Use palm leaves added to adobe for applications in the restoration process

Rasha Elborgy

Alex. Univ. Egypt
F.S.M.V Univ. Architecture Dep. Istanbul, Turkey
Rasha.borgy@gmail.com

ABSTRACT: This paper discusses two points: The first point is how to save that large heritage of Adobe buildings around the world, by restoring and repairing the damages of those buildings by talking about the restoration of Adobe. Sec. point is to find an alternative material to rice straw to be used for making Adobe brick, Provided that the same availability and quality of rice straw. Egypt is considered one of the oldest and famous countries for Adobe construction and it appears in Siwa Oasis and in Upper Egypt, like the new Qurna village which is one of Hassan Fathy's works.
The paper will show some of the reasons and types of Adobe damages, and the techniques of repairing and restoring Adobe, As is known, water is the enemy of Adobe buildings, so we will focus on an absorbing water test, testing the palm leaves as an alternative material to rice straw, and comparing between rice straw and palm leaves, first as a raw material in absorbing water, sec. after using them in producing the bricks.

KEYWORDS : Architecture of poor, back to earth, palm leaf, Adobe brick restoration, Earth architecture, rice straw

1. Introduction

Adobe structures are extremely durable and consider one of the oldest buildings that survived in the world. Compared to wooden buildings, adobe buildings offer significant advantages due to their greater thermal mass in hot climates.

Egypt is one of the oldest countries to start building adobe houses and temples. Egypt is also one of the largest producers of palm trees. The aim of this paper is to test Palm leaves as an alternative material to rice straw for making Adobe bricks and how can the new mixture be used in restoration works.

When we mention about Adobe buildings, the old buildings come to our minds first, and how to save and survive it again, it can be done by repairing and restoring it with material work out in high quality as the original materials of the building, also guaranteed to remain for a long time, and as it is known, water is a big enemy of Adobe buildings, for this point, Both rice straw and palm leaves were subjected to water absorption tests, before mixing both with the soil (as raw materials) and after mixing both with the soil (as a brick), we observed that the reaction of palm leaf with water was always slow while the reaction of rice straw was active with water and fast.

For example, the brick made of palm leaves was absorbing the water slowly to reach 7 cm after 5 hours while the brick made of rice straw absorbed over 11 cm after 5 h. and totally collapsed after 10 h.

Now, we will review the Qurna village as an example in Egypt and some of the damages of the Adobe buildings.

2. Qurna Village (Hassan Fathy)

Qurna village is located in the west of the city of Luxor in Egypt. In 1946, Hassan Fathi started to cooperate with the Egyptian government regarding the village. The reason for the fame of this village is the book "Architecture of the Poor", which recounts the story of establishing it. The village was established to accommodate the displaced from the tombs of Pharaonic tombs on the western bank to save it from robberies and encroachments, especially after the specialists and archeologists discovered the theft of a rock stone from one of the royal tombs. The government allocated a budget of one million Egy. pounds at that time to build the new village. The site was chosen to be away from the archaeological sites and near to the railway and agricultural land. **(Hasan Fathy, 1073)**.

Hassan Fathi started the first phase of the project of building the village by building 70 houses. Each house has its own characteristic. As for the design of the house, he depended on local materials and elements. The domes had their unique design and were used instead of ceilings that were based on wood panels or usual iron fences. An additional door has been allocated to livestock, which residents of the area acquired as a form of quarantine, for the safety of users.

Three schools were built in the village; one for boys, one for girls, and the third one was a school to teach handicrafts that were famous in the Qurna region, such as alabaster, spinning, weaving, and palm products. Through this school, he tried to preserve the spirit of pharaonic creativity in the new generations. As Fathi was concerned with the educational aspect, he did not ignore the religious aspect that distinguishes the villagers or the entertainment aspect to compensate them for their displaced homes. Fathi worked on the construction of a large mosque at the entrance of the village. The mosque was a masterpiece with its Tolonian style mixed with Islamic art in the Fatimid era. Unfortunately, the mosque suffered from the misuse of the Ministry of Awqaf that destroyed its Islamic architectural pattern. For entertainment, Fathi created a culture palace named after him, a Roman-style theater and a swimming pool. **(World Monuments Fund, 2011)**

Figure 1. The marketplace in Qurna village – Hassan Fathy - Luxor – Egypt, Author

Figure 2: An internal section showing a corridor in the marketplace in Qurna village- Hassan Fathi - Luxor – Egypt, Author

Figure 3: The cracks in a house wall, Qurna village- Hassan Fathi - Luxor – Egypt, Taken by the Author

Figure 4: A house facade in the new village of Qurna village- Hassan Fathi - Luxor – Egypt, Taken by the Author

Many parts of the village have been destroyed as a result of the total neglect of the buildings. Some Adobe buildings owners sold their houses and the new owners made some changes in the buildings. Some of the owners have completely damaged the original Adobe buildings and constructing new multi-level houses by reinforced concrete and bricks. This led to a change in the features of the village built by Hassan Fathi as well as the general nature of the place.

