Kerpic'22

9th International Conference
PROCEEDINGS

Re-Thinking Earthen Architecture for
Sustainable Development

MEDIPOL
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30 June - 03 July 2022

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Re-Thinking Earthen Architecture for Sustainable Development

30 June -03 July 2022

Organized by
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THEMES OF THE CONFERENCE

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- Charging with production and consumption
- Earthquake safety in adobe structures
- Earthen architecture with ultimate technologies
- Healthy life with earthen architecture
- Innovation in earthen architecture
- Learning from earthen architecture during climate change
- Management of earthen architecture
- New generation earthen architecture
- Evaluation of Risk and Protection against environmental effects and disasters
- Reducing, Reusing, Recycling
- Principles and methods of conservation
- Structural behavior; static, dynamic and numerical analysis methods
- Standards and guidelines
- Sustainability in building materials
- Sustainable architecture and sustainable cities
- Traditional construction techniques

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The vision of Istanbul Medipol University; to be an exemplary university in our country and in the world with its level of excellence in education and training, its determination to train well-equipped manpower who aspire to build the future of society, its highly qualified academic staff and contemporary infrastructure.

Our university aims to provide an education that designs a better future for our students and indirectly for the society we live in. In a limited time, it is an indicator of the success of being an institution that research, learns and teaches together with its students, which enriches it with its strong academic staff and diversity.

We are proud to host the 9th international Kerpic'22 conference with the main theme "Re-Thinking Earthen Architecture for Sustainable Development". I congratulate everyone who contributed to the Kerpic'22 conference and wish them success.

Prof. Dr. Bilge ISIK

Conference Chair Istanbul Technical University (Emeritus), Istanbul, Turkey

We are pleased to announce the call for the 9th International Conference on "Re-Thinking Earthen Architecture for Sustainable Development" and the post-conference workshop on earthen building production. The Conference will be held on 30 June – 3 July 2022 and organized by Kerpic Akademi, Kerpic Network and İstanbul Medipol University School of Fine Arts Design and Architecture.

The aim of the conference is to gather the findings and knowledge regarding the theme "Re-Thinking Earthen Architecture for Sustainable Development" and transfer these to the new generation.

The conference will focus on using earth as a building material and the event will include graduate students, academics and professionals exchanging their findings and experiences. The conference will provide for an opportunity to understand the strategies involved, advantages of and advances made in the contemporary construction technology of earth-based material.

For more than thirty years, Kerpic Network has been conducting research on the durability, seismic response and production techniques of earthen construction material. The durability research is based on stabilized earth (alker); the seismic response research is based on horizontal energy dissipating surfaces on the load bearing walls and additional research has been conducted on production techniques of earthen materials and walls.

Prof. Dr. H. Attila DIKBAS

Conference Co-chair
Istanbul Medipol University, Istanbul, Turkey

The İstanbul Medipol University School of Fine Arts, Design and Architecture deploys its resources to the utmost for the education of competent professionals, artists, researchers and academicians.

We integrate the vast cultural heritage and artistic creativity of our geography with the most recent knowledge and technical tools in the field in order to provide our students with a high level of education and skill set. Our programs have a practice-oriented vocational element and we work in close cooperation with the industry in order to best prepare our students for professional life after graduation.

We are proud to host the 9th internationally recognized kerpic'22 conference as the Istanbul Medipol University School of Fine Arts, Design and Architecture.

We will be discussing, within the scope of this conference, with academicians as well as professionals working in the field, the use of earth as a building material. We will be sharing with you, in the form of the Kerpiç'22 Conference Proceedings, the results and experiences obtained within the scope of this conference.

I would like to express my sincere gratitude to those involved in the organization of this conference and all participants who contributed their invaluable insight and experiences.

I wish you all a successful conference.

Assoc. Prof. Dr. Gulhan BENLI

Conference Co-chair
Istanbul Medipol University, Istanbul, Turkey

High-rise buildings and fast-growing cities, which are rapidly developing depending on the opportunities provided by technology, are one of the biggest factors that play a role in the pollution of our world. It is an accepted fact that renewable resources should be used in order to prevent problems such as increasing air pollution, decreasing food and clean water resources. However, it is possible to design buildings and living spaces that do not destroy the nature, consume minimum energy and use recyclable materials. Proliferation and promotion of studies on natural materials in our country, bringing together innovative designs and natural materials are of great importance in the formation of healthy cities in the future.

Earthen structures which have been encountered in any part of the world are examples of ecological structure and construction. The mudbrick structures, which are a product of soil material, on the other hand, offer an optimum living environment for the people living in them. At the same time, it can be recycled very quickly and reintroduced to the nature. Its' manufacture and application can be learned by everyone. Its' production is easy and economical. For this reason, adobe, a traditional building material, is known as environmentally friendly with minimum energy requirement from production to construction phases and has been used in architecture for centuries.

That's why we, academics, scientists, and professionals working on natural materials should rediscover the soil and make more efforts to learn about and teach natural building materials in order to leave a healthier living environment for our next generations.

"Re-Thinking Earthen Architecture for Sustainable Development" was chosen as the main theme of the 9th international Kerpic'22 conference, which brings to the agenda that adobe material can be reused in architecture, construction, and other design fields. I believe that this conference will be an occasion for the rediscovery of the use of natural and environmentally friendly earth materials in architecture.

I would like to express my gratitude and thanks to the Istanbul Medipol University family, who supported us in every way while organizing the Kerpic'22 conference hosted by our faculty. I hope that this meeting will produce a great deal of data and set a good example for the younger generations.

Assist. Prof. Dr. Gizem CAN

Conference Co-chair
Istanbul Medipol University, Istanbul, Turkey

Waste is a worldwide problem that should be managed well for better resource utilization. On the purpose of optimizing the limited sources for sustainable environment and contributing zero-waste circular economy in scope of waste evaluation, re-use fields of material wastes and natural materials should be considered.

Adobe is a natural material which has been used for many years. Although it was used in primitive architecture in early years of the world, it continues to be used as an effective and sustainable material for today's architecture. Adobe is one of the key factors for architecture to save the sources and provide sustainability of investment. So, it becomes important to manage the adobe structures to ensure efficient material because of sustainability.

Within the scope of this conference, adobe will be mainly discussed in terms of energy, sustainability, safety, health, innovation, management, structure and construction techniques by the academics and professionals. It is aimed to re-thinking adobe for not only as a traditional but also sustainable solution.

I hope this conference helps that earthen architecture can be evaluated as an imperative option for today's architecture in terms of waste and circular economy.

I would like to express my gratitude and respect to Istanbul Medipol University, hosts "Kerpic'22: 9th International Conference", for its support to our organization process. I also thank all the authors and participants who attend to the conference from different parts of the world to make this conference a big success.

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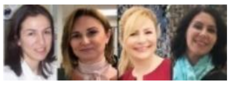
5		Aysun F. Guner, Gulhan Benli, Pelin Karacar, Sefika Ergin	Structural Features and Conservation Problems of Traditional Adobe Houses in Erimli Village, Diyarbakır	Diyarbakır, Istanbul, Turkey
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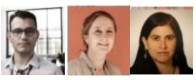
10		Berk Kesim, Nilüfer Baturayoğlu Yöney, Elif Denel	Drawing Connections to Archaeological Context: New Mudbrick / Kerpiç Designs for Tayinat / Kunulua on the Amuq Plain	Kayseri, Antakya, Ankara, Turkey
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Re-Thinking Earthen Architecture for Sustainable Development, VAN Field Project

Bilge Isık
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ABSTRACT

Earthen architecture is carrying knowledge from the history of mankind, as it is mostly used construction material. Living in earthen buildings is healthy. Indoor climate can be established with physical and mechanical property of earthen material. As a result, heating and cooling energy demand, up to the geographic living area, is minimized or not used. Today, demand for adobe structure can be identify in three ways: health living, little money for energy usage, 0-energy usage for sustainable environment. With the rise of global population and epidemic effect in recent years demand for widespread settlement gained importance. There is a need for re-thinking of earthen architecture: material durability, earthquake safety of loadbearing earthen walls, industrialized construction techniques. General usage of earthen material is for masonry or loadbearing structures. This study will summarize the findings on: *zero energy earthen buildings, *learning from earthen architecture heritage, *development strategy on earthen construction. With the field project in VAN province, the study will contribute for the demand on legal and administrative process using earthen architecture.

Keywords: Earthen Architecture, Zero Energy Buildings, Learning from Heritage, Development strategy, Development Strategy, Collaboration

Protecting the earthen heritage located in seismic areas

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ABSTRACT

Throughout the world, many earthen dwellings and historical monuments are at risk because they have been built with earth, and earthen structures have consistently shown extremely poor structural behaviour during earthquakes. Every single earthquake occurring in these areas has caused unacceptable loss of life, property damage and heritage destruction. Earthquakes are recurrent and construction damage is cumulative. It is urgent, therefore, to devise low-cost, easy-to-implement seismic reinforcement systems and to make them available to the actual dwellers and to heritage conservation professionals. A group of researchers at the Pontificia Universidad Católica del Perú has been working towards that goal, especially on improving the seismic capacity of one-storey adobe structures. They have proposed construction methodologies for a seismic reinforcement system consisting of a mesh of nylon ropes that confines all earthen walls. This reinforcement system would control the wall displacements and prevent the overturning of wall portions that may occur due to seismic shaking. To validate the effectiveness of the nylon rope mesh reinforcement on two-storey adobe dwellings, shaking table tests were conducted on unreinforced and half-scale reinforced adobe models, simulating the actions of slight, moderate, and strong seismic ground shaking. These models were designed to include the main construction features of typical adobe dwellings in the Peruvian Andes. The results of the experimental tests showed that the rope mesh reinforcement system was able to preserve the structural stability of the tested reduced-scale adobe models under strong motions, thus preventing collapse. It is expected that the proposed reinforced system would also improve the seismic performance of one and two-storey adobe constructions, reducing in this way their inherent high seismic risk.

Contemporary Earth Construction in Turkey

Matthieu J. Pedergnana
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ABSTRACT

Earthen materials have been used for construction since the beginning of human settlements. Older remains in Turkey and the Middle East show traces of earth constructions built more than 10000 years ago. However, despite the tradition of earth building being uninterrupted in most countries until the 20th century, and recent development in the mechanization and the understanding of earthen material properties, Turkish contemporary architecture pains to incorporate earth as a common building material. The construction industry still sees earth construction methods as unsafe and not fit for modern buildings whereas the acceptance by the public is linked to the capacity of earthen materials to perform equally with modern materials in terms of durability and maintenance. However, some earthen materials are often forgotten as they are the link between lightweight fibre construction and heavy mass earth construction. The technique called lightweight loam or slip-straw is one of these solutions to use easily earth as an infill material in lightweight construction. After a review of some buildings made in the recent years, by different architects or homeowners, the recent achievements of lightweight loam buildings by Atelier-Metis will be presented showing the advantages of using lightweight loam in contemporary Turkish buildings.

Acclimatization across Millennia: Thermal Zoning with Stereotomic Systems

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ABSTRACT

Since the widespread adoption of mechanical equipment for cooling buildings, thermal zoning has evolved into a design strategy that provides climate control and maintenance of steady-state interior environments regardless of building orientation or occupancy. Before the invention of mechanical cooling devices, early populations achieved thermal zoning by putting basic building attributes and material constituents to task, finely attuning earthen building assemblages to ever-changing climatic factors such as prevailing wind and solar path. The Bronze Age Anatolian settlement of Kaymakçı has been reconstructed and analyzed using environmental simulation platforms to disclose the passive acclimatization strategies deployed by early societies relative to variable climate inputs. This presentation reports the findings from this analysis and discusses how these attributes produce comfort levels that rival contemporary standards. Furthermore, the knowledge extracted from this early settlement has been adapted for contemporary construction to passively maintain thermal comfort in the newly constructed Asphodel Research Center located in West Central Turkey which generates a minimum net energy surplus of 120,000 kWh annually.

PROCEEDINGS:
ABSTRACT AND FULL PAPER OF AUTHOR (S)

1- A Suggestion for the Achievement of the Sustainable

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ABSTRACT

Throughout history, human beings have relied on their minds, both in atmospheric conditions and in relations with other animals, due to their deficient abilities throughout their existence in nature. The human, who does not have developed teeth, sharp claws, and cold-proof fur, has eliminated all these deficiencies with his/her mind in order to survive. Designing and producing clothes instead of fur, designing and producing tools instead of claws, (etc.) this can be expressed as a result of mental activation.

This process, which has passed from our distant ancestors, who used what is around them in their habitat as they are, to today's modern people who use all kinds of technological possibilities and innovations and eliminate the concept of unproducibility in the sense of form, has been achieved by the mastery of different materials and techniques in many different fields. This mastering; It has progressed by accumulating with discoveries, knowledge of experience, accumulated experiences, and reached the present day.

People who overcome their deficiencies with their mind and production are still developing, Producing and changing with both conventional, traditional and innovative approaches thanks to this accumulation. And one of the areas where this change/development is most questioned can be expressed as the relationship that people establish with shelter.

Shelter has been one of the deficiencies and the basic needs that need to be eliminated throughout the history of humanity, since the time mankind slept and lived in tree hollows and caves. As the "animal without fur" mentioned at the beginning, one of the most necessary elements for human survival in cold climates is shelter. The same shelter element fulfills many functions, from the function of protection from predators to sense of belonging.

