Western countries in Britain for example, it particularly employed in Cornwall and Hampshire, while the vast majority of this type of construction is in Devon in the southwestern part of England.

Similar to the construction of adobe bricks hay or chopped straw added to the mixture in large quantities, to avoid cracks when it dries off. The importance of fermentation is resulting from mixing silt with hay and kept for some days to help in melting some of its components as the cellulose in hay and in cow dung to acquire the mixture plasticity and cohesion qualities necessary for storm and water resistance especially when applied in plastering. Even though mostly used in the making of adobe bricks, figure (35).



Out of this mixture traditional builders from ball-like blocks easy to handle to each other. These blocks are then kept side by side in continues layers along the wall to be left about two days to dry before starting to build the next course. Despite the prevalence of this method of construction in the past, and even though it gives strong buildings, but it is not much employed in the present time.

In the Arab world; in the Arabian Maghreb; such as Tunisia and Algeria, and mostly in the Kingdom of Morocco, rammed earth as a mud construction technique commonly utilized. It as well utilized in the Western countries; in France, where its construction is a prevalent tradition in the Rennes Valley, in Spain coming from France and to a lesser extent in the southern parts of England.

The method of forming rammed earth compared to the previous ones characterized by adding little water to the soil, an amount of water that does not exceed 10%, enough to earn the wet soil plasticity and so much ease its compression. The soil then transferred and put in templates similar to those used in the construction of concrete beams. These templates installed on the walls that are to be constructed. Soil is then undergoes enough compacting in these templates using either a private wooden pieces, as is the case in developing countries, or using some easy mechanisms, as is the case in developed countries. When these templates make well-compressed earth they dislodged and moved horizontally until the completion of a continuous layer, then templates lifted vertically to work on another layer, and so on until the level of roofing reached.

The pressed brick, enhanced bricks or stabilized earth bricks construction technique is considered the latest construction technique of mud, therefore, still used in a few Arab countries, limited to some special projects in Egypt, Morocco, Yemen, Saudi Arabia and the Sudan, while spread in the Western countries, especially in America and France.

In this method of construction of mud, and appropriate mixing of soil with some improved materials or stabilizers such as cement, bitumen, lime or other materials, so as to increase strength or resistance to the influence of water, or both together is made. The mixture then compressed in molds or other private presses, taken after the compression to dry off and processed before used in construction. A number of machines and pistons easy to pull off developed to use in the preparation of the soil, mixing and compression operations. These machines produce single, a few or large number of stabilized earth bricks, figure (36). This method of construction of mud becomes the most common for the time being, due to its various characteristics, perhaps most notably the ease of construction and availability of appropriate technology.

The employment of mud as a building material in the Sudan and Saudi Arabia is for two different reasons. In the Sudan mud as a building material is widely used for economical reasons, precisely to lower the cost of the construction of buildings. The employment of mud for constructing buildings lowers the cost to the minimal; to a level that enables whoever faces difficulty in building using reinforce concrete, blocks or at least bricks to be encouraged to do so. The issue of cultural values in regards to the employment of mud as a traditional building material does not arise yet in the Sudan.

In contrary to that in Saudi Arabia, the issue of cultural values so much considered and as well very much celebrated by individuals and by the government alike. In Saudi Arabia, building in mud is restricted to urban heritage sites, most precisely in their preservation.

The difference in employment raises two notions; economical reasons and cultural values, which when critically defined the logic behind the employment of mud as a building material in the Sudan and Saudi



Figure (34) Adobe bricks  
Large commercial  
quantities mechanization



Figure (35) Fermentation resulting from mixing  
silt, hay and cow dung



Figure (36) Machines produce single, a few or large number of  
stabilized earth bricks



Arabia clearly understood.

#### 4- Cob and adobe or sun dried bricks techniques employment in the Sudan

Due to the economical retardation, the Sudan is facing for a long time, resulted in congestion in population at family members level extended at the national level to almost all the Sudan's main towns, people have no choice that to go for mud buildings. All these various mud building materials techniques; cob, adobe, pressed bricks, enhanced bricks or stabilized earth bricks, and wattle and daub with the exception of pise or rammed earth are available in the Sudan.

Cob (Jaloas) employed long time ago in the different parts of the Sudan, especially the northern regions where rainfalls are scarce. The building technique is the same as the one described earlier in the research. The same technique employed in the same manner until today with the exception of introducing a new plastering technique applied on interwoven wire mesh of iron connecting nails hammered into the wall replacing the traditional plastering method (zibala). The new trend of modernizing cob buildings replaces the traditional old roofing system with timber, zinc or aluminum roofing sheets, jack arch roofing system, vault-roofing system and reinforced concrete roofing system.