Some of the buildings were undergoing restoration processes. and the last restoration process was carried out in March 2019 under the supervision of UNESCO, the restoration of mud buildings "adobe buildings" is considering each building a special independent case upon the style and time required for restoration.

For this reason, the preservation and restoration processes for Adobe buildings were important to be mentioned in this paper, which will be discussed in the next point.

3. The Restoration of Adobe

- **Adobe Restoration process**

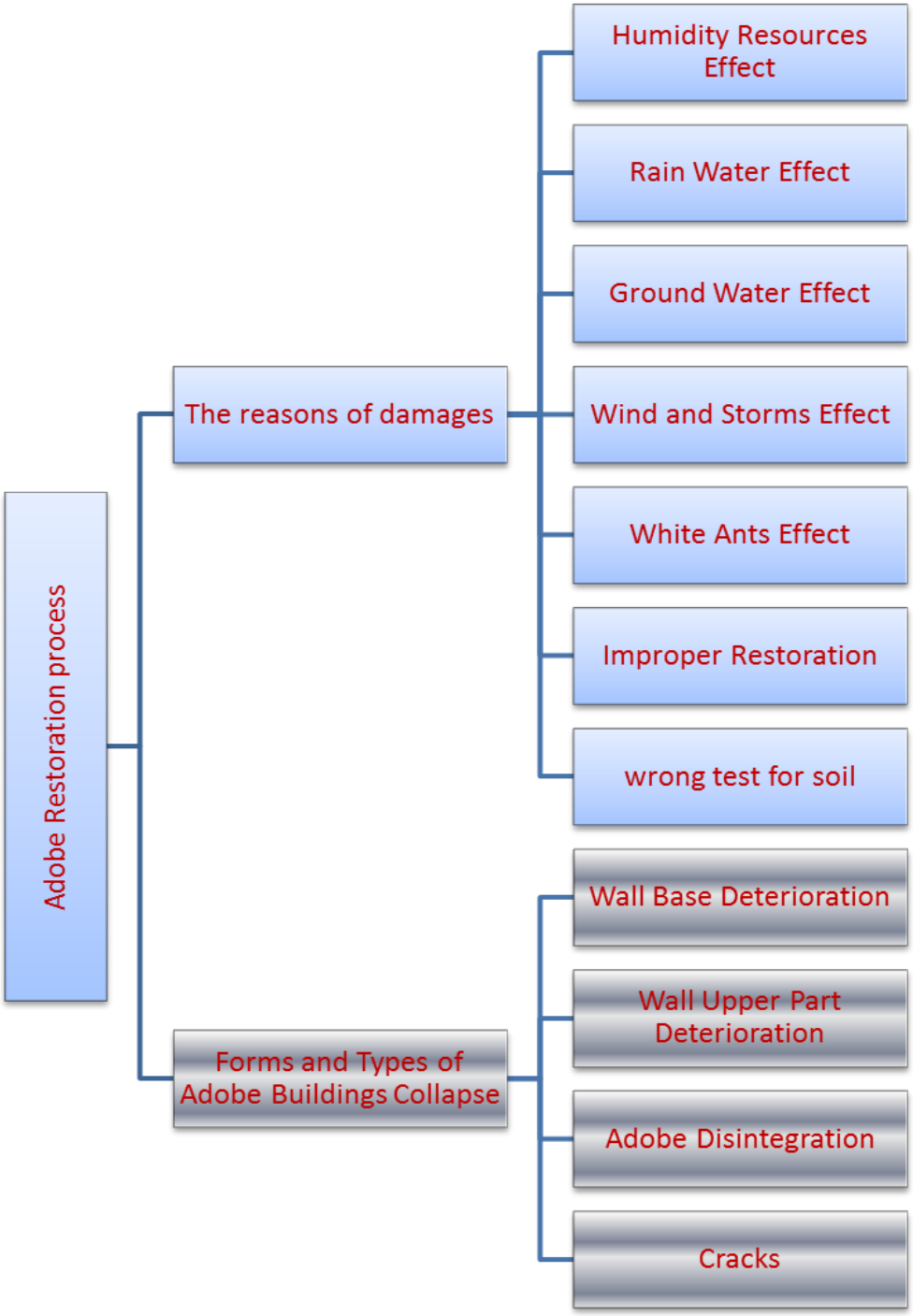


Diagram 1: The Diagram shows the Restoration process, the reasons of damage and types of collapse, by Auther