These realities, which we do not think much about in today's world (in urban life), actually constitute one of the most basic needs. On the other hand, the increasing population, carbon footprints, and waste materials make the world a difficult place to meet this basic need.
Although living conditions in harmony with nature are available in conventional and traditional production techniques that we already have, today's people are constantly chasing the "new" and "excess" (surplus). Although it is not surprising that people, who have moved away from their essence and reality with capital relations and perception management, are caught in today's dominant search, it is of major importance for the future of both the world and humanity to make a little more foresighted choices. In this context, both the consumer, the producer and the designer should have and create patterns of behavior and mindsets that take care of this sensitivity.

Today, we have many sustainable architectural techniques and sustainable materials compatible with nature in terms of permanent or temporary shelter solutions. Usage patterns, production

processes, final product states, atmospheric relations etc. are all known in detail. Many data such as tree houses of Aboriginals, adobe structures, the binding of straw as fiber, and the living areas of seasonal agricultural workers are available in the literature as natural structures that are truly sustainable. And many more can already be expressed as practical applications of these conventional and traditional techniques and are easily accessible to those who want.

At this point, it can be said that the important thing is to prefer this accessibility. In other words, although it is technologically and informationally possible to describe and produce a reality in harmony with nature, what makes it possible is the self that will prefer these methodologies.
In the context of sustainable architecture and sustainable cities, many studies have been carried out for years, most of these studies are used as an advertising element, a capital tool, a sales strategyin the context of popular culture and/or subcultures. On the other hand, the concept of sustainability, which is one of the important steps in creating the future and creating a world that can be transferred to new generations, should be a design core where reality occurs in topographyrather than being a pop culture or advertising commodity. Just as the object-subject relationship, which is established by the individual within the framework of his own belonging and with any commodity that is important to him, recurs in a careful and protective way, nature itself is the thing that we need to show the most belonging to within our essence existence. Likewise, at the point of contact with nature, we actually exist both in the role of subject and in the role of object. In other words, human beings are obliged to nature to maintain their existence as a product of nature. At this point, as individuals who shape life in architecture and design, sustainability should be one of the most fundamental ultimate goals, and this goal should not be considered as a commercial concern, but rather as a behavior driven by nature itself.

As a result, it can be said that the key to a world that is compatible with nature, sustainable and transferable to future generations; it is individual consciousness, preference and desire rather than technical, technological or cost. This consciousness, as a behavior pattern, does not ignore the natural existence of the individual, on the contrary, it has the opportunity to occur in reality with the expression of a description that it owns and respects. The state of being "natural" – "being one with the natural" as a behavioral pattern will be the most important reason for protecting a tree, creating a natural settlement/shelter relationship, describing a sustainable life.

It can be expressed as an epilogue that raising generations with this behavior pattern will be more valuable and more effective (futuristic) than raising a generation who knows the relevant techniques and materials. Likewise, when the Z generation and today's internet reality are considered, it is very easy and accessible for them to acquire information and learn the material which that wanted. However, their use of this knowledge depends on their preference to use it as mind and behavior pattern, not knowing it.

Keywords: Behavior patterns, production, natural material, sustainability, design

2- The Different Uses of Sustainable Soil Materials: The Examples of the Rüstem Pasha Caravanserai and the Hazrat Mevlana Tomb Restoration

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ABSTRACT

The physical cultural heritage from the past to the present continues to shed light on the next generations with its various aspects. In this respect, the Turkic Republics continue to exist examples in this geography which are coming from various nations and religions, with the most architectural diversity and cultural heritage in the world. These outstanding structures have been restored many times.

Restoration is a difficult process. Restoration applications require expertise. Moreover the using materials have to similar with the original ones. Two of these materials were used in both restorations that are the subject of our research. These are handmade bricks and tiles. Bricks were used to complete the vaults on the roof of the Rüstem Pasha Caravanserai. Tiles, on the other hand, were used on the outer surface of the Tomb of Hazrat-i Mevlâna. These materials were used by making them with traditional techniques, just like in adobe bricks. The bricks were shaped in wooden molds from mud and dried in the sun. The tiles, on the other hand, were hand-pressed in wooden molds with a technique called "pat pat" and dried in ovens. Both materials were applied to the structure with the help of Khorasan mortar. Felt was also thrown into the Khorasan mortar to strengthen the binding. Khorasan mortar is a traditional material as it is known. Therefore, the originality of the buildings was preserved and their sustainability was ensured. In addition, the original design of these materials has been preserved in the applications. As the research is an action research, the researcher was also involved in the entire process from the construction of the materials to the application. The aim of the research is to show the analogous construction techniques and usage patterns of traditional materials with examples.

It is thought that the research will shed light on the applications that future generations plan to do in the future.

Keywords: Restoration, handmade, sustainability, traditional materials, traditional techniques

1. INTRODUCTION

I will examine three materials that are the subject of my research. These; It is brick and tile that is similar to adobe. These materials are generally used in restoration today. These materials have been used for years for reasons of being healthy, cheap and easy to obtain from nature. However, today, with the proliferation of modern techniques, their use has decreased. They are still used in rural areas and in the renovation of historical buildings. The construction techniques of these three materials are similar to each other. They have content and binding differences in them.

Wooden formwork is used in all three of them. The materials coming out of the wooden molds are cut and the desired dimensions are created. Then they are subjected to heat to ensure their strength.

These materials of various sizes are applied to the places where they will be used, again with different techniques. In addition, another feature of these materials is that they are sustainable. The crumbs of these materials can be used as binders in similar products that will be produced new.

The researcher took part in the action in all of these processes. I worked in these two project as the Site Supervisor.

In this research, the comparison will be held on dealing with these materials. The comparison will include also the production - manufacturing and the application period.

The purpose of the research; It is to draw attention to these productions and applications and to shed light on the works to be done in the future.

2. PRODUCTION AND APLICATION PROCESSES

The restoration of Rüstem Pasha Caravanserai and The Hazrat Mevlana Tomb are all in Konya. The restoration of the Rüstem Pasha Carvanserai, we use bricks. The restoration of the Hazrat Mevlana Tomb, we use tiles. I try to explain the production and application processes relating to the building materials which are sustainable. These two materials, whose construction and application techniques are similar to adobe, have recently been restored. It is thought that the production and applications will reveal the similarities.

2.1. MANUFACTURING AND APLICATION OF BRICKS, EXAMPLE OF THE RESTORATION OF THE RÜSTEM PASHA CARAVANSERAI

2.1.1. MANUFACTURING OF BRICKS

Yellow earth, a little bit straw and water is produced by mixing until it reaches a consistency. It is then put into molds. This is the formula for the threshing brick. For the adobe, the formula is same except the quantity of straw. The straw in adobe is more than the threshing bricks.

The operations are performed as follows:

Stage 1: The dough is prepared and shaped in wooden molds (Figure 1).
Stage 2: The shaped parts (Figure 2 & 3) are left to dry for 2 days under a sun-permeable roof (Figure 4 & 5). The reason for this is to protect it from rain. The adobe can dry in 5 days.
Stage 3: For final drying for all pieces are making to change the position of the pieces. They are moved from the horizontal position to the vertical position for 5 days (Figure 6). The reason of this is to provide ventilation. In fact, another reason is to ensure that no surface remains damp.
Stage 4: Bricks freed from moisture are fired by burning in a mobile kiln which is not fabricated (Figure 7). The kiln is handmade structure. It is placed one row bricks and one row coal (Figure 8). Then, it is burned for 10 days. After 10 days, they allowed to cool in 5 days.
Stage 5: Adobe bricks are not burned in the kiln. They just stay under the sun for 5 or 10 days. This period is changing according to their dimensions.
Stage 6: After all these stages they are ready to use.
As a result; The Threshing Bricks take approximately 20-25 days, while Adobe Bricks are ready for use in 10-15 days.

The wooden mold used as a pulley. It is made by hornbeam, which will not bend, long lasting, not wear and tear. Then, these are fixed to each other with nails only.

Sand powder is used to prevent the bricks which are made by clayey soil, paste from sticking to the mold. Only water is used to prevent the bricks which are made by yellow soil, paste from sticking to the mold.

The bricks which are made by yellow soil are burned in the mobile kiln with the temperature 1100 °C. The bricks which are made by clayey soil are burned in the mobile kiln with the temperature 860 °C.

Some manufacturers sprinkle salt on the bricks during burning in the mobile kiln. They are doing this action for speed coloring. However, this causes some damages for the bricks. Because if this done, the inside of the bricks will not be burned or the fire will not penetrate inside. So the fire will affect only the outside. In other words, the surface will be the well done, but inside will not. Also we may call this as fiddle.



Figure 1. The dough (Resource: Personal Archive); Figure 2. The shaping (Resource: Personal Archive); Figure 3. The sizing (Resource: Personal Archive)



Figure 4. Transperent roof (Resource: Personal Archive); Figure 5. Under the sun (Resource: Personal Archive); Figure 6. Ventilation (Resource: Personal Archive)


Figure 7. The kiln (Resource: Personal Archive); Figure 8. The bricks and the coal rows (Resource: Personal Archive)

2.1.2. APPLICATION OF BRICKS

After manufacturing of the bricks, they are applied to the roof of the caravanserai (vault) with the traditional material which is khorasan mortar (Figure 9). The bricks application is done on the wooden mold surface (Figure 10). At the end, the joints are filled with also khorasan mortar including brick small pieces like dust and it is finished finally (Figure 11 &12).




Figure 9. The roof (Resource: Personal Archive); Figure 10. The mold surface (Resource: Personal Archive); Figure 11 & Figure 12. Final view (Resource: Personal Archive)

2.2. MANUFACTURING AND APLICATION OF TILES, EXAMPLE OF HAZRAT MEVLANA TOMB RESTORATION

2.2.1. MANUFACTURING OF TILES

Quartz sand (quartz mines + ground from stream beds + sand + kik + glass filite + water) is produced by mixing until it reaches a consistency. It is then put into molds.

The operations are performed as follows:

Stage 1: The dough is prepared and shaped in wooden molds (Figure 13).
Stage 2: The shaped parts (Figure 15) are free of wind and sun for 15 days. left to dry.
Stage 3: Final sizing (Figure 16) of the top and bottom sides of the pieces that dry on their own is done.
Stage 4: If there is only one firing, it is directly glazed and fired. If there will be double firing and under glaze decoration will be made, the parts that have been leveled and dimensioned are primed with a specially prepared primer. After priming, it is left to dry for 15 days again.
Stage 5: After the primed parts are completely dry, the 1st firing is done in the kiln(Figure 17).
Stage 6: Decor is made with underglaze paints consisting of metal oxides on the primed parts in the 1st firing. After the decoration process, the entire surface is covered with a kind of glass composition, which we call the glazing process, and neither is the final firing. Finally, the tile is produced.
As a result; Single fired tiles take approximately 30 days, while double-fired tiles are ready for use in 45 days (Figure 19).

In high quartz tiles, slow firing should be done due to the expansion behavior of the quartz mineral. It can vary between 18 hours or 50 hours. The kiln takes 1 day to heat up and 4 days to cool down (Figure 18).

The reason why the use of high quartz tiles is preferred is that they have low water intake rates, withstand high pressure, do not form glaze cracks and do not undergo deformation.
Features of high quartz tiles:
1. Colors have vitality and three-dimensional perception.
2. It becomes pure whiteness.
3. It gives a feeling of depth by penetrating into the glaze.

The wooden mold used as a pulley; the lower part is plywood, the upper part is pine, which will not bend, and these are fixed to each other with nails or screws.

Cotton fabric (Figure 14) is used to prevent the tile paste from sticking to the mold.
The temperature of the kiln is 920 °C.
The kiln which has the dimensions 110cm x 110cm, get 320 tiles inside. The kiln which has the dimensions 90cm x 90cm, get 175 tiles inside.
The distance between the shelves in the oven is 6 cm.
Four manufacturers have been evaluated for Mevlana tiles. Comparisons of these according to the results of the tests performed by the independent laboratory are given in below (Table 1).

CANDIDATES	WATER ABSORPTION	BREAKING LOAD (N)	BENDING STRENGTH (N/mm²)	BREAKING STRENGTH (N)	HEAT SHOCK RESISTANCE	FROST RESISTANCE	CHEMICAL MATTERIAL RESISTANCE	SMALL COLOR DIFFERENCE	SIO2 MUST >80,00
A	20,44	1257,6	13,26	2286,3 N	UNDAMAGED	25 TURN 10 DAMAGED 0 UNDAMAGED	AVERAGE (Not Bad - Not Good) (Acceptable)	THERE ARE COLOR DIFFERENCES	77,51 < 80,00 DID NOT
B	20,63	3148,1	16,38	5338,9	UNDAMAGED	24 TURN 10 DAMAGED 0 UNDAMAGED	AVERAGE (Not Bad - Not Good) (Acceptable)	THERE ARE NOT COLOR DIFFERENCES	88,32 > 80,00 DID
C	17,42	4111,6	28,42	7527,6	UNDAMAGED	100 TURN 5 DAMAGED 5 UNDAMAGED	AVERAGE (Not Bad - Not Good) (Acceptable)	THERE ARE NOT COLOR DIFFERENCES	90,45 > 80,00 DID
D	20,41	1877,4	12,83	3454,1	UNDAMAGED	100 TURN 6 DAMAGED 4 UNDAMAGED	AVERAGE (Not Bad - Not Good) (Acceptable)	THERE ARE COLOR DIFFERENCES	77,34 < 80,00 DID NOT
ASSESSMENT OF THE CANDIDATES ACCORDING TO THE DATA									
A	FROM 9 DATA: 2 OF THEM SUCCESSFUL, 7 OF THEM FAILED.								
B	FROM 9 DATA: 7 OF THEM SUCCESSFUL, 2 OF THEM FAILED.								
C	FROM 9 DATA: 9 OF THEM SUCCESSFUL, 0 OF THEM FAILED.								
D	FROM 9 DATA: 3 OF THEM SUCCESSFUL, 6 OF THEM FAILED.								
ACCORDING TO THESE RESULTS; C IS THE 1ST & B IS THE 2ND CANDIDATE.									

