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A PROPOSED MODIFIED ADOBE BRICK TO ENHANCE VERNACULAR CONSTRUCTION TECHNIQUES FOR ECOTOURISM IN EGYPT:CASE STUDY OF JABAL ELGEZERAH ELHAMRA, MARSALA ALAM

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Abstract

Egypt, has high potential attractions for ecotourism. There are a wealth of natural beauty and natural materials, which have already been used in ancient and traditional vernacular architecture, where there was a coexistence and compatibility with the surrounding natural environment, and is achieved by the concept of thermal comfort inside the housing unit and the effective use of energy, thus achieving sustainable development. This paper aims concerned with introducing new adobe mixture that, could enhance the durability and compression characteristics of the building block. This mixture could be used in areas where eco-friendly building techniques are desired in order to achieve sustainability as well as aesthetic values of methods and natural building materials, specifically in Alqusyir and Marsa Alam Cities on the Red Sea Coast in Egypt. Due to the nature of the region and the abundance of materials used in the construction, which is based on " Silt of stream segments ", to product of adobe brick by natural materials, with the possibility of adding a natural binders, and treatment of these materials to be able to withstand the pressure and tensile strength and water permeability in order to be a sustainable brick. Through analytical and laboratory study for those materials such as Sugar Cane (Bagasse) from sugar industry waste and (Molasses) bagasse, without including Cement. This mix is environmentally and suitable for the climate and local economy and social conditions. To ensure the durability of building materials and their cohesion in addition to protect the roofs and walls from rain , and it can be used efficiently in areas of development in Egypt and the ecotourism projects and in nature protected areas, which has the materials environmentally friendly and can be recycled. It will preserve the identity of the vernacular architecture in Egypt, which requires protecting and raising architectural and urban value in the comprehensive urban environment that integrates social and develop ecotourism.

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RESEARCH METHODOLOGY

This research is focused on a results of experiments predecessor and Laboratory analysis of the proposed mixture, depend on characterized in detail, including chemical, physical and mechanical properties, namely: chemical composition, mass, porosity, water absorption and compressive strength.

INTRODUCTION

Egypt is rich in the wealth of heritage architecture and diverse vernacular such as desert architecture as a city of Siwa and Dakhla and Farafra and rural areas adjacent to the River Nile, especially the South Valley (Aswan and Nubia), and regions of the ancient cities on the coast of the Red Sea (such as Al-qusayr, Marsa Alam) most of those areas, buildings, dependent on ecotourism, Some specialists and tourism operators to their own development and preservation of this heritage, but it is on its way to extinction as a result of several factors including deterioration of the situation of living and the absence of laws that prevent the demolition and replacement of those heritage buildings. There is no sufficient awareness of the true value of those buildings, they represent the identity of the place and value of architectural and environmentally friendly, natural materials that can be recycled and less of energy consumption, high thermal efficiency, with a heritage and cultural value and represent a visual architectural identity of the place. One of the main disadvantages that it does not keep up with the present technology and efficiency constructivism to bear vertical extension, and the scarcity of material essential ingredient mud, to criminalize land leveling mud and blocking silt of the Nile River behind the Aswan High Dam. Therefore a lot of professionals and businessmen in the field of tourism trying to achieve this concept, but using modern construction techniques of building materials such as fire brick and reinforced concrete, using shapes of the elements of Vernacular architecture, using local stones to cladding as a parody of nature, others on a small

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scale design buildings and ecolodges resorts in some areas such as the Siwa Oasis, and El Gouna coast of the Red Sea, and other areas that could use sources of renewable energy, organic food and the use of natural local materials in the construction, as these eco-friendly practices appeal to a growing number of specialists and beneficiaries of international tourism. The aim of this paper to produce adobe brick from natural materials based on Silt of stream segments and some natural addition such as Bagasse and Molasses to save the environment and preserve the heritage and vernacular building tradition using available materials in response to the local climate. An approach to develop ecolodges especially in the waterfront resorts and oasis. The most important ways to achieve sustainable development to preserve the natural resources are inspired by the old traditional design.