- **Techniques Used in the Adobe Restoration**

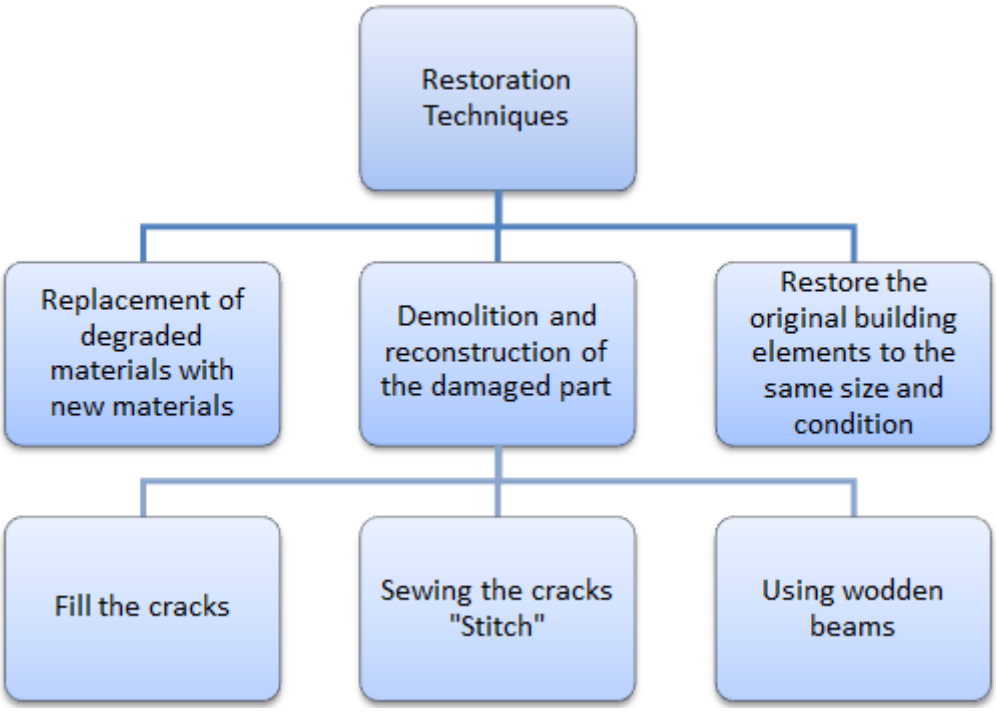


Diagram 2: The Diagram shows the Restoration Techniques, Author

- **Maintenance and Preservation**

Periodic maintenance has always been a success key to any adobe structure. Once restoration process is complete, the maintenance program must be started. The change to the building should be noted in particular. The early stages of cracking, sagging, or swelling in the walls should be monitored regularly. All damages caused by water must be observed and treated in the early stages. Other damages caused by plants, animals, and insects must be treated before it gets worst. The roof should be checked periodically. Surface coatings should be frequently examined and repaired or replaced as needed. Collapse mechanical systems must be monitored. Observation of mud-adobe buildings for minor changes and maintenance on a regular basis is an essential policy. The nature of adobe buildings can easily deteriorate, but regular maintenance can produce a relatively stable adobe building.