Table 1. The Comparison of The Tile Results, (Resource: Personal Archive)

The Table 1, shows the results and also the differences of the tiles of the four manufacturers. According to the results lead us to choose the right manufacturer. We get tiles from the manufacturers to choose. The criteria is decided according to resist for all weather conditions, because the tiles will be installed to the outsides the tomb and so did they.





Figure 13. The wooden mold (Resource: Personal Archive); Figure 14. The cotton fabric (Resource: Personal Archive); Figure 15. The shaped parts (Resource: Personal Archive); Figure 16. The shaping period (Resource: Personal Archive)



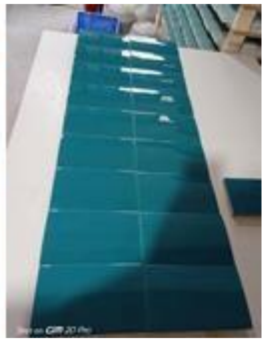

Figure 17. The tiles are in to the kiln (Resource: Personal Archive); Figure 18, The tiles are cooling (Resource: Personal Archive); Figure 19. The tiles are ready to use (Resource: Personal Archive)

2.2.2. APPLICATION OF TILES

After manufacturing of the tiles, they are applied to the tomb with the traditional material which is khorasan mortar (Figure 20). The tiles application is done on the bricks (Figure 21). At the end, the joints are filled and it is finished finally (Figure 22).



Figure 20. The tiles are applied with khorasan mortar (Resource: Personal Archive); Figure 21. The tiles are applied on the bricks (Resource: Personal Archive); Figure 22. The tile application is finished (Resource: Personal Archive)

CONCLUSION

The deterioration of the environment and the depletion of natural resources have increased the importance of such traditional materials, especially today, which leads to new searches in the field of architecture because such natural materials contribute to the sustainable environment. It is thought that researches continue to give importance to the construction of traditional architectural products and contemporary buildings by giving less damage to nature.

In the formation and decoration of our local architecture (Figure 23 & 24) since the first settlement ages in Anatolia; adobe, brick and tile materials are included in the masonry building system. They have always been a traditional building material chosen and preferred because they can be produced easily. In this study, the similar aspects of the construction and application techniques of adobe and the other two materials were tried to be evaluated. Similarities and differences in application techniques are discussed. The effects of the differences in their content on the production and application techniques were evaluated. In particular, the materials used in the techniques during the construction are also discussed. A review was also made in terms of manufacturing processes.

Figure 23. The Rüstem Pasha Caravanserai (Resource: Personal Archive); Figure 24. The Hazrat Mevlana Tomb (Resource: Personal Archive)

When the materials used are compared with each other, it has been observed that all of them can be found easily from nature. The differences between them are mainly the binders used in them. The wood used in the construction of these materials is also the most used material in architecture. It is still used extensively in the construction of contemporary buildings. Similarities are also observed in terms of the final shape. All of them are heat treated before use. Heat treatment times are also similar to each other.

It is hopeful that they are still used today, especially in restoration works. In this way, it makes a significant contribution to ensuring the continuity of materials and craftsmen. Thanks to this contribution, it can be thought that it paves the way for research and development.

As a result, these three materials have similar traditional manufacturing and construction techniques (Table 2). Also the dust or broken parts of these materials can be used into the dough to get strength and into the khorasan mortar while filling the joints. So, they all have sustainability in the buildings as a material. And also while restoration; these materials are easy to repair then the modern materials. Moreover they are friendly with the nature and the environment then the modern materials.

MATERIALS	DOUGH WITH EARTH (SOIL)	DOUGH INGREDIANTS (FOR STRENGTHENING)	DOUGH THICKENER	MOLD MATERIAL	DRYING PERIOD	BURNING	BURNING DEGREE	COOLING
ADOBE	YES	YES / A LOT OF STRAW	YES / WATER	WOODEN	UNDER SUN	NO	NO	NO
BRICKS	YES	YES / A LITTLE STRAW	YES / WATER	WOODEN	UNDER SUN	YES / IN THE MOBILE KILN	1100 °C / 860 °C	YES
TILES	YES	YES / QUARTZ	YES / WATER	WOODEN	IN THE SHADE	YES / IN THE FABRICATED KILN	920 °C	YES
ASSESSMENT OF THE CANDIDATES ACCORDING TO THE DATA								
ADOBE	FROM 8 DATA: 4 OF THEM SIMILAR WITH ONE OF THE OTHERS.							
BRICKS	FROM 8 DATA: 8 OF THEM SIMILAR WITH ONE OF THE OTHERS.							
TILES	FROM 8 DATA: 6 OF THEM SIMILAR WITH ONE OF THE OTHERS.							
ACCORDING TO THESE RESULTS; THEY HAVE SIMILARITIES WITH EACH OTHERS.								

Table 2. The Comparison of The Materials, (Resource: Personal Archive)

We all must keep going to develop the manufacturing techniques of these materials and the quantities of the buildings which are built with these materials. In this way, we will be able to reach the sustainable environment and friendly with the nature.

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3- Sustainable Usage of Earthen Materials as a Shelter forHomeless People in Palestine

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ABSTRACT

Sustainable development is development that meets today's demands without compromising the ability of future generations to fulfill their own needs. Nowadays, the building industry accounts for 23-40% of global greenhouse gas emissions, which has a negative impact on the environment. The average carbon footprint is estimated to be four tons. Modern construction materials with high energy costs and CO_2 emissions should be gradually replaced with widely available and environmentally friendly materials. Alker is a gypsum-stabilized earthen material composed of 6–10% clay, 2% lime, 10% gypsum, and 20–25% water by dry unit weight of soil. Alker Technology was developed at Istanbul Technical University to improve the properties of earthen buildings. Alker is a sustainable building material because of the availability of materials, ease of construction, energy efficiency, earthquake resistance, good thermal properties, and low cost. For these reasons, Alker can serve as a shelter for many people, particularly those who have been rendered homeless as a result of the war, and its applicability should not be underestimated. Earthen materials were the most cost-effective option in both urban and rural areas of Palestine's lowlands, and adobe buildings dominated the construction industry until the mid-twentieth century. Throughout Palestine's history, stone and earth have been used as the primary building materials. Palestine is known for its use of adobe masonry. Despite the fact that adobe masonry is more eco-friendly than other building methods, its use is declining in Palestine. A cost comparison of Alker and Reinforced concrete structures was performed, and it was found that Alker buildings are 13% less expensive than conventional construction materials. Alker materials were determined to be significantly more cost-effective than conventional building materials like steel, brick, and concrete. Earthen housing is a long-term, cost-effective, and environmentally friendly means of relocating forcefully displaced communities and disaster-affected places.

Keywords: Sustainable Development, Alker, Shelter, Eco-friendly, Cost effective

1. INTRODUCTION

Earth construction is becoming increasingly popular in today's environment as a means of generating and utilizing more environmentally friendly resources. Adobe is one of the oldest known building materials, and it is widely available everywhere at a low cost. They are not only simple and inexpensive, but they are also fireproof, durable, non-toxic, have a low degree of sound transmission between walls, and supply adequate heat to structures. The heat and moisture storage capacity of the earthen walls balances the relative humidity inside the building and so increases indoor comfort. Low-income people's access to cheap housing is tied to building materials and technologies [1]. Because of the minimal manufacture, recycling, and reuse, earthen houses are environmentally sustainable [2]. Earthen houses are regarded as beneficial to one's health. The health benefits were unknown, but most people attributed them to a pleasant indoor climate and the soil's ability to absorb poisons. There are a lot of parasites that can be dangerous to humans when wet feet come into the house during the rainy season.

For the world's homeless and poor populations, there is an urgent need to identify low-income housing solutions that are both affordable and sustainable. Traditional building materials such as concrete, ceramics, steel, and bricks have also become more expensive as a result of rising energy costs, resource scarcity, and transportation costs. Various dangerous compounds, such as high quantities of carbon monoxide, sulfur oxides, nitrogen oxides, and suspended particulate matter, are always released into the environment throughout the manufacturing process of those construction materials. Harmful substance emissions pollute the air, water, soil, vegetation, and aquatic life, harming human health and living situations. Earth saves energy making it an environmentally beneficial material [3]. Earthen walls have been shown in tests to absorb high-frequency electromagnetic radiation (radio, radar). They are non-toxic and have the ability to passively manage indoor temperature and humidity, which is very useful in hot areas. In addition they can absorb both interior temperatures and relative humidity due to their enormous heat and moisture mass [4]. Earthen materials are simple to use, fire resistant, and soundproof [5,6]. Clay has a high thermal mass but a low thermal conductivity [7-9]. Clay's water absorption capacity and hydrophilic nature aid to keep internal humidity levels acceptable. Earth is viewed as an appealing material capable of contributing to bioclimatic design in order to create optimal interior conditions, hygiene, health, and comfort [10].

In contrast, earthen materials exhibit poor mechanical properties, shrinkage, and low water resistance [11]. Water movement (capillary action, rain, floods, and so on) causes clay particle swelling and shrinkage, which eventually leads to fissures and material loss [9]. This technique is more effective on montmorillonite clay [12,13]. Although earth is one of the most commonly used building materials, it is also one of the most moisture-sensitive [14]. Water exposure lowers adobe's strength, erosion resistance, dimensional stability, and durability. It was discovered in 1978 by Istanbul Technical University, which has been researching earthen construction materials since then, that stabilizing earth with gypsum and lime increases its durability, as well as its physical and mechanical properties. Adobe stabilized with gypsum is known as "Alker," a Turkish abbreviation of the words "alçı" (for gypsum) and "kerpic" (for adobe) [15].

2. ALKER TECHNOLOGY

The earth used in Alker technology is significantly more readily available than the earth required for traditional earthen construction due to its lower clay content. Alker is a common term for a stabilized earth-based building material produced by adding gypsum, lime, and water to the earth. It consists of 10% gypsum, 2% lime, and 20–22% water, based on the dry weight of the soil [16]. The use of lime and gypsum in mixes minimizes the time required for mixing, molding, compacting, and turning out of molds [17]. Gypsum helps reduce the shrinkage of the building material, while Alker provides the durability required for load-bearing wall construction. Additionally, Alker is permeable and lighter than unstabilized earthen materials due to the fact that the gypsum hardens before the clay dries [18]. Heat resistance and durability are particularly high in gypsum-stabilized earthy materials, especially in wet conditions. The manufacturing process is simple, and the energy usage in buildings constructed with this material is negligible. Buildings that are healthy also generate a healthy environment for people.

The binding property of the earth can be achieved with a clay content of about 30–50%. The addition of gypsum assists in this binding, and the earth's clay content of between 8% and 10% is sufficient for the production of Alker. Işık et al.[18] discovered that a high clay content enhances shrinkage, whereas a low clay content reduces binding. Although the earth's clay mineralogy has not been defined, a sufficient amount of clay is required in order to create a suitable bond [19]. The use of Alker, a low-energy building material, helps achieve long-term sustainability in both indoor and outdoor construction [16].

3. ALKER AS A SHELTER FOR HOMELESS PEOPLE: A CASE STUDY FROM PALESTINE

Earth architecture is a viable option in many countries, including Palestine, where importing building materials is difficult due to the high cost and environmental impact of other commonly used materials (natural stone, for example). This choice is bolstered by the difficulty of importing building materials. In Palestine, earth architecture is an option. More than half of the world's population still resides in earthen constructions, which have been a common building material for thousands of years. There have recently been a number of initiatives in Palestine to develop a low-cost and low-effect alternative to natural stone because of the high cost and negative environmental impact of stone mining. A conventional house is more vulnerable to the effects of severe external air temperatures than an earth-sheltered structure. Earth-sheltered dwellings also require less outside care, and the earth that surrounds them acts as soundproofing. Earth-sheltered homes may be less expensive to insure since they provide more protection against high winds, hailstorms, and natural disasters like tornadoes and hurricanes.

Forced migration is the world's most serious developmental and humanitarian issue, impacting mostly poor nations. All sectors must work together to support millions of displaced people and victims of disasters. So, the most basic necessity for a displaced population is shelter. To improve living conditions and achieve the global sustainability goal, sustainable housing must be provided. Sustainability meets several financial and environmental criteria. Earth as a building material is environmentally friendly, natural, and adaptable. Using earthen housing also meets the three pillars of sustainability: economic, environmental, and social. Gaza's early recovery and reconstruction plan predicts that more than 10,000 homes were completely destroyed, over 10,000 had severe damage, and almost 40,000 had minor damage, according to the Palestinian national authority. Contrasting these numbers with the total number of families living there (220,000), which means around 60,000 families were homeless [20]. Residents are unable to repair entire communities, which remain in ruins. At the same time, Palestinians are not allowed to import building supplies from outside Gaza.

Despite this, there are a few examples of individual attempts to innovate. As a result of the pressing need for shelter, some organizations donated containers for homeless families to stay in, but they weren't enough for their daily needs and were simply a short-term solution. Resurrecting earth as a building material and building houses out of wood are two more noteworthy undertakings. Coinciding with the paucity of construction materials, an extra 71,000 housing units are needed for Gazans in 2020 (UN, 2012) to satisfy the population growth, which worsens the difficulty of providing people with acceptable residences and gives rise to the need for rethinking sustainable alternatives [20]. Because the prohibition encompasses steel and cement, among other critical resources, the siege of Gaza has rendered construction and reconstruction activity difficult. The siege has prompted some Gazans to build new earthen houses to protect themselves from the weather, utilizing compressed earthen bricks made from dirt excavations. The material used in

Palestine's return to earthen architecture is the most widely available and cheapest priced on the planet.