In some villages in remote areas of northern Sudan, remains of domed shaped cob huts still exist, figure (37). In old areas in almost all towns of the Sudan, people built by cob, even though its plaster (zibala) easily washed away by rainwater and removed by hot tropical sunrays and storm, figure (38), (39). Cob as a building material used in building by house owners and traditional builders alike, figure (40).

Some people removed these houses and replaced them by modern building materials in walling and roofing systems as baked mud bricks, burned mud bricks and concrete blocks roofed in timber, zinc or aluminum roofing sheets, jack arch roofing system, vault-roofing system and reinforced concrete roofing system. In some old cob houses, people maintain the walls, but replaced the traditional old roofing system with the modern systems mentioned before, figure (41), (42), (43) and (44).



Figure (37) Remains of domed shaped cob huts in northern Sudan



Figure (38) In old areas in almost all towns of the Sudan, people built by cob



Figure (39) Cob wall plaster (zibala) easily washed away by rainwater and removed by hot tropical sunrays and storm



Figure (40) Cob as a building material used in building by house owners



Figure (41) Cob's old roofing systems



Figure (42) Cob's timber roofing system



Figure (43) Cob's aluminum roofing sheets



Figure (44) Cob's jack arch roofing system

Adobe or sun dried bricks becomes the most employed mud building construction material. Even though the government issued a decree prohibiting the use of mud as a building material due to tremendous collapse of buildings made out of mud during floods big towns face almost every rainy season.

The researcher believes that a great number of middle and low class people can only afford adobe as a building material as they have no other choice, but also the use of adobe if well developed could be widely acceptable by many people and the government alike. To make this claim possible, the researcher went into a real adobe buildings experience beginning by building his own house at Omdorman southern outskirts called Al-ssalha neighborhood in 2003. The researcher applied building techniques developed the production of adobe bricks, brick layering course mortar mix, plastering on interwoven wire mesh of iron, vault roofing system and most significantly the finishes of the exterior and interior walls, figure (45), (46), (47) and (48).

For the betterment and the development of these building techniques, the researcher repeated these techniques avoiding lapses and acquiring experiences in nine houses built for relatives and friends at Al-ssalha neighborhood, the same area where he built his own house. Reinforced concrete lintels replaced timber lintels and baked mud bricks parapets introduced in place of the adobe ones.

The most important construction techniques the researcher introduced to save adobe buildings from flood and heavy rains are raising them up to one meter high from ground level in addition to the introduction of very steep slopes of broken tiles floors to the entire court inside houses, figure (49). Electricity supply, water supply using overhead water tanks kept on roofs and local improved soak away system made it possible for the researcher's adobe house, in which he lived for almost six years, to look like any other house built by other modern building materials.



Figure (45) The vault roofing system of the researcher's adobe house



Figure (46) The wall plastered (dark) on interwoven wire mesh of iron



Figure (47) The researcher's adobe house exterior walls



Figure (48) The researcher's adobe house interior walls finishes



Figure (49) Very steep slopes of broken tiles floors to the entire court inside researcher's adobe house

People of the Sudan have not been familiar with the pressed bricks, enhanced bricks or stabilized earth bricks building material technique. New trends of introducing mud building material techniques brought

about the stabilized earth bricks technique regarded by experts of this field as the best-enhanced bricks method answerable to economical retardation and environmental challenges related to the building industry facing not only the Sudan, but also the whole world, according to Adam, E. A. et al, (2001) and Agarwal, A. (1981).

There is a good few number of stabilized earth brick buildings, constructed under the supervision of the Technology Research Institute, the National Research Center, the Sudan. Exemplars of these buildings are the Haj Yousif Model Secondary School, University of Dongola Teaching Staff Residents, Bajrawia Chalets, Dinder National Park's Guest House Chalets, The Abu si'ed's Police Barracks and the Holm English Medium Schools, figure (50) and (51).