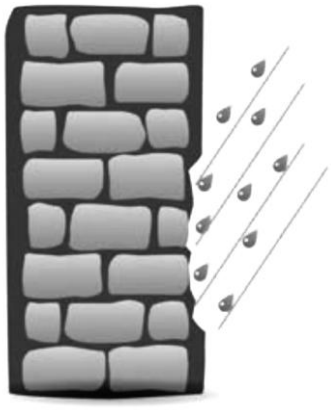


Figure 5: Rainwater impact on adobe walls

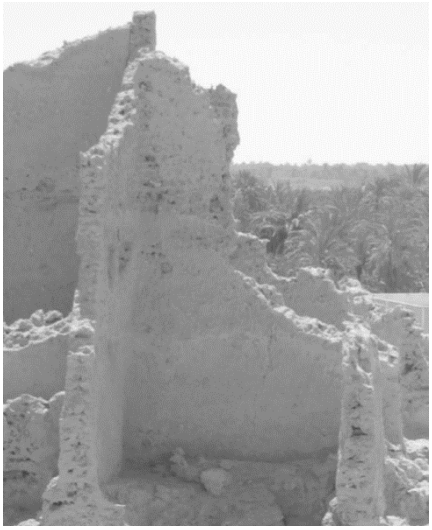


Figure 6: The wind effect on an Adobe wall, Siwa, Egypt,

Figure 7: The ground water effect on an Adobe wall

Figure 8: Wall Bulging and Slumping, El.Qurna- Luxor, Egypt, Taken by Author

Figure 9: Adobe Disintegration, El.Qurna- Luxor, Egypt, Taken by Author

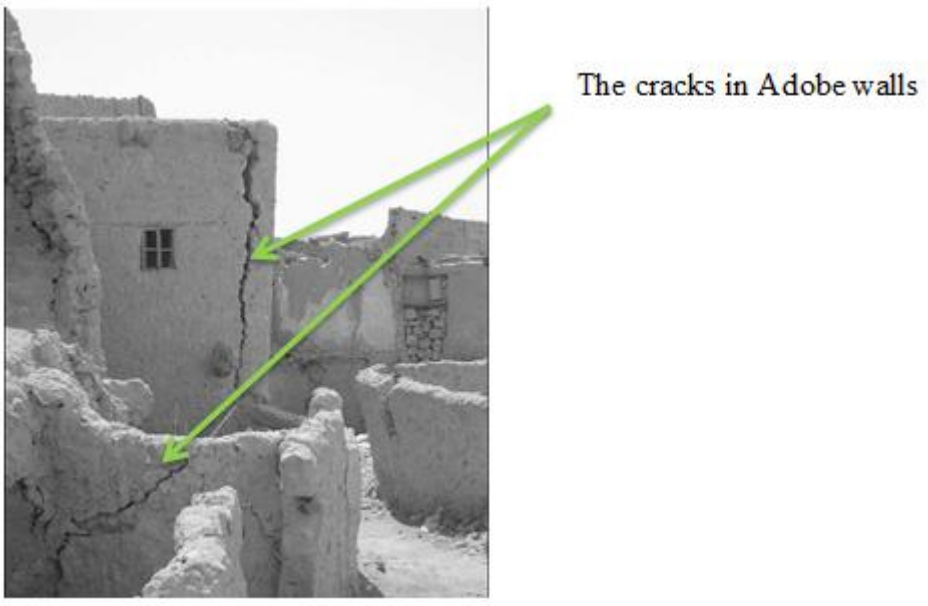


Figure 10: The cracks in the wall, Siwa, Egypt

Figure 11: Installation of timber beams for the treatment of a vertical discontinuity

Figure 12: timber beams at the corner of adobe wall

4. The Adobe Brick and its Components

In Egypt:

2 Soil (2clay + 1sand) + 1 straw + water = the mixture

2 : 1

70% : 30% : as the mixture needs

Mix all components together and leave it to ferment well for 8 to 40 h; cover the mixture by a plastic cover. the fermentation process produces lactic acid because of the Lactose in the straw. After the fermentation process, we start to put the mixture in the brick form (25*15*5 cm), and then we leave it under the sun to dry well for 3-6 days. We found that the brick made of pure soil shrank 37% after the drying process. but there two advantages for adding the straw to the mixture: First, it works as a fabric for the mud that makes bricks coherent, and sec., it reduces the shrinkage rate of bricks.

Figure 13: the mixing process

Figure 14: the framing process

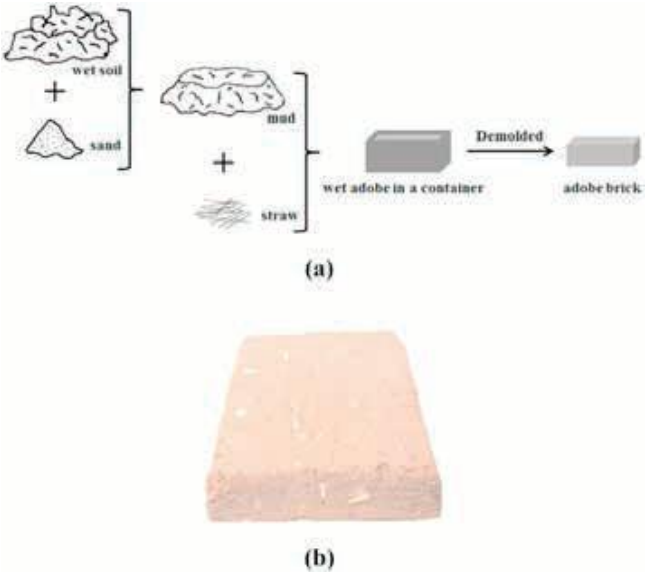
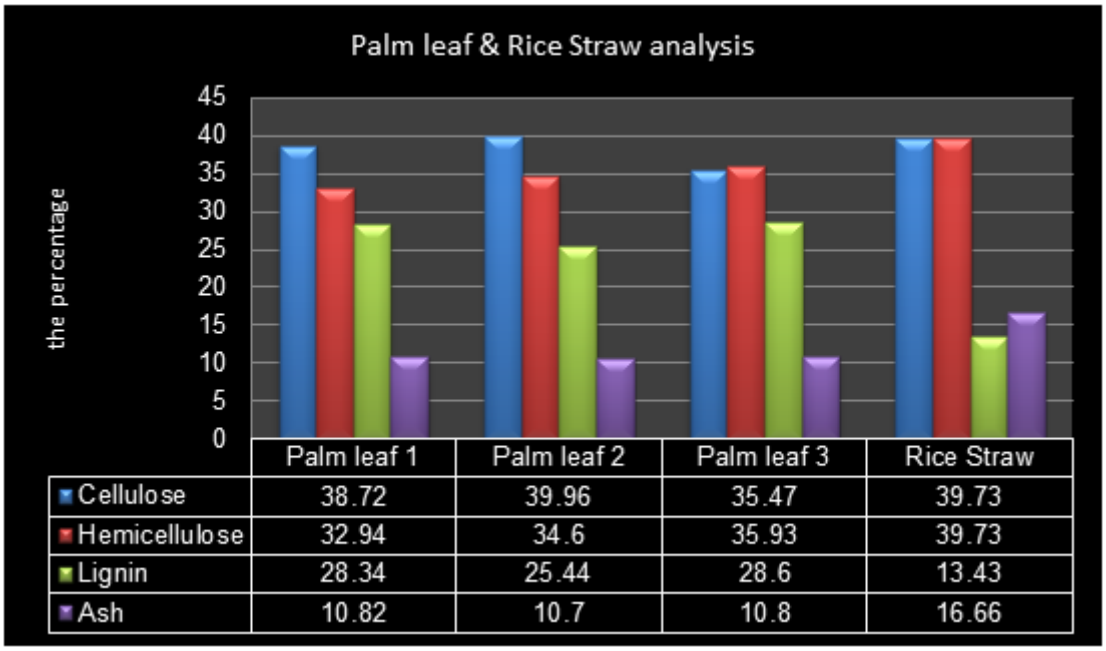