Gaza's housing shortage is a major problem. The Mediterranean Sea's proximity to the Gaza Strip makes it a key strategic location for Palestine. There were numerous attacks on Gaza by the Israeli occupying troops. These hits resulted in the destruction of a large number of buildings. The Palestinian early recovery and reconstruction plans for Gaza estimate that about 10,000 homes were completely destroyed, another 10,000 were seriously damaged, and another 40,000 homes were slightly damaged. Even though there are only roughly 220,000 people in the area, these numbers indicate that 60,000 families have become homeless as a result of the recent storms [20].

Communities have been destroyed, and residents have been unable to rebuild their houses. The importation of building materials (such as steel, cement, and so on) from outside Gaza is also prohibited. Some groups provided homeless families with a kind of container to live in, but it was simply a short-term solution; it wasn't suitable for their core needs of living; it was only a temporary solution.

Individual efforts to build using wood and other low-cost materials are aimed at reintroducing earth as a building material. The population of Gaza was predicted to increase by 71,000 in 2020, making it more challenging to provide appropriate housing for the growing population [21]. Because traditional building materials are becoming scarcer, it is more important than ever to look for environmentally friendly alternatives.

In comparison to other countries, Palestine is currently experiencing political and economic setbacks as a result of the occupation, in which Palestinians are unable to control their natural resources or make use of urban expansion regions for future development. In the same manner as elsewhere in the world, the building sector needs to be rethought in order to save money and restore social and cultural ties in the community. To do this, viable and low-cost supplies for construction materials such as earth, as well as employ active solutions in architectural design to save money while restoring social and cultural bonds in the community must be identifed. A typical earth-sheltered house is illustrated in Figure 1.

Figure 1. Design of Earth-Sheltered House

4. CRACK PROPAGATION OF REINFORCED ALKER

Ahmad et al. [23] investigated the image processing conducted on the Alker samples to examine the crack propagation (Figure 2). Figure 3 shows the Peak Signal to Noise Ratio (PSNR) results for 1, 7, 14, and 28-day images of control and modified Alker samples comprising 0.5, 1.0, and 1.5%.

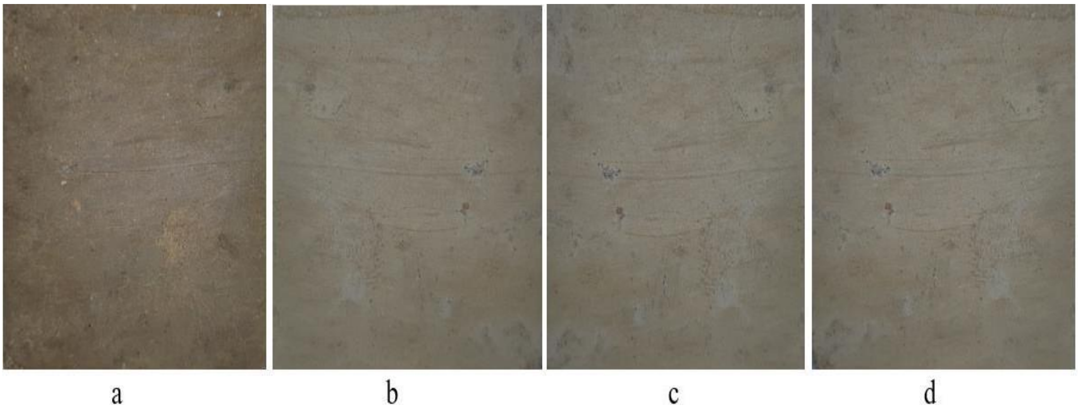

Figure 2. Images of Alker with 1% SPW on days (a) 1 (b) 7 (c) 14 and (d) 28

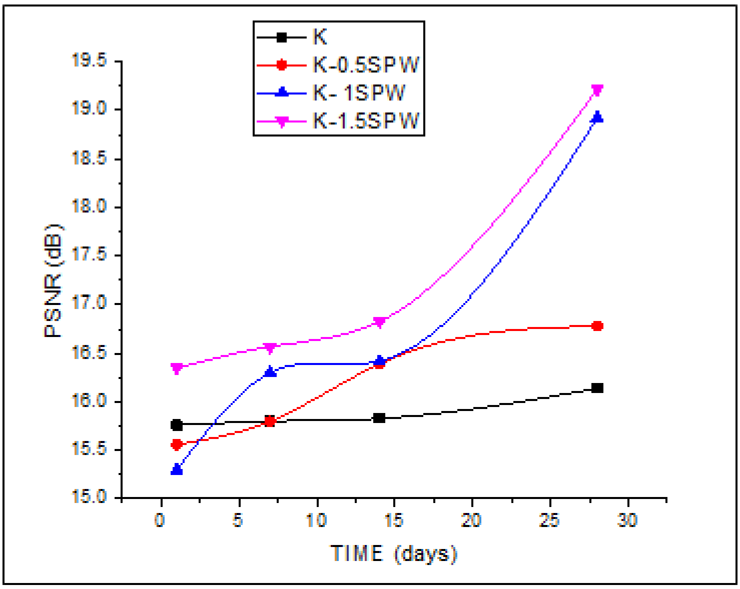

Figure 3. Propagation of cracks in Alker

The PSNR of the control samples rose by 0.25 and 0.44 % after 7 and 14 days, respectively. The gain was 2.35 % after 28 days. The PSNR values of the modified samples with 0.5 % SPW improved by 1.52 and 5.06 % after 7 and 14 days, respectively. Furthermore, after 28 days, the PSNR increased by 7.27 %. The crack behavior was much improved over the control sample. PSNR values increased 6.14 % and 6.82 % in 7 and 14 days for modified samples with 1.0% SPW. The 28-day PSNR rose 19.13 %. The adjusted sample with 1.5% shredded plastic waste recorded 1.33, 6.12, and 14.93%.

The Alker sample having 1.0% shredded plastic wastes content demonstrated better results compared to other samples. The PSNR value increase after 28-day reveals that there was a close bonding of the internal structure of the sample when the air drying happened, consequently permitting restricted shrinking, which reduced the spread of the cracks. This also explains the limited linear shrinkage findings observed in the sample modified with 1.0% compared to the control and other modified samples. Images of crack behavior in Alker samples were previously analyzed using image processing, and our finding is in line with Onochie and Balkis [19].

CONCLUSION

Earth as a building material is a prehistoric and popular building technique employed by populations in poor countries. Earth has changed over time and space to meet a wide range of social and cultural needs. This has led to a rich cultural heritage that can be found all over the world. Adobe construction is currently playing a significant role in Palestine due to its availability and low cost in contrast to other construction materials. Experimental houses were developed in order to assess the cost analysis of the materials used in construction. Alker buildings are 13% less expensive than conventional construction materials, according to cost estimates [23]. To sum up, earthen housing is a sustainable, cost-effective, and environmentally beneficial method of resettling forcibly displaced communities and disaster-affected areas.

A green and sustainable environment with minimal lifecycle impact is achieved by using eco-friendly materials and metrologies. Around the world, earth is the most common building material. To improve the lateral load carrying capacity of the building and to minimize cracking due to drying, reinforcing should be added to important areas. A stabilizer is also added to earthen structural members to boost load-carrying capacity and material strength. Resettling forcibly displaced communities and places damaged by disasters with earthen houses is both economical and environmentally friendly.

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4- The Role of Women as a Carrier of Intangible Cultural Heritage in Earthen Architecture, Cıldıroba Village, KilisProvince

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ABSTRACT

Soil is a building material that people have primarily preferred for building since prehistoric times. The fact that adobe can be prepared easily at the place where the building will be built and that it can be done by everyone are the reasons why soil is a widely used building material. Adobe; It is obtained by pouring the mud mortar, which is formed by mixing soil, water and straw, into molds and drying. Mud mortar has also been used for decoration purposes in traditional buildings, apart from making adobe blocks. The traditional methods applied by the local people in building construction and the decorations that reflect their unique values create the authenticity of traditional buildings. These practices, which are based on the knowledge and experience of local users and transmitted from generation to generation, are called intangible cultural heritage. Women, who are actively involved in almost every aspect of traditional life, also have a great role in keeping the intangible heritage items alive, teaching and protecting them. Women, who are involved in every stage of the production of adobe structures that make up the traditional texture in the village of Çıldıroba in Kilis, which is the subject of a completed master's thesis, are the guardians of the intangible cultural heritage elements in this region. In this study, the plaster renewal method regularly performed by women in Çıldıroba village and the shelf decorations in the "yatak odası" units of the buildings are discussed in the context of the techniques, materials and tools used. It is aimed to make a documentation in this field, which has never been studied.

Keywords: Kilis, Cıldıroba, adobe shelf decorations, women's labor, earthen architecture

1. INTRODUCTION

Traditional architecture generally consists of structures built with knowledge based on experience and experimentation [1]. Adobe is one of the most preferred building materials in traditional architecture from prehistoric times to the present day. The fact that adobe can be prepared easily at the place where the building will be built and that it can be done by everyone are the reasons why soil is a widely used building material [2]. As an earth-based material, adobe is still preferred in our country, especially in rural areas of Anatolia. Adobe, which is obtained by mixing soil, water and straw in certain proportions, is obtained by completely natural means by pouring it into molds and drying it in the sun. These rates, which do not have a fixed value, vary from region to region and according to the type of soil. Mud mortar, which is easily prepared and shaped easily, is used for plastering walls, decorating on plaster and for decoration purposes in the building as well as for making adobe blocks. In the traditional adobe buildings in Çıldıroba village, it is seen that the mud mortar prepared by the local people is used both for plastering the adobe walls and for the decorative shelves where they display their belongings in the main living spaces they call the "yatak odası".

Local building materials and traditional construction techniques used by local builders in rural settlements constitute the authenticity of traditional building culture. In addition, the methods and practices used by the local people in the maintenance and decoration of traditional buildings are also a part of this originality [3]. The continuity of these methods and practices is very important in terms of preserving originality. Therefore, these cultural values, together with their tangible and intangible aspects, should be documented and protected.

Traditional crafts and handicrafts are recognized as intangible cultural heritage items in the 2003 UNESCO Convention [4]. The knowledge of the local builders and the techniques and skills they use in rural architecture are intangible cultural heritage elements [5]. In addition, traditions and practices maintained by users for generations also have intangible cultural heritage value.

In this study, the regular plaster renewal methods applied by the local women in the village of Çıldıroba, which is the subject of a completed master's thesis, in traditional mudbrick structures and the construction techniques of ornamented shelves were examined in the context of the building materials.

2. ARCHITECTURAL FEATURES OF HOUSING IN ÇILDIROBA VILLAGE

The village of Çıldıroba, which is 27 km from Kilis and 6 km from the town of Elbeyli to which it is affiliated, is a plain village on the Syrian border (Fıgure 1, 2). It has been learned from the oldest source that the village was founded by the Elbeyli Turkmens. The exact date of establishment is not known.

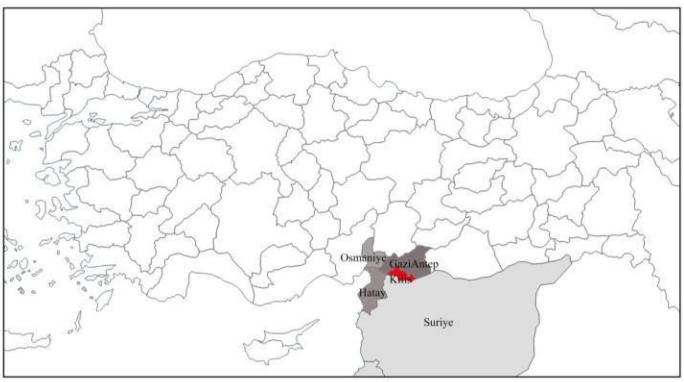

Figure 1. Locations of Kilis on Turkey map

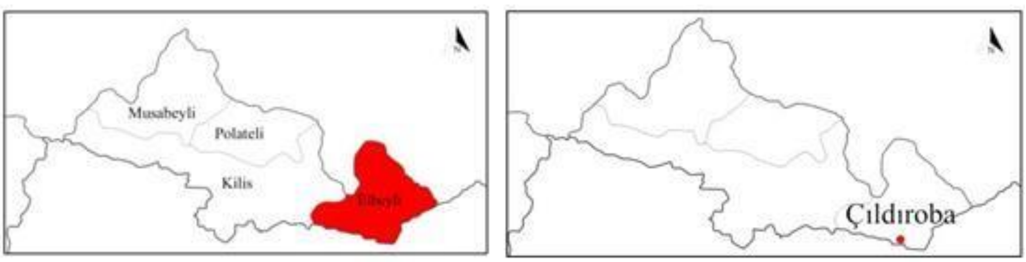

Figure 2. Locations of Elbeyli district and Çıldıroba village on Kilis provincial map

The unique texture of the village consists of single-storey mudbrick structures built around a courtyard and built with the traditional method (Fıgure 3). The buildings consist of living spaces and service units. The main living spaces are the "room" where daily life takes place, and the units called "bedroom" where beds, quilts and kitchen utensils are put. Barn, hearth, woodshed and haystack units are service spaces.

Figure 3. View of the eastern and northen part of the village from the mosque minaret of Çıldıroba village, 2020

All structures were built with mudbrick blocks on a stone foundation (Figure 4).