Figure (50) The Haj Yousif Model Secondary School, University of Dongola Teaching Staff Residents and the Bajrawia Chalets



Figure (51) The Dinder National Park's Guest House Chalets, The Abu si'ed's Police Barracks and the Holm English Medium Schools

The other building material technique as the wattle and daub is as well, known in the Sudan. It employed mostly in the tropical rainy areas as the Blue Nile and Nuba mountains, especially in their remote villages and rural areas. In urban areas, this building material technique is not widely acceptable by people, therefore, no more used. A typical thatched roof and wattle and daub house construction in the Doleib Hill Sudan, 1977. Rashayda people of eastern Sudan build their mud huts in the wattle and daub method. Similar huts found in other parts of the Blue Nile and Nuba mountains, figure (52), (53) and (54).



Figure (52) Wattle and daub house construction in the Doleib Hill, Sudan, 1977



Figure (53) Rashayda people of eastern Sudan's wattle and daub huts



Figure (54) Similar huts found in other parts of the Blue Nile and Nuba mountains

At the individual level, few people were convinced to build their houses using this technique, but quite a few number of national huge projects built employing stabilized earth bricks. The tremendous collapse of buildings made out of mud during floods made the government to ban using mud as a building material. This ban made individuals to be hesitant, therefore, dealt with the use of the different building techniques with skepticism. The individual use in most cases did not exceed one or two buildings in a house. The cultural aspect of the employment of mud as a building material is never widely thought of. The main

gate of the Child's Garden located south of Afra Shopping Center is an exemplar of the scarce cultural employment of mud as a building material. The Khaleefa's house, assumed to be a significant historical museum, built out of cob. This house, considered the best preserved historical mud building, could be the most valuable cultural heritage if cared for and maintained as the case in similar buildings in Saudi Arabia as the Bassam house in Unaiza, Qassim region. The Bassam cultural house, part of the Musoukaf traditional market located a stone through from where the researcher resides, is an individual cob house well preserved by the government and becomes a considerable national cultural heritage to which people come and visit all the time, figure (55) and (56).

This two examples show that cob was first employed in the two countries before the use of other traditional mud techniques, even though adobe later on becomes the only technique adopted in the two countries by individuals mainly for their houses and trade places in the Sudan, but mainly by the government urban heritage cultural sites in Saudi Arabia. Cob also used in normal people's buildings as residents, commercial buildings and guesthouses in Saudi Arabia.



Figure (55) The Khaleefa's house, a significant historical museum, built out of cob



Figure (56) The Bassam cultural house, part of Musoukaf the traditional market built out of cob

### 5- Cob and sun dried bricks techniques employment in Saudi Arabia

Among all these various mud building materials techniques; cob, adobe, pressed bricks, enhanced bricks or stabilized earth bricks, and wattle and daub and pise or rammed earth, only cob and adobe available. The same as the Sudan, cob was used first in the construction of traditional mud buildings. The two urban heritage sites out of the three sites Saudi Arabia succeeded to register in UNESCO's World Heritage List (WHL) by the Saudi Commission for Tourism and Antiquities (SCTA) built out of mud, precisely cob. They are At Turaif District in ad-Dir'iyah registered in 2009, and Al-Balad, Jeddah registered in 2014. Exemplar of Ad- Dir'iyah mud building is the Saad ibn Saud Palace and that of Al-Balad is the Nasseef house. These two exemplars, which are part of a great number of buildings in these two sites besides many traditional buildings cared for in different parts of the country, preserved and acquire great cultural values, figure (57) and (58).



Figure (57) Saad ibn Saud Palace exemplifies cob buildings at Ad-Dir'iyah



Figure (58) The Nasseef cob house at Al-balad

Saudi regions close to Yemen employ cob as the main traditional building technique. The traditional mud houses in Abha, Najran and Asir are the best exemplars, figure (59), especially the Najran fort, figure (60).

Various collapsed houses in these regions, shown below are evidences of the use of cob long time ago. The famous Al Shada Palace in Abha, where cob employed artistically that never known anywhere in the world, made the preservation of such buildings, a continuous effort the Saudi Commission for Tourism and Antiquities (SCTA) shouldering, worth it.



Figure (59) The traditional cob houses in Abha, Najran and Asir



Figure (60) The Najran fort

The construction technique of cob in Saudi Arabia is the same with the technique explained earlier in this research. All the regions in Saudi Arabia employ cob in the same manner with the exception of the southeastern regions. In Asir for example, a projecting course of flat coral stones introduced in between each two-cob courses to give the wall more strength and to help easing rainwater drainage, which make the construction technique looks different, figure (61).

The Najdi region is another place in Saudi Arabia rich of mud building techniques. It is in this part Saudi Arabia succeeded to register its second site, the Turaif District in ad-Dir'iyah, in UNESCO's World Heritage List (WHL) by the Saudi Commission for Tourism and Antiquities (SCTA). Buildings here constructed out of mud, precisely cob.