THE ENVIRONMENTAL CHARACTERISTICS OF THE (GABAL ELJESERA ELHAMRA) - MARSA ALAM

Gabal Eljesera Elhamra is the region that fall under the Red Sea province,(as shown in figure .1), which is one of the most charming of the distinct nature areas, and depend largely on the ecolodges sector. Nature of the soil in coastal areas is a crusty layer of coral reefs fossilized, and feature many valleys (Wadis), such as Wadi Um Galloway, Wadi Ghalib (nowadays is known as port Ghalib) and wadi Mubarak which is near El Fayrouz Plaza Resort and others (as shown as Fig. 1) which are about stream segments feature soil of silt, they can be used as background materials building after the additions needed to become a strong bond material.

Al-qusayr ancient city is characterized by a large number of archeological and Vernacular buildings, which still exists, located on the distance of 70 km north of the study area, (as shown as Fig. 2).



Figure 1: Stream segment Wadi Ghalib and wadi Mubarak Marsa Alam
Reference: Photographed by the author April 2015



Figure 2: Al-qusayr ancient city- adobe brick and Local environmental stone.
Reference: Photographed by the author April 2012

Climate studies are the majority of the territory of the coast of the Red Sea territories climatically and one semi-homogeneous, and that the participation effect Latitude is limited due to the control of the sea impact on its counterpart on the same latitude inside. The average bone degrees ranging between 31.21, 39.92°C7. And relative humidity between 11% to 51%, and those indicators within the scope of thermal comfort throughout the year 3.

knowing that the average temperature region of Marsa Alam in the winter up to 31 ° C range in the summer between 20 to 35 °C. Table (1) shows the climate data and graph temperature in Marsa Alam. The climate in Marsa Alam is called a desert climate. There is virtually no rainfall during the year in Marsa Alam. The average temperature in Marsa Alam is 25.3 °C. The average annual rainfall is 5 mm. (Climate-Data, 2015).

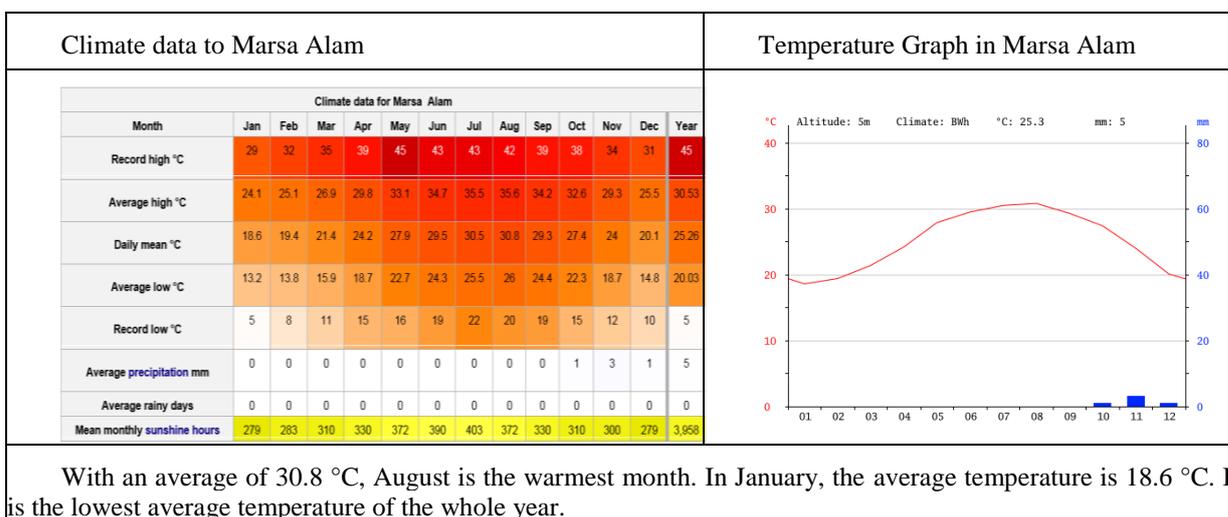


Table 1: Climate data to Marsa Alam. (Climate-Data, 2015).