Figure 4. Stone foundations in traditional buildings, 2019.

The mudbrick blocks were made by the local people from the soil excavated while the foundation was being excavated or from the black soil found in the surrounding area. While adobe blocks are being made, soil, water and straw are mixed and kneaded, then they are kept covered for a day. The next morning, the adobe blocks work begins. The poured mud bricks are dried in the sun for a week. It is waited for a week to dry the other sides. At the end of 10-15 days, the blocks are ready for construction (Figure 5).

Figure 5. Adobe molds used for traditional buildings, 2019.

After the walls were built, the inner and outer parts were plastered with a mud mortar called "sıvak" (Figure 6). In the village, the walls are not performed in all of the plaster refreshes each year, only deteriorated places are re-filtered. White soil, which is defined as both concise and strong, is used for plastering the walls. Village residents obtain the white soil from the border area south of the village.

Figure 6. Facades plastered with mud plaster, 2019.

After the walls are finished, wooden beams, which the locals call "pillars", are placed. Intermediate layers, which change according to the period, are laid on the beams (Figure 7). A 50 cm thick soil layer is laid on it and leveled. Finally, the mud made with black earth used in the construction of adobe blocks is plastered with mortar (Figure 8). This plaster is renewed every year.

Figure 7. Beams and interlayers, 2019.

Figure 8. Traditional flat earthen roofs, 2019.

2.1. PLASTER RENOVATION IN TRADITIONAL BUILDINGS

Women play a major role in every stage of the construction of traditional buildings in the village of Çıldıroba. Women, who take part in every stage from the construction of adobe blocks to the construction and plastering of the walls, also take an active role in the maintenance and repair of the buildings.

In the traditional construction tradition of Çıldıroba village, the plasters of the walls do not have to be renewed every year, they are the building elements that are renewed as the walls deteriorate. But the plaster of flat earthen roofs is renewed every year. The mud mortars required for renewal are also prepared by women. Although white soil is used for wall plasters and black soil is used for roof plasters, the preparation methods of plasters are the same.

Straw, soil and water are mixed, and the mixture is kneaded by hand so that the mortar is well mixed and compacted. It is covered with nylon and left for a day or two. The more the mortar is absorbed, the longer its life will be. The ready mortar is applied to the application area and plastered with a trowel. After waiting for half an hour, water is sprinkled on the mortar on the wall and plastered again with a trowel. The second plastering job is called "polishing". All of this process, which is done entirely by women, is called "sıvak hazırlama" [6] (Figure 9).


1. Soil, water and straw mixed.


2. The mixture is kneaded by hand for consolidation.


3.It takes a while for it to fully merge.


4.The mortar is adhered to Wall to the plastered.


5.The mortar is plastered with a trowel. It is plastered again after half an hour.

Figure 9. Mud plaster preparation shown by local user.

2.2. DECORATIVE SHELVES IN TRADITIONAL BUILDINGS

Motifs are the name given to each of the elements that form a whole by coming together in works such as decoration and decoration [7]. Throughout history, human beings have always expressed themselves on two- and three-dimensional forms, and in primitive times, they have tried to give meaning to events by making them concrete through art. They did this with symbols [8].

These symbols, which have been passed down through generations and survived until today, appear in different areas of traditional life. In the "yatak odası" unit, which is one of the main living spaces of traditional buildings in the village of Çıldıroba, these motifs, which carry traces of the past, can be seen on the decorated shelves made by women from mud mortar with their own hands (Figure 10). Under the decorated shelves, there are motifs made by women from mud mortar (Figure 11). Very few examples of this practice, which has been passed down from mother to daughter in the village for generations, have survived. There is no one who remakes these shelves today.

Figure 10. Original shelf decorations made by women with white earth and wheat straw, 2019

Figure 11. Distorted original motifs made by women with white soil under the shelves, 2019

These decorated shelves were made with mud mortar prepared with white soil mixed with straw and wheat stalks with reinforcement function. Pieces of wood of that size were also used instead of wheat straw. The details of the construction are as follows: Wheat litter or wood chips are cut into pieces of the same length. The mixture prepared with white soil is glued on these pieces, covered by hand and shaped. The mortar must be solid for this process. A board is placed on the wall, the top is plastered with the same mixture prepared. The models made are glued to the wood, and they are attached with the same mud from the bottom side. No bonding material or nails other than mud are used. The motifs under the shelves, on the other hand, are made with the same white mud without garbage. Again, women roll and shape the mud with their hands as if they were making a type of cookie called "kahke" in their local language. They stick them on the wall [6]. These shelves are used to stack large plates and trays.

CONCLUSION

As a soil-based building material, adobe is easily accessible, easily applicable and ecologically preferred in the past and today. The village of Çıldıroba, which is the subject of the study, is a rural settlement whose traditional texture is composed of adobe structures. The mud mortars used in the construction of adobe blocks in the village of Çıldıroba are also used in the plastering of the walls and the original flat earthen roofs and in the construction of the ornamented shelves inside the buildings. Women, who take an active role in every stage of the traditional architectural construction process in the village, also make these practices themselves. The maintenance and repairs made by the local women in the village for the preservation of traditional buildings and the ornamented shelves that are part of the originality of the buildings are intangible cultural heritage elements that need to be preserved and maintained.

Many studies are carried out to maintain intangible cultural heritage in the world and in our country. The "Conservation of the Intangible Cultural Heritage [4]" convention, prepared by UNESCO in 2003, aims to preserve and sustain these values. Our country became one of the countries that accepted this convention on March 27, 2006. Many types of crafts are the original products that cultural expressions and diversity are reflected in [9]. In October 20,2005, "Convention on the Protection And Promotion Of The Diversity of Cultural Expressions [10]" in Paris accepts the cultural diversity as a decisive nature of humanity and it should be protected because humanity is the common heritage of humanity [11].

In our country, the Ministry of Culture and Tourism has identified the cultural heritage carriers to promote production in intangible cultural heritage areas and to determine the cultural heritage carriers for traditional culture and have certain criteria to the People's Culture Information and Document Center. The "artist introducing card" is given to those seen by the board [12].

Studies for intangible cultural heritage in our country and the world are very important for the sustainability of this heritage. Holistic documentation and preservation of these methods and architectural elements, which are under the threat of disappearance, with their tangible and intangible aspects are important in terms of not forgetting these traditions and transferring them to future generations.

The traditional adobe buildings in Çıldıroba village have different values in terms of their construction techniques, desing concept, uses and historical backgrounds. These structures that need to be preserved have various conservation problems due to natural causes and behaviours of its users [13]. Decorative shelves in traditional buildings and traditional plaster technique made with mud mortar are also cultural heritage values that are under the threat of disappearance.

With this study, it is aimed to document these practices carried out by local women in this area, where no work has been done, in the context of the construction methods, materials and tools used in the center of women's being the carrier of intangible cultural heritage.

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5- Structural Features and Conservation Problems of TraditionalAdobe Houses in Erimli Village, Diyarbakır

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ABSTRACT

Since the global warming problem caused by high energy consumption in the production and use of building materials in the construction industry has become a serious threat all over the world, the search for renewable energy sources, use of ecological materials and especially the research on earthen architecture have gained priority in recent years. Adobe, used as a building material in many parts of the world and produced from soil, is a cheap, environmentally friendly, easily supplied, and shaped material.

One of the regional examples of adobe houses, which are seen in rural settlements in Turkey, especially in Anatolia, that have survived and continue to be used today, is the earthen houses in Erimli village, Diyarbakır. Soil is the main building material of many buildings in Erimli village, with its old name Simaki, located in Sur district of Diyarbakır province. It has been determined that climatic conditions, geographical location, topography, local material opportunities, social and cultural structure; traditions and customs, social life, production and consumption styles and beliefs shape the earthen architecture in Erimli village. In addition to low-rise, flat-roofed, prismatic looking adobe houses, structures such as adobe garden walls surrounding them, barn, shed, hayloft, warehouse, pigeon houses (boranhane) have also been effective in the forming of Erimli village in the process.

In this study, it is aimed to define the architectural and structural features of the adobe houses in Erimli village, where life has been going on for about 100 years in Diyarbakır and to determine the usage and conservation problems. For this purpose, adobe houses in Erimli village were examined on-site and documentation studies were carried out. It has been observed that these houses faced many physical and structural problems over time and some of them were demolished and rebuilt as reinforced concrete. In order to ensure the continuity of adobe structures today, it is necessary to adapt them to contemporary conditions, to strengthen them in terms of materials and structural features and to systematically maintain and repair them. Within the scope of the paper, findings of earthen architecture in Erimli village, Diyarbakır, usage and conservation problems will be shared to preserve the original earthen architecture, whose numbers are gradually decreasing and to ensure that it is passed on to future generations.

Keywords: Earthen architecture, adobe houses, sustainability, construction, conservation

1. INTRODUCTION

Erimli village in Diyarbakır province is one of the rural settlements that attracts attention in the region with its adobe houses and boranhane examples, where life continues actively today. Soil is the main building material of many buildings in Erimli village, with its old name Simaki, which is 21 km away from Diyarbakır city centre, located in Sur district of Diyarbakır. (Figure 1-2-3)

Figure 1. Location of Erimli (Simaki) Village, Diyarbakır (Yandex maps); Figure 2. Erimli (Simaki) village (2021)

Figure 3. Erimli village, low-rise, flat-roofed, prismatic looking adobe houses (2021)

Low-rise, flat-roofed, prismatic looking adobe houses, structures such as adobe garden walls surrounding them, barn, shed, hayloft, warehouse, pigeon houses 'boranhane' have been effective in the forming of Erimli village in the process. (Figure 3) It is seen that climatic conditions, geographical location, topography, local material opportunities, social and cultural structure; traditions and customs, social life, production and consumption styles and beliefs shape the earthen architecture in Erimli village.

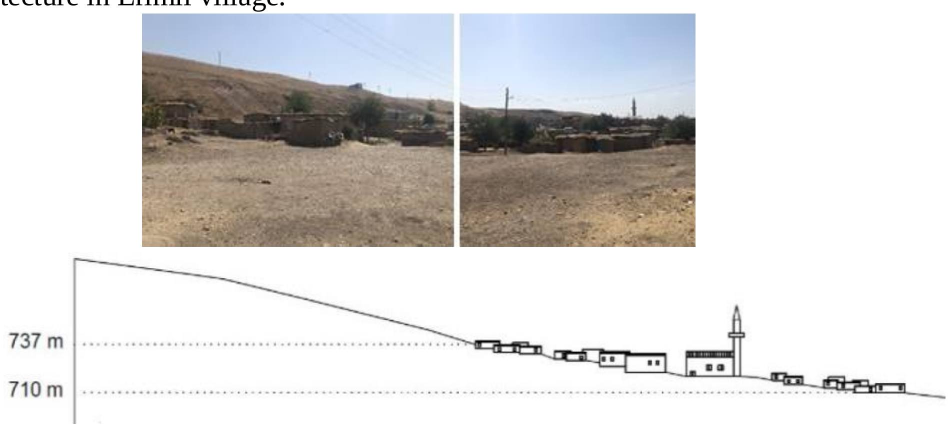

Figure 4. Settlement silhouette of Erimli Village [1] (2020)

Erimli village, which is approximately 1.2 km from the Tigris River in the west, which provides climatic and agricultural advantages in the settlement, is located on the western slope of a low hill with an altitude of 770 meters in the east. The average altitude of the settlement is between 710 - 737 meters. [1] (Figure 4)

Buildings are generally, also depending on the parcel condition, oriented by considering the hot-dry climate conditions, which are hot and dry in summers and cold in winters and in the planning, it is aimed to control environmental factors such as protection from sun rays, shading and wind effect. In terms of reducing the external surfaces exposed to solar radiation, the buildings are mostly in rectangular and compact form. There are also almost square-formed structures and examples that have lost their form due to the additions made over time. The houses are positioned close to each other, and it is also seen adjacent buildings. (Figure 5) Factors such as climate, common needs, family ties and social relations have determined the distance between buildings. The buildings in the settlements on the north-south axis form a shield against each other against the winds blowing from the north thus the cooling effect of the wind is utilized. The wide facades of the buildings are generally positioned to the south. There are also examples positioned to the east. The windows face south to protect from solar radiation from the east-west direction. In this way, the temperature inside the houses is kept at the desired level even when it is very hot in summer. [1]

Figure 5. Buildings positioned close to each other, adjacent buildings (2021)

Erimli village is also known as a place that grows huge and delicious watermelons during the Watermelon Festivals held in Diyarbakır. In the village where the main livelihood is agriculture and animal husbandry, in order to obtain more tasty products from vineyards and gardens, natural fertilizer obtained from pigeon manure was used. It is stated that this fertilizer is used in the sandy lands by the Tigris River and melons, watermelons etc. productions are carried out, thus humidity of the land prevents the seedlings from being dehydrated without the need for irrigation the seedlings and the seedlings grow faster. Pigeon houses, 'boranhanes', where wild pigeons called 'boran' are raised and whose manure is used in the production of watermelon, which was transported by camels in the past and cut with swords due to its large size, are among the important structures of the village in this respect. In the past, while the villagers were building their houses, they also built a boranhane nearby or in a higher place. Boranhanes made of adobe attract attention with their generally rectangular forms, their internal structures designed for pigeons and pigeon entrance holes in various rows on the walls in a high position. [2] (Figure 6)

Figure 6. Pigeon house 'Boranhane' (2021)

Pigeons are fed for their meat as well as their manure. It has been stated that the number of boranhanes in Erimli village decreased from 300 to 4, since the pigeon manure, which was exported abroad during the Ottoman period, has been replaced by artificial fertilizers today. [3] It was observed that only 2 boranhanes remained standing on-site examinations. The abandonment of this tradition also affects the usual size of the Diyarbakır watermelon. Huge size watermelons are now traditionally produced only for competitions. [2] Since animal husbandry is another important source of livelihood, it is seen that animals are housed in the gardens surrounding the houses and places such as barns and haylofts can also be located inside the house.