In the Area of Qassim, the technique employed dominantly and for a long time was cob (labin) using the layers (oroag) method, well plastered to look elegant in urban heritage sites preservation efforts, adobe followed later on, which now preferably used, figure (62) and (63).



Figure (61) Projecting course of flat coral stones



Figure (62) Cob (labin) construction technique using the layers (oroag) method



Figure (63) Well plastered to look elegant in urban heritage sites preservation efforts

Hundreds of traditional settlements and private residents and trade sites, all over Saudi Arabia, faced with heavy government fortune expenditure under the supervision of Saudi Commission for Tourism and Antiquities (SCTA). These sites considered by the government as urban heritage sites. For the government to own these sites, it went to the extent of compensating owners of some of these sites paying them too much money. The researcher happen to be a participant in the preservation efforts in two urban heritage sites (SCTA) is presently working on commenced couple of years ago. The College of Architecture of the Qassim University signed an agreement with (SCTA) to be the sole consultant in the vast number of Qassim regions. These two urban heritage sites are the Oyoon Al-jewa heritage village and the Al Khobra old village. They are undergoing a comprehensive preservation to become one of the Qassim region various significant tourism sites. Adobe dominantly employed in almost all these preserved cultural urban heritage sites. According to Abdul Aziz Ali El-zenaidy (2010), mixing up silt, hay or chopped straw and water by the mixers (mulabineen) feet to be used for making adobe bricks, whereas if left for three months to be fermented to be applied in laying foundations and plastering walls externally and internally. Hay or chopped straw added every three days to the fermented silt (harah) obtained from valleys, figure (64) and (65).

This continuous addition simultaneously accompanied by mixing, ensures good fermentation to become a well-fermented mix (shiba'a) or (zibala) as called in the Sudan, figure (66). This process is termed (liaq). The form (malban) in which mud (labna) is formed into blocks is similar to the ones shoed earlier in the research with possible differences in size becoming 50x30x20 cm in Qassim region, figure (67).

The wet blocks left to dry totally before used in the preservation processes. Buildings undergoing preservation works in these two sites when finish, become welcoming to the visitors and very enticing to their eyes. Pictures shown bellow in the Oyoon Al-jewa heritage village and the Al Khobra old village sites, give an idea of the preservation processes taking place in hundreds of sites all over Saudi Arabia. The cultural values of the preservation not only must be celebrated by people from the educational institutes and in tourists' occasional visits, but also must be enriched by life events during religious and national occasions. The researcher had the opportunity to participate in the preservation possesses in the two sites together with (SCTA) workers and officials in training workshops given by local expert builders, students during summer training and colleagues, figure (68). These tremendous preservation efforts uplift cultural urban sites from their former deserted states to their present livable situations, figure (69).



Figure (64) The fermentation process



Figure (65) The mixing up process by the mixers (mulabineen) feet



Figure (66) Well-fermented mix (shiba'a) or (zibala)



Figure (67) The form (malban) in which mud (labna) is formed into blocks



Figure (68) Part of the preservation possesses attended by the researcher

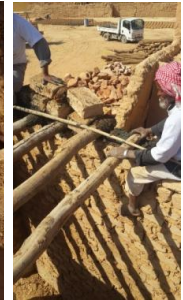


Figure (69) Tremendous preservation efforts uplift cultural urban sites to their present livable situations

The importance the government placing on these sites shows the much significance it gives to cultural values found in mud traditional building materials. This significance as well evidenced in normal people's buildings as residents, commercial buildings and guesthouses, even though buildings in this case built with concrete blocks, but externally and externally finished in such a way that looks so much similar to traditional mud buildings people are very proud of imitating them, figure (70).