Figure 15: showing the components and process of making Adobe brick

4.1 The Rice Straw and Palm Leaves

The Cellulose ratio in both rice straw and palm leaf is considering an important factor in the fermentation process in making the Adobe brick for producing lactic acid. So when we compare the analysis results of rice straw and palm leaves, we got:

1. The result was almost as close between rice straw and palm leaves samples as for Cellulose.
2. The result was higher in rice straw than in palm leaves samples as for Hymselolose.



	Palm leaf 1	Palm leaf 2	Palm leaf 3	Rice Straw
Cellulose	38.72	39.96	35.47	39.73
Hemicellulose	32.94	34.6	35.93	39.73
Lignin	28.34	25.44	28.6	13.43
Ash	10.82	10.7	10.8	16.66

Charts 1: Comparison between the results of rice straw and palm leaves sugar percentage: The Author

4.2 Water Absorption Rate for Both Rice Straw and Palm Leaves Samples

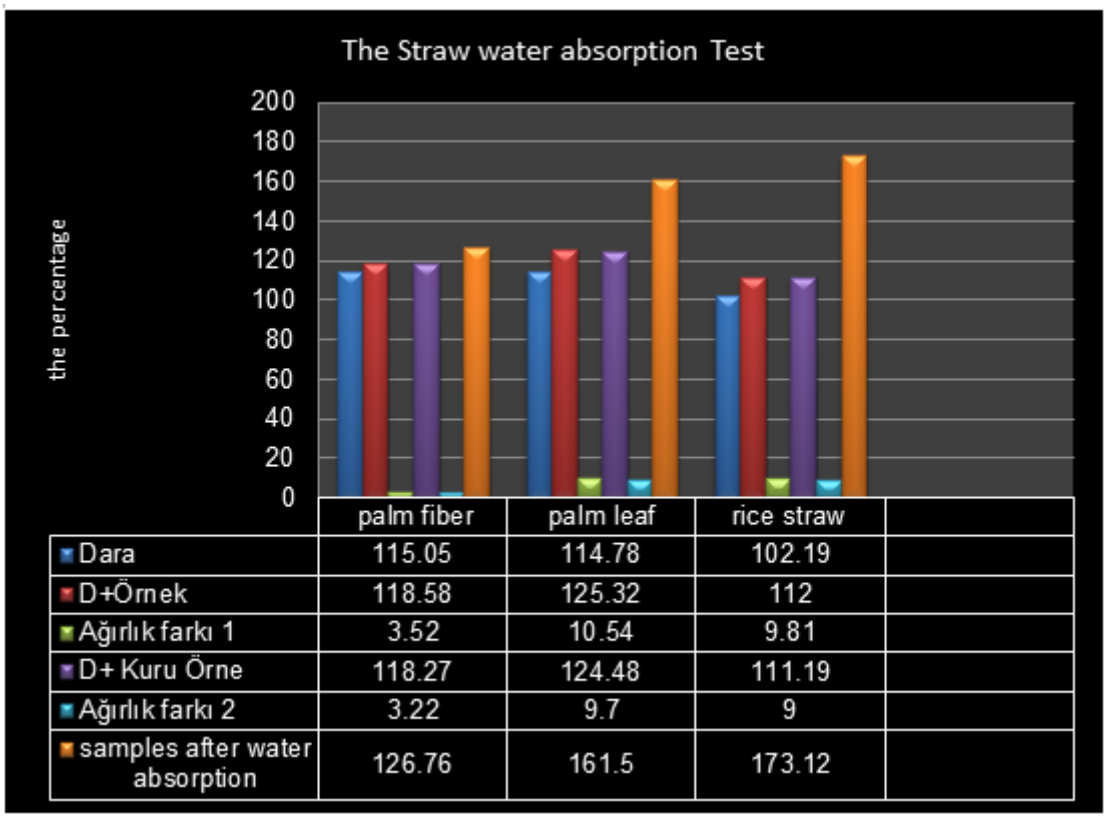
In three samples of rice straw, palm leaves and palm fiber

The test tube was weighed completely empty and clean and the weight was taken. Each sample in the test tube was placed in an oven under 105 ° C until completely dried. It is then weighed in three stages to ensure final reading for the

completely dried samples.
calculated upon absorption ratio

$$A = \frac{(ma - md) * 100}{md}$$

Where A is the final percentage of water absorption, "ma" is the sample final reading after water absorption and "md" is the last reading of the sample after complete dehydration



	palm fiber	palm leaf	rice straw	
Dara	115.05	114.78	102.19	
D+Örnek	118.58	125.32	112	
Ağırlık farkı 1	3.52	10.54	9.81	
D+ Kuru Örne	118.27	124.48	111.19	
Ağırlık farkı 2	3.22	9.7	9	
samples after water absorption	126.76	161.5	173.12	