Earthen roofs, one of the elements that create the rural texture, have been formed depending on the hot-dry climatic conditions in the region and the social and cultural life of the local people. Earthen roofs are used as product drying place, storage, living and sleeping place in summer. (Figure 7)

There are around 40 adobe houses in Erimli village, with a population of 490 and a household of 150. It is seen that these buildings faced some physical and structural problems and some of them were abandoned because of migration. In this study, it is aimed to define the architectural and structural features of the adobe houses in Erimli village and to determine the usage and conservation problems. For this purpose, adobe houses were examined on-site and findings of earthen architecture in Erimli village, Diyarbakır, usage and conservation problems have been shared to preserve the original earthen architecture, whose numbers are gradually decreasing and to ensure that it is passed on to future generations.

Figure 7. Use of earthen roofs (2021)

2. STRUCTURAL FEATURES OF TRADITIONAL ADOBE HOUSES IN ERIMLI VILLAGE, DIYARBAKIR

In Erimli village, flat-roofed, prismatic-looking houses are generally single-storey. Two-storey examples are also seen. The gardens of the houses are separated by walls. Sofa-centred planning features are seen in the settlements. The entrance to the house and the transition to other places are made from a common place called 'sofa'. There are sofa, rooms, kitchen, bathroom, toilet, and warehouse in single-storey buildings. (Figure 8-9-10) A stove is also used to heat the rooms in winter and to meet the need for hot water in the bathroom. The use of 'tandır' for making bread and cooking is carried out in a place with a separate entrance or in a separate unit in the garden. In the two-storey buildings, there are bedrooms and living room on the upper floor. If the family is engaged in animal husbandry, the barns in which the cattle are housed, are planned either inside within the scope of the building planning or near the building separately. The sheds in which sheep and goats are housed or poultry hut are mostly located adjacent to the building from the outside.

Structural Features

The main construction material is soil in rural areas such as Erimli village in Diyarbakır, where wooden and stone materials are scarce, but soil materials are more abundant. [4] In Erimli village, masonry system adobe constructions, which are mostly seen in rural settlements of Anatolia and called 'masonry (massive) adobe', are seen in which the walls are made of block (cast in the form of bricks) adobe and there is no wooden bond beam on the walls. [5]

With the help of the deputy headman of Erimli village, we learned from our conversation with 98-year-old Mrs. Sultan Oyan, who is one of the elders of the village and was also involved in the construction of the adobe house where she still lives with her family that the adobe buildings in the region have a known history of 100 years, there was an old building with a high entrance for the loading of mules, which was demolished and the house they currently live in was built on it, thus the area was actually inhabited 100 years ago, adobe mud consisting of a mixture of straw, soil and water was brought by mules from the village exit, wooden moulds were used, the adobe poured into the mould was waited for 2 days to dry, then turned upside down and dried on the other side, the adobe dimensions are 1 full and 1 half, salt is poured on the earthen roof to preventgrass from growing. It was stated that when the family expanded, an additional reinforced concretefloor was added to the upper floor of the single-storey adobe building.

In the masonry adobe wall technique, which rests on a stone foundation made of round stones, mostly below the floor level of the houses of Erimli village, two different sizes of adobe, one full and one half (one half the other) called 'ana ve kuzu' are used.[6] The main adobe size, which is seen to be the most used in the examinations, is 30x30x8 cm. With adobe plaster is applied on both sides of the wall, the thickness of the outer walls can be generally 80-85 cm, and the inner walls can be 55-60 cm. [1] In some examples, apart from the wall system, wooden posts with struts are used to bear the span. (Figure 10)

Figure 8. Sultan Oyan house, sofa-centered plan, entrance, sofa (2021)

Figure 9. Sultan Oyan house, side room, bathroom, toilet, upper floor with wooden stair (2021)

Figure 10. Sultan Oyan house, barn with seperate entrance (2021)

Flat earthen roofs are joined on wooden rafters with a diameter of 10 cm, which are placed on the walls at intervals of 60-70 cm in the short direction in such a way that 5 cm diameter wooden rafters form approximately 50 cm eaves. (Figure 11) After the rafters are covered with materials such as tree branches and bushes, mud mortar with straw and clay soil is laid on it. Salt is added into soil to prevent grass from growing. There is a slope towards the corners for easy discharge of rains. [1] Every year in September and October, the roof is compressed by passing over it with a cylinder made of stone called "loğ taşı" and maintained. Thus, a flat roof surface protected against external effects is obtained. [5]

The floor coverings of the masonry adobe houses were either left as compressed earth ground or covered with natural stone, depending on their functions. [5]

Figure 11. Flat earthen roof (2021)

A wooden lintel was applied over the door and window openings. Wooden windows are placed on the inner surface of the wall to protect from rains and wind. [4][1] The dimensions of the windows are small, and bars are placed in front of them, on the outer surface of the wall, both for security and to prevent animals from entering the spaces. [4] (Figure 12) Adobe plaster application is seen in all the buildings in the region. Plaster thicknesses are generally measured as 3.5-4 cm, although in some examples 7-8 cm has been applied.

Figure 12. Wooden window and door example (2021)

3. CONSERVATION PROBLEMS OF TRADITIONAL ADOBE HOUSES IN ERIMLI VILLAGE, DIYARBAKIR

It is seen that approximately 40 adobe buildings that have survived in Erimli village face physical and structural problems, some of them continue to be used with these problems, and some of them are not used or abandoned because of migration. The factors that cause the destruction of adobe buildings that require regular maintenance can be grouped into three main topics: temperature (decomposition and crumbling of soil material due to temperature difference), water (moisture accumulating on the roof and wall surface) and various biological causes. The fact that adobe is affected by water and humidity is the weakest aspect of the material and structural problems focus on the relations between water and clay. [5]

Figure 13. Abandoned adobe buildings in Erimli village (2021)

Abandonment of buildings because of migration, lack of regular maintenance, improper maintenance, repairs and applications, natural causes such as climatic conditions are the main conservation problems observed in the region. Abandoned, empty and derelict buildings are destroyed more quickly because the necessary maintenance and repairs are not made and thus the collapse process of the buildings is accelerated. (Figure 13) Wall and roof maintenance should be performed regularly without neglect. Since the roof cover will collect water after rains, it is very important to compact this cover system with stone roller 'loğ taşı' with regular maintenance and to provide a roof surface that is constantly protected against external effects. Similarly, when grass grows on the roof, since this surface will hold more water, the roof load increases, the walls cannot carry this load and structural problems and collapses occur both on the roof and on the walls. (Figure 14-15-16) Since the structure will be strengthened with bond beams, the absence of wooden bond beams on the walls in these constructions reduces the load bearing capacity of the walls and fractures, cracks, out of plane collapses occur on the walls. Fractures and cracks on the walls can be caused by the increased roof load as well as the ground and foundation problems.

Figure 14. Structural problems, inability of walls to carry the roof load (2021)

Figure 15. Collapsed roof and destroyed walls, greening of earthen roof (2021)

Figure 16. Covering the collapsed roof with metal sheets, adobe plaster openings, cracks, ruptures and spills (2021)

Figure 17. Fractures and cracks on the walls, replacing windows and doors with PVC and metal materials, cement-based plaster application (2021)

Unqualified maintenance and applications are another protection problem. Such weighting of the roof covering, to which soil is added as it decreases every year for the purpose of renewing the earthen roofs, causes structural problems. For easy discharge of rains during maintenance and repair works, the slope towards the corners should be preserved and attention should be paid to prevent grass from growing on the roof. Covering the roof with metal sheets as a result of the collapse of the roof, the decay of the soil layer on the roof cover, replacing the windows and doors with PVC and metal materials, additions made with materials such as bricks, use of cement-based plaster, etc. are wrong applications in terms of protection. (Figure 16-17)

In the examinations made, it was observed that there is no awareness of conservation in the village due to the change in the social structure and economic problems. In the interviews, those living in adobe houses talked about the difficulties they experienced and their plans to demolish their houses and rebuild them with reinforced concrete. This situation is the biggest obstacle in ensuring the continuity of adobe buildings.

CONCLUSION

The culture of traditional adobe building in Erimli village began to disappear as a result of many negative factors. It is necessary to create a conservation awareness at first to ensure the continuity of adobe buildings today. Adobe is an important construction material in terms of being produced from soil that easily found in nature, having low thermal conductivity, balancing the humidity inside, providing natural air circulation, being environmentally friendly, economic and fire resistance. [7] The value of adobe buildings and the fact that these buildings are a part of the cultural heritage should be explained to the local people through trainings and showing good examples. It is necessary to adapt the buildings to contemporary conditions, to strengthen them in terms of materials and structural features and to systematically maintain and repair them. In this context, a conservation plan should be established with the participation of all relevant disciplines, educational, public, and private institutions, focusing on the social and economic problems in the village. In Diyarbakır, which is in the 3rd region in terms of earthquake risk, it is stated that the city centre and its immediate surroundings are under the influence of fault systems that play an active role in the seismicity of the Southeast and East Anatolian Regions, thus this issue should also be taken into consideration in future planning studies. [8]

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6-A study on Risks of Earthen Architecture due to ClimateChange

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ABSTRACT

Climate change (CC) is one of the biggest common problems of humanity. We have only the IPCC reports as main source to understand the issue. In the latest published IPCC report on CC, it is asserted that if necessary, measures are not taken, the adverse impacts of CC will emerge sooner than predicted. Despite, the issue affects all over the World in different sizes and forms, the governments still have not taken the necessary and realistic steps to solve the problem. This situation makes heritage more vulnerable to CC.

Some traditional materials such as earthen are more susceptible versus the CC impacts. Therefore, adverse impacts of CC on adobe heritage should be identified and measures should be taken before CC damages the heritage irreversibly. For this reason, in this study, it is aimed to define the general indicators of CC that emerge risks for cultural heritage and, address vulnerability of adobe heritage.

While some of the degradation mechanisms in cultural heritage arising from climate change are fast developing and measurable effects, some are slow and long-term impacts. The most damaging risks of CC to the cultural heritage are related to meteorological events such as extreme rains, flash floods, heat waves and droughts. In addition, unfortunately now the changing climate emerges the risk of occurrence of these weather events successively, especially extreme rain after drought terms. Both drought and, extreme rain is severely hazardous to the adobe heritage because of its material properties. After the drought term, the earthen material becomes more brittle form and, if any flash flood event occurs right after this term, it is devastating for the heritage. In the scope of this study, the CC impacts on cultural heritage and, the emerging risks of the Earthen Architectural Heritage are defined in general.

Keywords: Climate change impacts on cultural heritage, adobe heritage, sustainability

1. INTRODUCTION

Scientists have detected an increase of approximately 1°C in the temperature of the earth in the last century compared to the pre-Industrial Period [1]. This 1°C increase, which is certain to be of anthropogenic; has caused the change in the world climate and the increase in atmospheric events.

In the 80s, when climate change was scientifically revealed as a global problem, governments did not yet have the opportunity to predict what they could do about the issue due to lack of data. As a matter of fact, there were great uncertainties about what exactly the problem in front of them was, how it would shape in the future and how it could affect the world. Scientific data and consistent measurements were needed to eliminate uncertainties, and therefore, to prepare scientific reports on climate change the IPCC (Intergovernmental Panel on Climate Change) was established in 1988 under the United Nations in partnership with the WMO (World Meteorological Organization) and UNEP (United Nations Environment Program) [2].

Although climate change is the biggest common problem of the whole world, the fact that the measures to be taken will affect many sectors, especially energy and industry, has caused the problem to be ignored and even denied at the international level for a long time. However, after the 2000s, the remarkable increase in the number of disasters with hydro-meteorological character and it's the concretization of the connection with climate change made the problem more widely accepted in the whole world, first in European countries.

When EM-DAT (Emergency Events Database) comparative natural disaster data is examined, it has been observed that since 1980 there has been a continuous and significant increase in the number of hydro-meteorological disasters in the large-scale natural disasters due to climate change in the world [3]. According to the data obtained, it is stated that 64% of the disasters experienced in Europe since 1980 occur directly due to severe weather and climatic conditions such as floods, storms, droughts and heat waves [4].

In the subtropical Mediterranean climate zone, in which Turkey is located, three major problems such as drought, heavy precipitation and flash flooding, and increase in sea level tend to increase due to climate change [5]. Due to being located in the Mediterranean Basin, Turkey will be more affected by heat waves and droughts, heavy and excessive precipitation events, and weather events such as thunderstorms and tornadoes in the future. However, there is a risk of a decrease and irregularity in precipitation, and excessive precipitation in the western and northern coastal parts of Turkey, especially in summer [6; 7]. In parallel with this, the damage risks due to climate change to the cultural heritage will increase in the future.

2. CLIMATE CHANGE AND CULTURAL HERITAGE

Until the year 2000, no national or international study on the effects of climate change on cultural heritage could be found. The first studies on this subject started after 2004 and Europe assumed a leading role in studies. It is thought that the negative effects of the Central European floods that occurred in 2002 on the cultural heritage were effective in raising awareness about the issue in Europe [8]. Noah's Ark, funded under the European Commission 6th Framework Programme, is the first comprehensive project on the subject aimed at identifying all risks posed by climate change on cultural heritage [9]. After the project outputs, the problem started to attract more attention in the field of protection [10].