SPECIALISTS IN THE CONSTRUCTION ADOBE BRICK

Architect Hassan Fathy on construction adopted brick mainly in many of his works shown in Figure (3), after he carried out many experiments to get the maximum strength and durability under different loading adobe brick circumstances. The mechanical properties of adobe, its lack of tensile and shear strength have always been a problem for ancient builders when they had to design roofs, but the Nubian vaults were already used in the XIII century B.C as shown (as Fig. 4), Nubian vaults are built without centering's and this is possible because of the stickiness of the mud mortar, the shape of the vault and the inclination of the courses that are placed one upon the other and finally on the supporting wall which was thicker than the lateral walls. The basic vault form, thanks to the builder's experience, was very similar to that of an inverted catenary (unesco, World Heritage 2011). However this method is simple, but it is an effective practice in the construction of vaults style architecture of ancient Nubia (as shown as Fig.5). While Ramses Wissa Wassef, has added gypsum to the mud giving the bricks more solidity, which has kept it lasting until today (Mosaad, 2004).through it's the Harraniya Crafts Centre is a third community project, typology designed by Fathy, Carried out in collaboration with the architect Ramses Wissa Wassef (as shown as fig.6). And contemporary works of the adobe building Architect Adel Fahmy, a specialist in Adobe Architecture field using the earthen material in the same location, and adds some bonding such as lime or cement according to the nature of the soil and their properties to increase the cohesion and hardness (El-Sharouny, 1998). (Shown as fig .7). As Fathi emphasizes the importance of the local character of the building and its impact on construction economics, saying: "It is not reasonable to pay tribute to oriental house in Europe or European house in the Arabian desert, the nature of the local climate impose the style of housing, it is wrong to transfer ideas from one country to another without any regard for local climatic conditions and social traditions. "He adds meaning Cairo buildings constructed of aluminum and glass: "When the stock of such a building, which stores the sun's heat to become closer to him to the oven housing and consume tons of fuel to reduce the temperature, this is folly." (Afifi, 2002).

The method adopted by the Egyptian farmer to make adobe brick surround the Nile River Delta region is the mixing mud and straw (wheat straw), either in the upper level are mixing mud with animal manure and in addition water and leaves several days to ferment and then flows into wooden molds and leave to dry (Dabaieh, 2011).

In western oasis region such as Siwa city, Farafra, Dakhla and others, the possibility of using Adobe bricks technique for build from silt Lakes, and the use of material stone Al-karsheef in the construction of old traditional buildings, as well as the use of the subjects (Silt countryside of the White Mountains) and silt Lakes (as shown as Fig. 8) Use this style in several resorts such as Adrere Amellal-desert Ecolodge Siwa, Egypt. (As shown as Fig. 9).



Figure 3: Hassan Fathy technique to build a vaulting



Figure 4: Ruins of the granary of the Ramesseum in Luxor, Egypt, (Mosaad. 2004)



Figure 5: Nubian technique of Adobe brick and vaulted



Figure 6: Harraniya Crafts Center



Figure 7: Adel Fahmi technique to add lime or cement to make a adobe brick (El-Sharouny, 1998)



Figure 8: Traditional roofs structure making process in the Dakhla oasis



Figure 9: Adrere Amellal-desert Ecolodge Siwa



In addition to the villages located on the Nile River, especially in Upper Egypt, such as the villages in Edfu, Aswan and Nubia, in spite of the Vernacular architectural riches and has a heritage and environmental value large for this previous work and reflect the values, but they are rare as a result of many of the most important factors no cultural awareness for the people of these regions shows the great economic return of eco-tourism in the case of the increase in such buildings in the tourism sector, as well as the scarcity and the difficulty of obtaining the silt of the Nile River and need maintenance and treatments for many of the pests result of adding organic material from waste animal to get a mortar, elastic strong to withstand the weather.