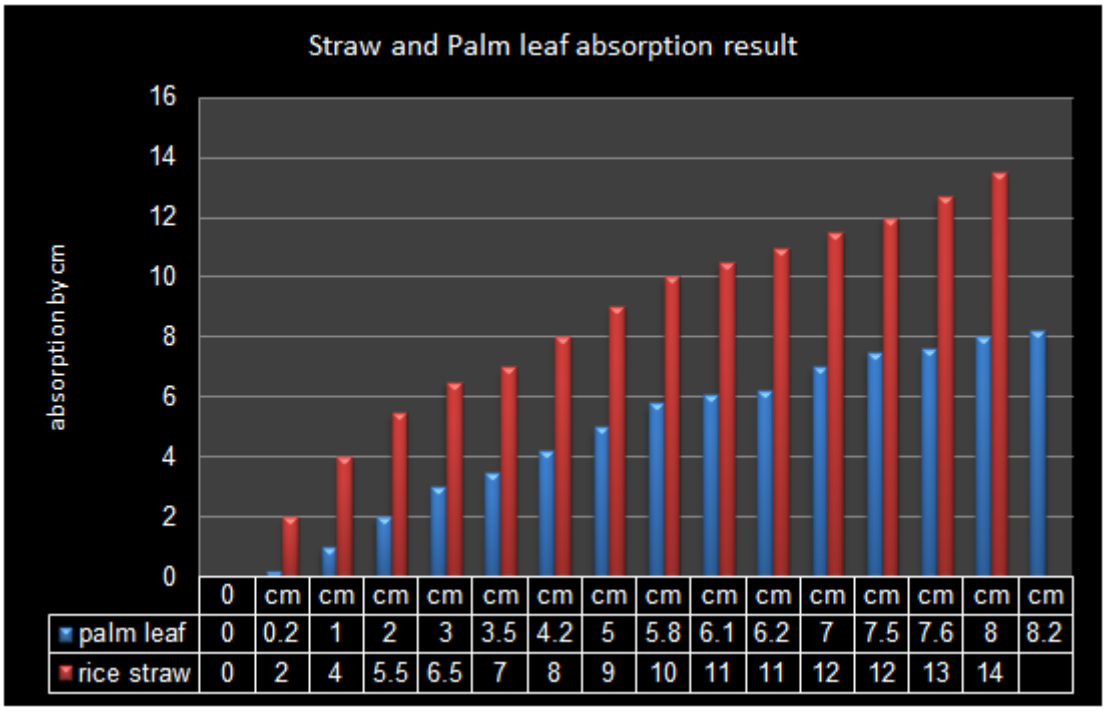
Charts 2: water absorption rate of rice straw and palm leaf, Author

The importance of this test is to know the ability of the three samples to absorb water, as this fiber is an essential element in the composition of the adobe and therefore the more capacity used to absorb water increased the chance of saturation of the brick with water, and this presents the brick to rapid damage**.**

4.3 Adobe Water Absorption Test

According to the ASTM C1585 standard which is using in absorbing water tests, This test was made to determine the percentage of water absorption in Adobe brick made of palm leaf and rice straw, as our work is mainly focused on the palm leaf as an alternative to rice straw. So both must be compared.

As shown in the chart3, the red color indicates to the Adobe brick made of rice straw, while the blue color indicates to the brick made of palm leaf, the horizontal is the absorption of water by "cm" and the vertical is the absorption speed in "hr", So, we will notice that the amount of water absorption in cm/hr in the Adobe made of rice straw is higher and faster than the amount of water absorption in cm/hr in the Adobe brick made of palm leaf.



Charts 3: Constant- Soil (Turkey) Variable-hay (rice straw and palm leaves)

The first experiment of water absorption for Adobe bricks made of Palm leaves.

R: Rice Straw Adobe brick, P: Palm Leaf Adobe brıck

Figure 16: At the beginning of the test, compering between two Adobe brick made of rice straw and palm leaf. Author

Figure 17: After an hour of the test, the Amount of water absorbed in both bricks. Author

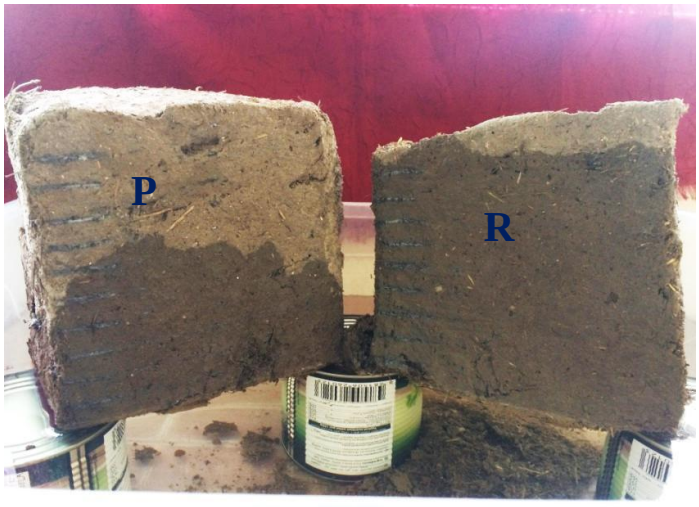


Figure 18: After 5 hours of the test, the Amount of water absorbed in both bricks. Author