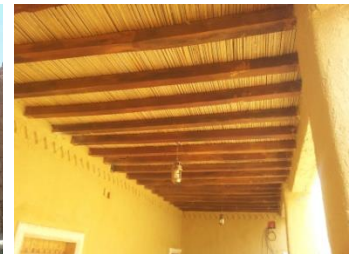


Figure (70) Building and finishing imitation of traditional mud buildings

## 7-Conclusions

The research shows differences in the techniques and methods of employing mud in all construction stages from the stage of bringing the most suitable soil used in making bricks until the stage of its employment as plastering and decorative material. The research also showed that cob first employed in the two countries before the use of other traditional mud techniques. Even though adobe later on becomes the only technique adopted in the two countries by individuals mainly for their houses and trade places in the Sudan, but mainly by the government in Saudi Arabia for the preservation of urban heritage cultural sites. In Saudi Arabia cob used in normal people's buildings as residents, commercial buildings and guesthouses. For the betterment of more employment of mud building techniques traditionally used in the two countries; the Sudan where cob and stabilized earth bricks mainly used and Saudi Arabia where dominantly cob is used the following tactics recommended. At the governmental level, decrees organizing buildings and planning regulations necessarily issued. The media has a role to play in public awareness of the significance of building using mud construction techniques, especially the improved methods necessary for energy preservation. Preservationists and environmentalists are to focus on in the media. Educationalists are to introduce subjects and



courses signifying the necessity of building using mud construction techniques in energy preservation at a time global warming becomes a worldwide challenge. Conferences, workshops and scientific forums in which educationalists are main participants, the necessity of building using mud construction techniques in energy preservation necessarily discussed. Socially, social civic organizations, printing presses and similar social groups necessarily have a role in the public awareness of the significance of building using mud construction techniques, especially the improved methods necessary for energy preservation. Culturally, values of the preservation not only must be celebrated by people from the educational institutes and in tourists' occasional visits, but also must be enriched by life events during religious and national occasions. Governments need to place more significance on traditional buildings, built out of mud, by initiating the idea in the Sudan and making sure that people necessarily attracted to developed and preserved sites in Saudi Arabia.

## 8- References:

- 1- Mardith-Schuetz-Miller, (2011), *the Empire Builders, A Socio-economic History of Architects and Building Artisans from the Neolithic to the Renaissance*, Perfect Paperback, Blue Oaks Arts, California, US.
- 2- Marchand, T. (2009), *the Masons of Djenne*, Bloomington: University of Indiana Press, US.
- 3- Dethier, J. (1982), *Down to Earth*, Centre of Georges Pompidou, Paris, 1981. English edition published by Thames & Hudson Ltd. London, UK.
- 4- Al-Jadeed, M. A. (1994), *Building with Earth: Traditional Architecture & New Technology with Special Reference to Saudi Arabia*. Unpublished Ph.D. Thesis, Welsh School of Architecture, University of Wales, Cardiff, UK.
- 5- Ashurst, J. et al. (1988), *Practical Building Conservation*. Gower Technical Press Ltd. England.
- 6- Davey, N. (1961), *A History of Building Materials*. Phoenix House Ltd. London, UK.
- 7- McHenry, P.G. (1984), *Adobe and rammed earth buildings*. A Wiley-Interscience Publication, New York, US.
- 8- El-Fadil, A. (1993), *Thermal Performance of Earth Dwellings in Hot Dry Climates with Special Reference to Sudan*. Ph.D. Thesis, Welsh School of Architecture, University of Wales, Cardiff.
- 9- Adam, E. A. et al, (2001), *Compressed Stabilized Earth Block Manufacture in Sudan*, UNESCO, 7 Place de Fontenoy, 75352 Paris 07 SP, France.
- 10- Agarwal, A. (1981), *Mud: the potential of earth-based materials for third world housing*. Earthscan, London (1981), 100p.

## 9- المراجع العربية

- علي الزنيدي، عبد العزيز (2010)، معمار عنيزة التقليدي من الخلوة إلى المنفوح، عنيزة، المملكة العربية السعودية.