This paper is looking for solutions that can be used as an alternative to the Nile silt, to their rarity and guessing the private use of existing hull behind the Aswan High Dam, and prevent the razing farmland, and caused by organic waste from animal health and environmental damage. And through the use of silt storm water drains available to those areas as a basic material, plus some materials and natural-free Portland Cement Association, such as lime, ash furnaces and organic materials such as plant as an alternative to hay or rice straw or waste sugar cane and molasses. This is done through the work of laboratory analytical study to measure the ability of the constituent materials of the brick building block to withstand the stresses and resistance to water absorption.

SPECIMENS PREPARATIONS

As an attempt to simulate the atmospheric conditions of Marsa Alam. All specimens were exposed to identical specified condition specimens were subjected to warm temperature typically in the range of 37°C. All specimens were air dried in Wadi Mubarak- Marsa Alam for two weeks before transported and tested in faculty of engineering Alexandria University. All specimens were tested under compression in a 300 KN capacity universal compression testing machine (Safouh, 2015). The defection control mode was also adopted using a rate of 2 mm/min.

The use of silt stream segments as essential in the construction due to several reasons:

- Proximity to ecolodges sites, which reduces the cost of transportation and materials.
- Available and have no detrimental effect on the environment, good material to form a brick has good properties, bear the stresses and thermal insulation and thus can be used for ecolodges, revival of Vernacular architecture, which was stood a hundred years especially in Al Al Qusayr and Marsa Alam ancient cities.

Local experience similar in Siwa Oasis.

As the similarity of the chemical properties of the Siwas Oasis Silt, which are found surrounding lakes (Silt L), mixture with (Silt M) brought from the mountain known as White Mountain or Adrere Amellal. Chemical analysis of both silt was performed, the results are listed in Table (2). The results indicate that the main chemical composition of both silts is silica dioxide (SiO_2) (Hussein, 2008). Since the used silts are natural materials it was not of interest to find whether or not the high percentages of SiO_2 in both silts are in amorphous states. In addition, silt M contains higher amount of Calcium CaO (11.40%) as compared to that found in silt L (1.96%). The chemical composition of a mixture of silt M and silt L following the ratio 1:4, respectively is simply calculated (as indicated in Table 2). And chemical properties of silt stream segments (as indicated in Table .3).

Constituent	Total Silica SiO_2	Calcium Oxide CaO	Aluminum Oxide Al_2O_3	Ferric Oxide Fe_2O_3	MgO
Silt L	74.91	1.96	3.80	2.00	-
Silt M	69.03	11.40	1.50	0.44	-
Mixture	73.7	3.80	3.30	1.70	-

Table 2: Chemical Composition of Silt L & Silt M in Siwa (Hussein, 2008).

Specimens can be grouped according to their chemical similarity, (as shown as fig. 10), being the groups characterized by the average values and respective standard deviation for the various determined chemical elements. The analysis of the bricks are similar within each provenance and that the component silicon oxide (SiO_2) which is the largest component in clays, contributes very little with other components such as aluminum oxide (Al_2O_3), iron oxide (Fe_2O_3) and potassium oxide (K_2O) (Francisco M. Fernandes, 2010).