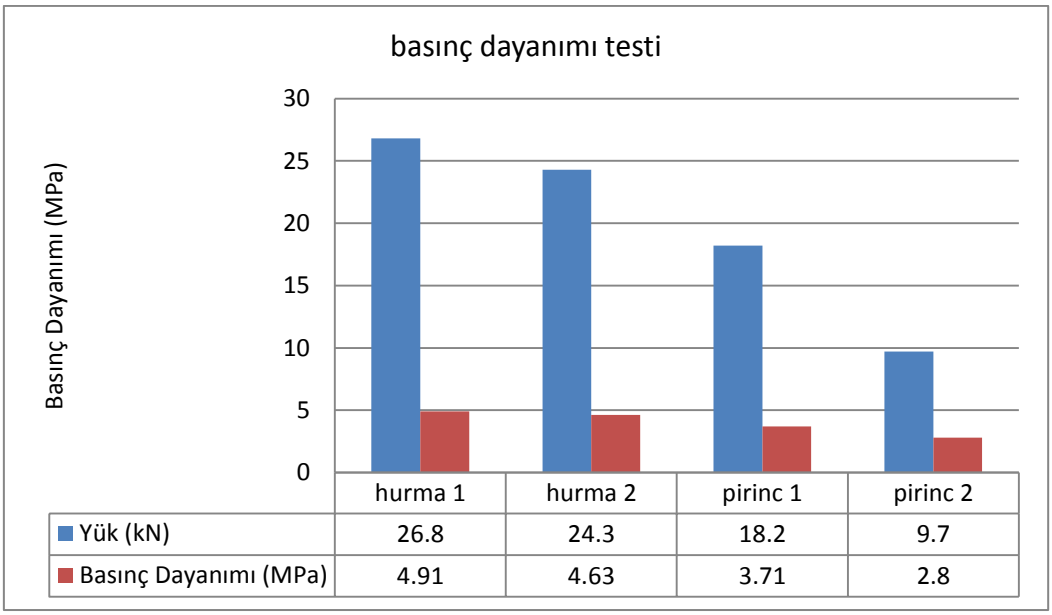
Figure 19: After 12 hours, the final result is the collapse of the rice straw Adobe brick, Author

4-4 Strength Test (Compressive Strength Test)

Strength resistance test, Turkey, FSMV University, the test in the laboratory, was performed by a machine that measures the strength of the power brick. The Adobe brick was placed in the machine, power was applied and pressed gradually, and the values obtained were read and noted. Pressure was continued until adobe was broken. The adobe samples used here are made of palm leaf and rice straw. The results are as follows in the table in chart 3

Figure 20: Adobe made of Palm Leaves

Adobe made of Rice Straw



Charts 3: Adobe samples sized 7 * 7 * 7 cm made of rice straw and palm leaf,

The result of compressive strength test of four adobe samples.

(Hurma: Palm, Pirinc: Rice, **Load**, **Pressure**)

5. Conclusions

Adobe construction simply means (land + plant). So that Adobe brick changes in some of its properties depend on the main contents. The exploitation of surrounding environmental materials, such as rice straw or palm leaf and mix it with silt and clay in all cases produce an environmentally friendly building, all construction materials under our feet on the site. So by using a palm leaf as an alternative material to rice straw, the result was positive as follows.

The added palm leaf mixed with the soil proved to be very effective in the low absorption of water, in both cases First: before mixing it with the soil, while it is a raw material still, and after adding it to the soil to make the Adobe brick, the result was slow and less absorption of water compared to the Adobe brick made of rice straw. The importance of this point (absorption of water) is in dealing with the Adobe brick later in its resistance to moisture, and its slow absorption or interaction with groundwater, which are the causes of the destruction of Adobe buildings. Also, the lack of water absorption will make the repairing process less periodic maintenance in this way, the building can be quickly checked and controlled in the case of discharge of the water, due to the low and slow absorption of the water in the new mixture made of palm leaves, even the result was positive in the Compressive Strength Test with Adobe made of Palm leaf.

REFERENCES

Satprem Maïni, 2005, EARTHEN ARCHITECTURE FOR SUSTAINABLE HABITAT AND COMPRESSED STABILISED EARTH BLOCK TECHNOLOGY, UNESCO

Ramadan A. Nasser, 2016, Chemical Analysis of Different Parts of Date Palm

(Phoenix dactylifera L.) Using Ultimate, Proximate and Thermo-Gravimetric Techniques for Energy Production, Energies 2016, 9, 374; doi:10.3390/en9050374

M.S. Salit, 2014, Tropical Natural Fibre Composites**,** Engineering Materials, DOI 10.1007/978-981-287-155-8_2

Hamed Niroumand, 2013, Earth Architecture from Ancient until Today, 2nd Cyprus International Conference on Educational Research, (CY-ICER 2013), M.F.M Zain, Maslina Jamil, Shahla Niroumand

Abdou A. O. D. El-Derby, 2016, THE ADOBE BARREL VAULTED STRUCTURES IN ANCIENT EGYPT: A STUDY OF TWO CASE STUDIES FOR CONSERVATION PURPOSES, Mediterranean Archaeology and Archaeometry, Vol. 16, No 1,(2016), pp.295-315, Copyright © 2016 MAA, Open Access. Printed in Greece. All rights reserved. Ahmed Elyamani

J. E. QUIBELL., 1898, EGYPTIAN RESEARCH ACCOU,

THE RAMESSEUM, THE TOMB OF PTAH-HETEP. LONDON**:** BERNARD QUARITCH, 15, PICCADILLY, W.