Reports were prepared after the World Heritage Committee requested observations and determinations from the presidencies of the World Heritage Sites, which are under the threat of losing the heritage criteria due to the negative effects of climate change [11; 12]. Thus, the problem began to be examined more effectively in the field of conservation, and UNESCO, English Heritage, the European Commission and the Council of Europe carried out pioneering studies (Table 1). With the efforts of these organizations with high international effectiveness, the IPCC, in its 5th report published in 2014, included for the first time "the necessity of protecting cultural heritage in climate adaptation policies", unlike its previous reports [13]. After the commitments at the COP 21 Paris Climate Summit in 2015 and the report of the IPCC, the issue of cultural heritage has started to be included more in the climate policies of organizations and countries [14].

Year	Organization	Action
2004 2007	European Commission 6th Framework Programme	In its 6th Framework programme, the European Commission has agreed to finance the Noah's Ark Project to study the effects of climate change on cultural heritage in Europe.
2005	UNESCO World Heritage Committee	At the 29th meeting of the World Heritage Committee in Durban in 2005, organizations and individuals, including environmentalist groups, drew attention to the problem of the impact of climate change on World Heritage natural and cultural assets.
2005	English Heritage Centre for Sustainable Heritage (University College London)	Commissioned by English Heritage in 2005, the institution published the report "Climate Change and the Historic Environment" prepared by May Cassar.
2009	Council of Europe	The Council of Europe financed the continuation of the activities of the European University Center for Cultural Heritage in Ravello, Italy, in organizing courses on climate change risks for cultural heritage.

Table 1. Pioneering initiatives on the effects of climate change on cultural heritage [8] (Gökmen Erdoğan, 2022).

According to Rockman, climate change indicators that will cause damage to cultural heritage; sea level rise, storm surges, precipitation, temperature and wind variations, flooding, ocean acidification, increased atmospheric humidity, drought, fire, increase in invasive species [15]. In another similar study conducted by WHC, climate change indicators are given under 7 headings: atmospheric humidity change, temperature change, sea level rise, wind, desertification, combined effects of climate and pollution, climate and biological effects [12]. When climate change indicators are taken into account, it is seen that each of them poses serious risks to existing and emerging degradation mechanisms in cultural heritage.

In this study, it is aimed to determine the risks of adobe heritage due to climate change due to the limited scope. In this direction, in the next section, after the properties of adobe material are mentioned in general, it is tried to be revealed by examining which climate change risks the adobe heritage is more vulnerable to.

3. ADOBE MATERIAL PROPERTIES

When the earliest dates of humanity started to meet the building needs are examined, it is seen that the soil, which can be easily accessed, processed and compatible with the environment, comes to the fore in the context of materials. The combination of soil with other natural materials, especially straw and water, forms adobe. It is seen that adobe was used as a building material when natural materials such as wood and stone could not be acquired since the first periods of the settled civilization [16]. Adobe material, which is a sustainable material due to its low energy requirement and low cost in its production, has been used for thousands of years almost all over the world.

The most common use of adobe material in buildings is construction with adobe blocks or compacted soil [17] (Figure 1). The building will have a long life, if the adobe material is kept for 2 years before being used in the building and the construction is done with appropriate techniques and methods [18]. In addition, the type of soil to be used in adobe material is important because the properties of adobe material vary depending on the type of soil [19]. Although various metal oxides such as iron, magnesium, titanium oxide may be present in the clayey mud-brick soil, whose chemical composition is aluminium silicate, organic substances should not be present [17].

Although the compressive strength of the soil material is high, the tensile strength is low, so straw or similar fibrous materials are added to increase the tensile strength [18].

Figure 1. Adobe material [20]

Adobe material is sensitive to water and if necessary precautions are not taken, water penetrates into the material and starts the dissolution process of the binder clay. For this reason, rainwater washing the surface, water contacts due to insufficient drainage, flooding, rising ground water cause serious damage to the adobe material. However, sensitivity to the increase in humidity in the air and expansion and contraction mechanisms due to temperature changes are the properties that increase the vulnerability of the material to various factors [19].

4. THE RISKS OF ADOBE HERITAGE DUE TO CLIMATE CHANGE

Climate change has many negative effects in almost every field. Studies on their effects on cultural heritage generally examine climate indicators and the risks associated with them. The current threats posed by climate change on cultural World Heritage properties are defined as hurricanes and storms, sea level rise, erosion, floods, changes in precipitation regime, drought, etc. [12] (Figure 2).

Climate change impacts can be subtle and can occur over a long period of time. However, some climate change parameters such as a freezing, temperature and relative humidity shock can change by large amounts over a short period of time and can be measured. As for, slow-developing effects can only be detected by long-term observation and measurements. Therefore, within the scope of this study, while the risks caused by climate change in the adobe heritage were revealed, the slowly developing effects were excluded from the evaluation. To identify the major global climate change risks and impacts on cultural heritage, the climate parameters tabulated in the Table 2 are used by scientists.

Climate indicator	Climate change risk	Physical, social and cultural impacts on cultural heritage
Atmospheric moisture change	- Flooding (sea, river) - Intense rainfall - Changes in water-table levels - Changes in soil chemistry - Ground water changes - Changes in humidity cycles - Increase in time of wetness - Sea-salt chlorides	- pH changes to buried archaeological evidence - Loss of stratigraphic integrity due to cracking and heaving from changes in sediment moisture - Data loss preserved in waterlogged / anaerobic / anoxic conditions - Eutrophication accelerating microbial decomposition of organics - Physical changes to porous building materials and finishes due to rising damp - Damage due to faulty or inadequate water disposal systems; historic rainwater goods not capable of handling heavy rain and often difficult to access, maintain, and adjust - Crystallisation and dissolution of salts caused by wetting and drying affecting standing structures, archaeology, wall paintings, frescos and other decorated surfaces - Erosion of inorganic and organic materials due to flood waters - Biological attack of organic materials by insects, moulds, fungi, invasive species such as termites - Subsoil instability, ground heave and subsidence - Relative humidity cycles/shock causing splitting, cracking, flaking and dusting of materials and surfaces - Corrosion of metals - Other combined effects eg. increase in moisture combined with fertilisers and pesticides
Temperature change	- Diurnal, seasonal, extreme events (heat waves, snow loading) - Changes in freeze-thaw and ice storms, and increase in wet frost	- Deterioration of facades due to thermal stress - Freeze-thaw/frost damage - Damage inside brick, stone, ceramics that has got wet and frozen within material before drying - Biochemical deterioration - Changes in 'fitness for purpose' of some structures. For example overheating of the interior of buildings can lead to inappropriate alterations to the historic fabric due to the introduction of engineered solutions - Inappropriate adaptation to allow structures to remain in use
Sea-level rises	- Coastal flooding - Sea-water incursion	- Coastal erosion/loss - Intermittent introduction of large masses of 'strange' water to the site, which may disturb the metastable equilibrium between artefacts and soil - Permanent submersion of low lying areas - Population migration - Disruption of communities - Loss of rituals and breakdown of social interactions
Wind	- Wind-driven rain - Wind-transported salt - Wind-driven sand - Winds, gusts and changes in direction	- Penetrative moisture into porous cultural heritage materials - Static and dynamic loading of historic or archaeological structures - Structural damage and collapse - Deterioration of surfaces due to erosion
Desertification	- Drought - Heat waves - Fall in water table	- Erosion - Salt weathering - Impact on health of population - Abandonment and collapse - Loss of cultural memory
Climate and pollution acting together	- pH precipitation - Changes in deposition of pollutants	- Stone recession by dissolution of carbonates - Blackening of materials - Corrosion of metals - Influence of bio-colonialisation
Climate and biological effects	- Proliferation of invasive species - Spread of existing and new species of insects (eg. termites) - Increase in mould growth - Changes to lichen colonies on buildings - Decline of original plant materials	- Collapse of structural timber and timber finishes - Reduction in availability of native species for repair and maintenance of buildings - Changes in the natural heritage values of cultural heritage sites - Changes in appearance of landscapes - Transformation of communities - Changes the livelihood of traditional settlements - Changes in family structures as sources of livelihoods become more dispersed and distant

Table 2. Principal climate change risks and impacts on cultural heritage [12]

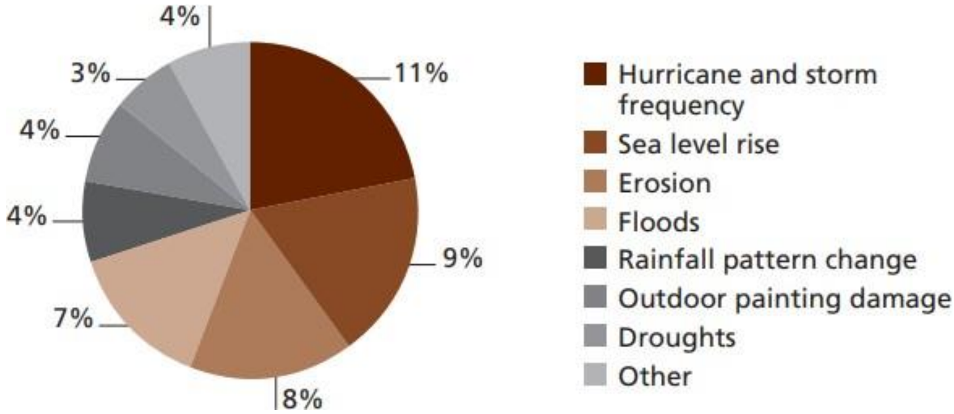

Figure 2. Threats of climate change for World Heritage sites [12]

The World Heritage Earthen Architecture Programme (WHEAP) suggests that 34% of the 150 earthen heritage sites on the UNESCO World Heritage List are currently under threat from climate change [21].

Considering the sensitivity of adobe material to water, air humidity increase, sudden temperature changes and drought, it is thought that all the climate indicators in Table 2 that have adverse impacts on the cultural heritage may pose different damage risks on the adobe heritage. However, when adobe material is evaluated in terms of its properties, it is thought that it is more vulnerable to risks related to atmospheric humidity changes, temperature changes, wind and drought indicators. In this direction, the climate change risks of the adobe heritage are examined below, based on these indicators.

Figure 3. Typical water-ingress problems [22]

Figure 2. Threats of climate change for World Heritage sites [12]

*Risks of Adobe Heritage due to Atmospheric Moisture Change: The risks posed by this climate indicator are defined below (Table 2) [12]:

- Sudden intense and heavy rains,
- Changes in water levels (unlike sea level rise)
- Floods (coastal / river / urban),
- Changes in soil chemistry,
- Changes in groundwater properties and level,
- Changing humidity cycles,
- Increased wet time

The adobe, earthen, structures are easily damaged by natural erosion as they become exposed to air and rain and require continuous conservation efforts and substantial ancillary measures [23]. Because, the high humidity in the air causes the adobe wall to dissolve, and it's load-bearing to decrease and the tensile and compressive strength of the clay-bound soil walls to decrease [24]. The risk of collapse in the superstructure will increase due to the soil saturation with the rise in the groundwater level. In addition, increases in floods also pose serious threats to the adobe heritage.

Figure 4. The archaeological site of Meroe after flood [28]

*Risks of Adobe Heritage due to Temperature Change**:** The risks posed by this climate indicator are defined below (Tablo 2) [12]:

- Diurnal, seasonal, extreme events such as heat waves and snow looding;
- Changes in freze-thaw cycles and
- Increase in ice storms and wet frost

Although climate projections indicate that freezing temperatures are likely to be less common in the future, increased winter precipitation and periods of seasonal extreme temperatures mean that freeze-thaw cycles will remain a threat to the integrity of adobe structures into the future. Because external surface deterioration is associated with damp frost and subsequent thawing [22].

Extreme temperatures at the surface of material can occur under intense solar radiation. In earthen materials, this can lead to thermoclastic deterioration from repeated expansion and shrinkage. These fluctuations cause internal stresses that can compromise the comprehensive strength of the blocks and reduce overall structural strength [25].

Risks of Adobe Heritage due to Wind:* Wind movements have major effects on storm systems and precipitation patterns, and wind and precipitation patterns have changed with climate warming [26]. The risks posed by this climate indicator are defined below:

- Wind-driven rain and sand;
- Wind-transported salt
- Winds, gusts and changes in direction

The moisture susceptibility and friability of earthen building materials makes them highly prone to damage by abrasive processes. Wind-driven rain can impinge directly on the exposed walls, causing considerable damage. Heavy winds cause the rain to come almost horizontally to the building facades, and especially on the facades with porous materials, this wind-blown rainwater reaches the depths of the texture of the buildings. A similar process occurs when wind-driven sand has aggressive effects and causes damage to both soft and hard building materials. Likewise, salts reach the land and structures with the effect of wind in places close to the shore [27]. The wind causes the wall surfaces to dry and cracks to form, sand, salt and dust particles coming with the wind abrade the wall surfaces; porous material penetrates into them and causes contamination [10]. Furthermore, it causes unwelcome accumulations against walls [22]. In storms, loads cause deterioration of building elements; it can cause vertical structures such as adobe minarets to collapse.

*Risks of Adobe Heritage due to Desertification: The risks posed by this climate indicator are defined below (Tablo 2) [12]:

- Drought,
- Heat waves
- Fall in water table

Desertification, one of the indicators of climate change, is one of the most serious threats posed by the increase in global temperatures [13; 2]. Desertification consequences include expansion of dunes, further erosion, and sometimes complete loss of vegetation in the area [10]. Drought increases the risk of fire and causes changes in the physical, chemical and biological properties of materials [14]. Heat waves caused by climate change caused the frequency of fires in the Mediterranean, the USA and Australia to increase by 300% and the lakes to dry up [2].