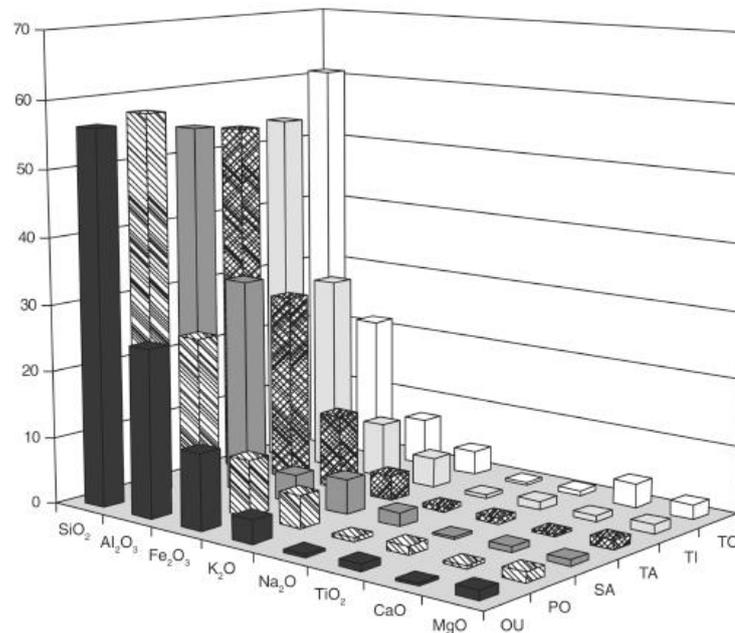


Figure 10: Average proportion of the principal chemical components of old clay bricks (Francisco M. Fernandes, 2010).

Chemical Properties of Silt Stream segments.

Samples were taken from Silt Stream segments in Wadi Mubarak on the coast of the Red Sea in Gabal Eljesera Elhamra - Marsa Alam.

Mineral			Concentration (neq/1)							Density (g/cm3)	Permeability
			cation				Anion				
clay	sand	silt	Ca+	Mg+	Na+	K+	Hco3	Co3	So4		
33.42	32.04	34.52	4.10	3.2	0.34	0.31	3.90	1.44	4.50	1.36	Quickly

Table 3: Chemical and physical properties of Silt Wadi Mubarak
Lab of test properties of materials, faculty of Engineering- Alexandria University.

Constituent	Total Silica SiO ₂	Calcium Oxide CaO	Aluminum Oxide Al ₂ O ₃	Ferric Oxide Fe ₂ O ₃	MgO
Silt Wadi Mubarak	71.40	4.43	5.37	3.91	1.89

Table 4: Chemical Composition of Silt Wadi Mubarak

From the above illustrates the convergence of the chemical properties of the components of mixture silt Siwa oases with sample silt Stream segments in Wadi Mubarak.

Mixing of base silt with raw Materials

Adobe bricks are made with a completely saturated mixture of clay or Silt and sand (and sometimes straw or manure), poured or pressed into forms, which are then removed. After the bricks have dried for several days. Typically, mud mortar is used, a lime-based mortar has also been employed in certain cases (Paul J. Krumnacher, (2001). This paper is searching for another mixing raw materials with Silt stream, through previous experiences.

(Lime) has been used to create durable mortar and adobe bricks and it has exceptional water retention capability and proven performance. Lime can enhance the workability and water retention of plasters and mortars. In the hardened state, lime products react with carbon dioxide to regenerate calcium carbonate or limestone. Lime and mud plasters are relatively rare in the ecolodges in Egypt. The advantages of these plasters include "breathability," softness to the touch, aesthetic qualities, workability and easy reparability, as well as economy of materials. Less brittle than cement-based plasters, those based on lime or mud adhere and "move" with the underlying wall, lessening cracks and often making stucco netting unnecessary. Protected from rainfall and other liquid moisture, a viable in any climate (Paul J. Krumnacher, (2001).

(Bagasse) is the fibrous matter that remains after sugarcane stalks are crushed to extract their juice. It is used as a biofuel and in the manufacture of pulp and building materials, for each 10 tons of sugarcane crushed, a sugar factory produces nearly 3 tons of wet bagasse (Rainey, 2009). Since bagasse is a by-product of the cane sugar industry. The high moisture content of bagasse, typically 40 to 50%, is detrimental to its use as a fuel. In general, bagasse is stored prior to further processing for electricity or Molasses production, and waste fly ash (Leo V. Curtin, 2008).

Effect of Bagaase and Molasses, preliminary trial indicate that Bagasse may act for adhesives, new binders for fiber composites, bear the stress and is best used environmentally and economically. Molasses may act as water reducing admixture to improve the consistency of the mortar. It is obvious that molasses does not have a direct effect on the mortar strength, however it may improve the mortar strength through reducing the water content without affecting the consistency of the mortar. When you add the Bagasse and the percentage of molasses residues it is working to improve the efficiency and consistency of the mixture to be used both in the work of Adobe brick or outer lining, (as shown as the table.5).