P. HALUSCHAK, 2006, LABORATORY METHODS OF SOIL ANALYSIS, CANADA-MANITOBA SOIL SURVEY.

Gernot Minke, 2010, Building with Earth. Design and Technology of a Sustainable Architecture, Birkhäuser – Publishers for Architecture, Basel · Berlin · Boston

Dan Babor and Diana Plian, 2010, THE PRESERVATION OF ADOBE BUILDINGS, Publicat de Universitatea Tehnică „Gheorghe Asachi" din Iaşi

Marwa Dabaieh, 2013, Earth vernacular architecture in the Western Desert of Egypt.

Luisa Rovero, 2009, **Fabio Fratini**, The salt architecture in Siwa oasis – Egypt (XII–XX centuries)

Mahmoud Abd El Hafez, 2015, Adobe Architectural Heritage in Egyptian Oases - Risks and Methods for Protection and Rehabilitation

Australian Standard AS 3700:2018, Masonry structures

NEW AUSTRALIAN STANDARDS FOR MASONRY IN SMALL STRUCTURES
S.J. LAWRENCE

NAPAT SRIWATTANAPRAYOON, 2014, Engineering Properties of Adobe Brick for Earth Structures

Elsayed A. Elbadry, 2014, Agro-Residues: Surface Treatment and Characterization of Date Palm Tree Fiber as Composite Reinforcement

Edward W. Smith1 and George S. Austin2, 1989, Adobe, pressed-earth, and rammed-earth industries in New Mexico

Pusit Lertwattanaruk* and Jarunsri Choksiriwanna 2011, The Physical and Thermal Properties of Adobe Brick Containing Bagasse for Earth Construction

Ayşe Bilge Işık 2018 **Negar Javadi**, OF SUSTAINABILITY INDICATORS; NATURAL LIGHT IN IRANIAN BAZAAR, Conference: Kerpic'18 –6th International Conference Hasan Kalyoncu University, Turkey

Ayşe Bilge Işık, 2008, **Hanifi Binici, Metin Köse, Hüseyin Temiz,** Mechanical Properties of Clay with Fibers Used in Mud bricks, International Conference Cyprus International University, Lefkoşa / Northern Cyprus 4-5 September 2008 ISBN 978-975-6000-2-07-0

Ayşe Bilge Işık, 2008, **Nejla Cini, Tülay Tulun**, An Archaeometric Study on a Hımış Type Old House from Central Anatolia, International Conference Cyprus International University, Lefkoşa / Northern Cyprus 4-5 September 2008 ISBN 978-975-6000-2-07-0

Ayşe Bilge Işık, 2015, **Hakan İrven**, Materials Used in the Construction of Village House in Van, Istanbul Aydin Univ. International Journal of Architecture and Design.

Ayşe Bilge Işık, 2008, Branding earthen architecture in northern Cyprus as cultural capital, International Conference Cyprus International University, Lefkoşa / Northern Cyprus 4-5 September 2008 ISBN 978-975-6000-2-07-0

URL 1 http://www.microbiopharm.com/en/business/fermentation11.html

URL 2 https://www.sciencedirect.com/science/article/pii/B9780120403028500057

URL 3 https://www.hort.purdue.edu/newcrop/ncnu02/v5-017.html

URL 4 https://en.wikipedia.org/wiki/Cellulosic_ethanol

URL 5 https://en.wikipedia.org/wiki/Geography_of_Egypt

URL 6 https://www.kuoni.co.uk/egypt/regions

URL 7 https://www.roughguides.com/maps/africa/egypt/

URL 8 https://eartharchitecture.org/

URL9 https://culture.pl/en/article/earth-architecture-building-the-future-with-ancient-solutions

URL 10 https://en.wikipedia.org/wiki/Earth_structure

URL 11 http://www.solidearth.co.nz/adobe-brick-technique.php

URL 12 https://link.springer.com/chapter/10.1007/978-94-017-9694-1_3

URL 13 https://www.youm7.com/story/2019

URL 14 https://sources.marefa.org

URL 15 http://www.fao.org/fileadmin/user_upload/GSP/docs/NENA2014/Egypt.pdf

URL 16 https://www.ecomena.org/arab-islamic-architechture-ar/

URL 17 http://www.unesco.org/new/ar/unesco/resources/earthen-architecture-the-environmentally-friendly-building-blocks-of-tangible-and-intangible-heritage/