## 10- Website sources

- 1- <http://www.touropia.com/amazing-mud-brick-buildings/> Siwan Berbers
- 2- [https://en.wikipedia.org/wiki/Adobe#/media/File:Djenne\\_great\\_mud\\_mosque.jpg](https://en.wikipedia.org/wiki/Adobe#/media/File:Djenne_great_mud_mosque.jpg) Djenne
- 3- <https://www.pinterest.com/douglasmccabe39/african-traditional-architecture/> Hausa
- 4- <http://www.ancient-origins.net/ancient-places-americas/chan-chan-largest-mud-brick-city-world-001954>
- 5- [http://en.wikipedia.org/wiki/Earth\\_structure#mediaviewer/File:Kharanagh-minaret.jpg](http://en.wikipedia.org/wiki/Earth_structure#mediaviewer/File:Kharanagh-minaret.jpg)(Iran)
- 6- <http://www.bdonline.co.uk/Arabia-felix-the-architecture-of-yemen-until-january-193096985.article>
- 7- <http://www.overlandwestafrica.com/marrakechtotangier/>
- 8- [http://archive.ramsar.org/cda/en/ramsar-pubs-notes-photo-essay-algerian-main-ramsar-1-30-168%5E19606\\_4000\\_0\\_\\_](http://archive.ramsar.org/cda/en/ramsar-pubs-notes-photo-essay-algerian-main-ramsar-1-30-168%5E19606_4000_0__)
- 9- <http://www.libyaadventures.com/tripolitania-ghadames-7-days/>
- 10- <http://topyaps.com/top-10-greatest-fortresses-and-castles-ever-built/citadel-of-aleppo-syria>
- 11- [http://upload.wikimedia.org/wikipedia/commons/9/91/Aleppo\\_citadel001.jpg](http://upload.wikimedia.org/wikipedia/commons/9/91/Aleppo_citadel001.jpg)
- 12- [http://andrewmccconnell.photoshelter.com/image/I00000\\_8qpBUret4-](http://andrewmccconnell.photoshelter.com/image/I00000_8qpBUret4-)
- 13- <http://castlesandmanorhouses.tumblr.com/post/83626659905/amarah-palace-najran-aba-al-saud-historical>
- 14- <http://saudijeans.org/2008/08/06/old-kout-hofuf/>
- 15- <http://www.nexus.globalquakemodel.org/gem-building-taxonomy/overview/glossary/cob-or-wet-construction--etc>
- 16- <https://en.wikipedia.org/wiki/Adobe#/media/File:Milyanfan-adobe-bricks-8038.jpg>
- 17- <http://www.africanvision.org.uk/2012/03/16/first-rammed-earth-building/>
- 18- <https://commons.wikimedia.org/wiki/File:HouseBuildingInNorthernVietnam.jpg>
- 18- <http://czphx.com/work-rammed-earth.html>
- 19- <http://i.ytimg.com/vi/4W8O-eBEU0/hqdefault.jpg>
- 20- <https://en.wikipedia.org/wiki/Adobe#/media/File:Milyanfan-adobe-bricks-8038.jpg>
- 21- [http://old-photos.blogspot.com/2012/10/adobe-house\\_29.html](http://old-photos.blogspot.com/2012/10/adobe-house_29.html)
- 22- [http://static.wixstatic.com/media/267db4\\_47066d94a9034217b3d539432613de2f.jpg\\_srz\\_p\\_401\\_273\\_75\\_22\\_0.50\\_1.20\\_0.00\\_jpg\\_srz](http://static.wixstatic.com/media/267db4_47066d94a9034217b3d539432613de2f.jpg_srz_p_401_273_75_22_0.50_1.20_0.00_jpg_srz)
- 23- <http://www.lowimpact.org/lowimpact-topic/wattle-daub/>
- 24- <http://gladbird.blogspot.com/>
- 25- <http://www.homeenergy.org/show/article/id/729>
- 26- <http://seed.org.za/apt-internship-week-7-natural-building/>
- 27- <http://www.diyhousebuilding.com/cob-building-henry2.html>
- 28- <http://www.oyp.com.ar/nueva/revistas/209/1.php?con=2>
- 29- <http://365days365businessideas.blogspot.com/2013/12/start-mudbricks-making-business.html>
- 30- <https://anneandandyinnamibia.wordpress.com/2009/05/>
- 31- <http://laurafly4.com/>
- 32- <http://www.meshkat.net/content/30166>
- 33- <https://www.flickr.com/photos/edk7/8514994152>
- 34- [http://go.galegroup.com/ps/i.do?id=GALE|CX3424602566&v=2.1&u=mlyn\\_n\\_galvinms&it=r&p=GVR&sw=w&asid=680954d169e9527c54c51d2b82b85837](http://go.galegroup.com/ps/i.do?id=GALE|CX3424602566&v=2.1&u=mlyn_n_galvinms&it=r&p=GVR&sw=w&asid=680954d169e9527c54c51d2b82b85837)
- 35- [ar.wikipedia.org](http://ar.wikipedia.org)
- 36- <http://en.wikipedia.org/wiki/Diriyah>
- 37- <http://www.saudicaves.com/saudi/oldjeddah.html>
- 38- <http://occasionallyarchitectural.com/2010/12/19/abha-traditional-architecture/6-2/#>
- 39- <http://www.asir.me/archive/index.php/t-133900.html>

40- <http://www.michaelcreasy.com/photos/saudiarabia2.html>

41- <http://mrbarton-abcjs.weebly.com/monumental-architecture-and-urban-planning-defensive-walls.html>