Total of 5 mixtures were involved in the experimental study. Same two mixtures from each mix. Specimens were basically tested at the age of 28 days; for comparative purposes. The silt is sieved through a 0.70 mm sieve, the materials were mixed thoroughly in dry state. Then other materials were added to the mixture thoroughly in dry state. Water was added to the mixture approximately 20%. The workability of all mixes were comparable (as indicated in Table .5).

Mixing was done manually for about 5 minutes. The constituent solid materials were first mixed after which the specified amounts of water and molasses were added gradually while mixing continued. In most cases, the consistency of the mortar was very close to the target. However some additional amounts of water or molasses were used in some mixes.

It was observed during mixing that the presence of the fly ash adversely affected the consistency of the mortar. This was expected due to the relatively high surface area of the fine particles of ash.

Mechanical tests of the brick

All specimens were tested under compression in a 300 KN capacity universal compression testing machine. The deflection control made was adopted using a rate of 2mm/min. The compressive strength results of all specimens are given in table .5. Each representative strength value is the average of two tests.

Mix No.	Mix Designation	Blending Ratio of Solid Materials					Water (w)	Absorption (%)	Comp. Strength Kg/cm ² 28 Days
		Silt S	Lime L	Fly Ash F	Bagasse B	Molasses M			
1	Silt+ Lime	4	1	-	-	-	20%	37.2	15.4
2	S +L+F	4	1	1			20%	36.7	15.7
3	S +L+B	4	-	-	1	-	18%	34.5	17.8
4	S +L+B	4	1		1	-	17%	33.7	38.3
5	S +L+B+M	4	1	-	1	2	15%	33.2	53.8

Table 5: Grouping of specimens to evaluate the effect of adding Materials on mortar strength
Lab of test properties of materials, faculty of Engineering- Alexandria University.

TEST RESULTS

The mechanical properties of specimen's adobe bricks are given in Table5. These results show it is more than 20 kg/cm², that's Egyptian standard requirement.

A dosage of molasses on order of 4% of solid materials weight is suggested. Based on the result in table (5), it may be concluded that both Bagasse and Molasses has positive effects on reducing the mixing water content hence improving the strength of mortar. Therefore recommended to be introduced the Adobe-brick and mortar.

In mix No. 2 shows the effect of ash on the compressive strength of the mix gave almost the same results, which indicates the presence of ash does not play any role to improving the mechanical properties of the mortar. In fact, ash is not available around this regions.

When Bagasse and Molasses are introduced in Mix No.5 the water content dropped from 20% to 15% and hence the strength after 28 days was 53.8 Kg/cm² (F= 57.2 Kg/cm²), which gives indicates the strength of Mix 5 after duration 56 days may exceed farther. This finding is considered very promising in improving the construction of ecolodges through Vernacular Architecture technique based on silt stream and the additions that's shown in this paper.

CONCLUSIONS

It is possible to make an adobe brick by using natural materials available in site, that's to conserve, preserve the environment and revival of the vernacular architecture as it's without any falsification to develop the ecolodges in Egypt must provide and understanding of the following:

- The traditional construction technique in vernacular architecture regions resulted into unique distinguishable architectural style of shelters but at the same time these shelters are not safe due to the weakness of the natural building materials used.
- The mechanical strength pressing of adobe brick in the ancient Nubia buildings more strength and durability for the use of clay and silt of the Nile River and its cohesion and strength of a good strain properties but is not present in the premises of the local Nubian modern architecture of the weakness of clay used and the lack of awareness of most Builders previous components and scarcity.
- The need to modify the components of Adobe brick by adding other natural materials available for use in the resorts and protected areas in Egypt, this is the aim of the paper.
- Preliminary experiments indicated that a good set of silt stream segments are available in Red Sea coast between cities Elqusair and Marsa Alam is a staple good to create Adobe brick and mortar Association with the assistance of additions to the raw natural such as (Bagasse)&(Molasses).