It is known that there is numerous adobe heritage in regions such as Timbuktu in Africa, where desertification due to climate change is experienced. Heritage assets in these areas are exposed to adverse effects of sand and dust due to the expanding desert.

CONCLUSIONS

With the Industrial Revolution, the world has begun to experience the first anthropogenic climate change. Initially, the problem was air pollution caused by coal smoke, but it has grown and become more complex. Today, climate change, which has evolved into much bigger problems such as drought, storms, hurricanes, floods and rising sea levels, also poses great risks for cultural heritage. Climate change, which has been accepted as a global problem since the 1980s, poses many different risks of vulnerability for the adobe heritage, including the complete loss of the heritage.

The adobe structures, which are concentrated in Africa, Central Asia, Central and South America, but examples can be found almost everywhere in the world, are quite abundant in our country, especially in the Middle Anatolia, Eastern and South-eastern Anatolia Regions. Apart from these geographical areas, it is known that there are approximately 500,000 adobe structures in England, most of which were built in the twentieth century, and that about 30% of the world's population lives in mud-brick structures [18]. Considering the number of adobe structures in the world, it is understood that many adobe structures are vulnerable to risks arising from the adverse effects of climate change.

Within the scope of this research, the risks posed by climate change on the cultural heritage were examined and, the risks that would affect the adobe heritage in the short term were tried to be determined. In this scope, the climate parameters that are thought to pose serious fragility risks in the adobe heritage are determined as "atmospheric humidity change", "temperature change", "desertification" and "wind", and possible risks are defined due to those. However, due to the limitations of the study, the risks are given in a general framework.

In future studies, the adverse impacts of climate change on the adobe heritage should be examined more comprehensively and how the adobe heritage will be protected from these effects should be discussed. To mitigate the impacts, new conservation methods that are compatible with heritage values should be explored.

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7- Innovative Solutions in Soil Surface Architecture to Against Desertification

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ABSTRACT

In a discussion with drought and drought in a natural way of global warming, you need to think more deeply about the environment.

Applications, along with the application area for applications in all countries of the world, can also find application for the places where the topography allows, and the application of drought begins. These innovative solutions, consisting of layer on the soil surface, predict the conservation of the land and the soil erosion planning of at the same time.

In this review, a value-added application of these comprehensive and comprehensive solutions in the geography of the region is planned. Protective belt applications are thought to enrich the country's lands. At the same time, planting will be contributed to living local population in areas dealing with agriculture and animal husbandry.

With this study, it is also aimed to raise awareness about how innovative solutions can be produced in soil surface architecture to combat drought. In the study, the models will also be included that will be built on the surface covering and structuring of arid and designed.

Keywords: Drought, adobe, earth surface architecture, innovative solutions

1. INTRODUCTION

According to Argentinian writer Jorge Luis Borges ''Nothing is built on stone; all is built on sand, but we must build as if the sand were stone'' [1]. In interlocking angular quartz grains of sand, we find fascinating forms and emergent patterns; possibilities,potentials. In short, interactive opportunities [2] through accretive processes, materials become buildings that become cities.

That scenario might indeed form the basis for future projects. For this reason, constructions that originated built with sand presents to various solutions especially desertificationed areas.The aim presented here, to create an architectural speculation and suggests elemental ground manipulation in our country that threatened by desertification. This proposition also advocates a radical shift in structural thinking beyond away from pre-fabricated or in situ construction.

The interactive opportunities presents solutions for desetification areas with creating a network of solidified sand dunes in the desert.

The method of the study consists of a literature study. At the same time, it is aimed that to give solutions for desertificated geographies especially vulnerable to climate change with sand construction samples, especially climate change scenarios.

1.1. SAND STRUCTURES THAT TURN INTO CITIES STRUCTURES

At the last times, architects work about solidified sand dunes where all design is fundamentally focusing sand material. The potential of accumulation processes of materials causes sand dunes's tur into cities structues. A network of solidified sand dunes in the desert advocates a radical shift in structural thinking, and it also suggests exactly a basic ground manipulation. The structure made from the desert itself is a habitable anti-desertification structure. It also a sand-stopping building made out of sand. In transformation the dune into a micro environmental support structure, helping conserve the scarce water and mineral resources and in preventing of droughtness, solidified sand dunes is aceepted an excellent material.

The solidification of sand and its transformation into building material and the use of material properties help to create special spatial structures. These spatial pockets especially is solution proposal for drougt region. Because this climate-conscious architecture is an answer primarily points toward adaptive responses to the potential threats of future. These sand structures tomitigate the continual migration of sand dunes and provide controlled biocementation process as a strategy.

1.2. DESERT AND DESERTIFICATION AS A THREAT

At the heart of the world's drylands are five major zones of natural desert:the Afro-Asian Desert, the North American Desert, the Atacama and Patagonian Deserts in SouthAmerica, the Namib and Kalahari Deserts in south western Africa, and the GreatSandy, Great Victoria, and Simpson Deserts in Australia [3]. However, Turkey geography is under the desertification effect with each passing year.Because of the dry areas cover more than one-third of the earth's land surface[4]. Many specialists thinks that in the field to be one ofthe desertification is the most serious environmental problems facing our world.

Desertification has been on the international agenda for about half a century,but we still do not know precisely how fast, or indeed whether, our deserts are growing, especially for Turkey geograpy.

It is estimated that firewood collection, excessive grazing, and overcultivation accountsfor nearly 90% of what is perceived as desertification [5].

Unsustainableland management practices in Turkey drylands, continuous cropping, with reductionsin fallow and rotations, repetitive tillage and soil nutrient mining; are another effects of desertification.

The impacts of these practices include loss of natural resources, changes in naturalhabitats and ecosystems, loss of agrobiodiversity and degrada-tion of ecosystem services, decreases in productivity of arable land lead to poor harvests and food shortages and result in poorliving conditions and poverty.

Climate change and increasing weather variability already be exacerbate these problems. It is pre-dicted to bring further challenges in the coming decades, with rising temperature sand changes in rainfall patterns [6].

1.3. ACTION PLAN OF THE NATIONAL STRATEGY TO COMBAT DESERTIFICATION (2015-2023)

Combating Desertification with people signed on 15.10.1994 in Paris; To die on the date of 11.02.1998 with the Law No. 4340 and by being published in the Official Gazette on May 16, 1998. Contracting Party contracts to implement National Action Plans. In order to interact more with desertification, an "Action Programme" was prepared to "actuate desertification and realize it nationally" and was completed with the circular (2005/2) published in the Official Gazette on 09 March 2005.

"Assessment of Land Degradation and Monitoring of Support and Good Practices for Sustainable Land Management Project" within the scope of Decision Support for Mainstreaming and Scaling up of Sustainable Land Management, a joint venture of UNCCD and FAO is being prepared. Dissemination of the concept of sustainable land management to combat land degradation in the global Project involving Turkey, Bosnia and Herzegovina, Argentina, Bangladesh, China, Colombia, Ecuador, Lesotho, Morocco, Nigeria, Panama, Philippines, Thailand, Tunisia, and Uzbekistan and it is aimed to develop the capacities of the countries. General Directorate of Combating Desertification and Erosion coordinates the project on behalf of Turkey.

There are also cooperation plans for the protection of the land and the protection of the environment in the fight against desertification. In the meantime, using the existing aggregate material as a building material and contacting the ground can be an effective solution.

Balancing land degradation in Turkey; improvements and architectural solutions are the works that need to be done in order to prevent desertification like other countries. Developing the capacities of countries with Desertification, Land Degradation and Drought includes planning plans in accordance with land use, topography and geology. Architectural structuring is also a combination of these decisions.

1.4. GENERAL EVALUATION OF DESERTIFICATION IN TURKEY

Although not available in Turkey of course; Its appearance, climate, topography and soil increase its sensitivity to drought in the country throughout the country, from this extreme situation and from drought to the fact that the most vaccination takes place throughout the country.

Causes of obsolescence in Turkey; It is not in favor of soil erosion, wrong agricultural practices and use, preparation by application method, salty, gypsum and alkaline main material, deforestation, completion and high cost. next to it, the demand and pressure, which increase one step further with each passing day, are the most basic information of necessity. In general, 65% of school climates are semi-arid and climatic.

The destruction of the vegetation of this ecologically secure land and the balancing of the route open it to the attack of the soil and main education. Especially Konya, Iğdır Provinces and Southeastern Anatolia

Being in the region of Turkey, daily land degradation-desertification is observed.

2. MATERIAL PROCESS, CONSTRUCTION, STRUCTURE FOR DESERTIFICATION ARCHITECTURE

Designing with aggregates may be permanent solutions for desertificated areas. This construction method may be guide the design and/or construction process.

Grains of sand are at the same time granular and massive, simple and complex, static and dynamic, too heavy to be held in suspension in the air yet light enough to be moved by the wind. [7]. It is also ever-present in architecture: its history is part of the material history of the discipline. Without sand no brick, no building construction. There are many building made of sandsuch as cathedrals and churches mosques.

Exceptionally sensitive physical interventions in the landscape can be successfully designed with aggregates.

There are building examples exceptionally sensitive physical interventions in care against desertification designed with aggregates.

2.1. SANDSTONE ARCHITECTURE IN AGAINST TO DESERTIFICATION

That word— 'sandstone architectures'—can be explained established as a new way of creating new architectures at a human scale.

In the next step, should be define potential strategies and methods for how to actually construct the microbial sandstone structures in situ. The aggregational qualities of sand is explored redefinition of existing sand dunes. Instead of viewing the dunes as hills of sand built by aeolian processes, they should be read as readymade building volumes. This conceptual shift opens for the process of densification, adhesion and petrification binding the grains together into solid sandstone surfaces: a floor datum; a wall membrane; a spatial divider. Once excavated, the biocemented sandstone surfaces demarcate habitable spaces, turning the interior and exterior of the dune into a perfectly seamless, seemingly 'weightless' architecture of solidified sand caves inside of the initial volume.

New strands of the dune can then be precipitated with the microorganism, producing an infinitely variable structural system.

Two construction options were developed: pneumatic balloon precipitation and injection pile precipitation.

The former involves to create creating a pneumatic, balloon-like structure. In this structure, it is given let to sculpturing of sand dune, an then is obtained thee sand dune into an optimal shape for the solidification process to take place. The microbial solution that is specially prepared is distributed through specifically designed apertures in the skin of the structure, solidifying the sand surrounding it into structural compressive surfaces.Some time after the solidification, once the interior of the resulting sandstone structure has reached optimal strength, the balloon structure is recycled for the construction of the next stretch of the scheme. This method could be viewed as similar to that of the application of spraycrete, the high-strength polymer coating designed predominately for the re-surfacing of old concrete and tarmac. Using air compressors and various levels of air pressure, the spraycrete can be sprayed straight onto the surface to be treated (Fig. 1,2).

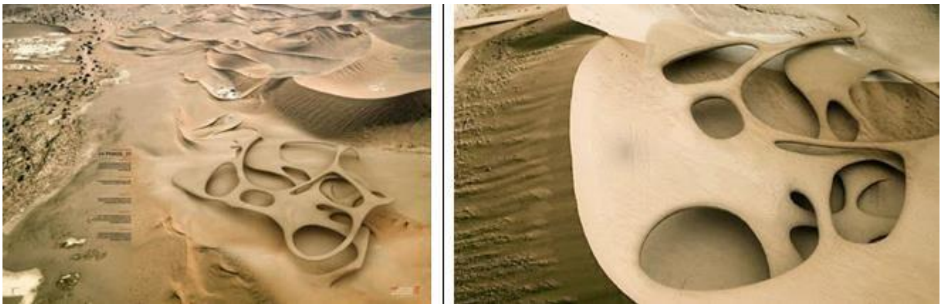

Figure 1.Sand dwelling Kevin Hand-Building foundation(https//www.dune+ desertification +architecture)

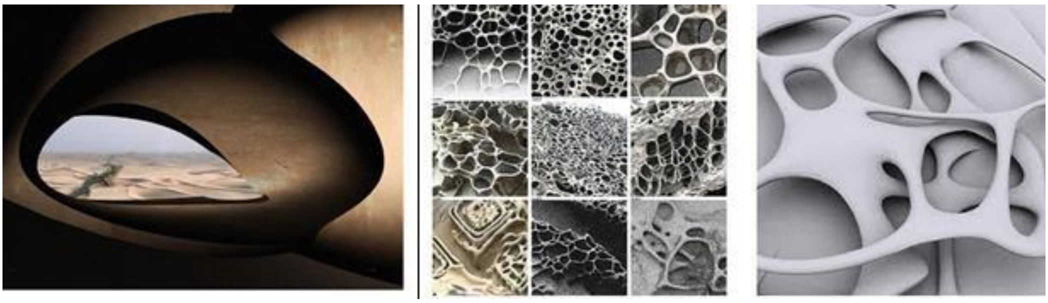

Figure 2.Generating giant sansdstone walls to flight desrtification (inhabitat.com)

The second alternative is method of using injection piles. These injection methos is used to solidify the sand dune. Injection piles are pulled up, and then are created almost structurally sound a shape.The procedure would be analogous to using an oversized 3D printer, solidifying parts of the dune as needed [8] (Fig. 3).

Figure 3.Arenaceous Anti-Desertification Architecture

CONCLUSION

Estimates of recent losses of productive land show that the arable land in the world have being lost every year.Most specialists seem to agree that we will continue along this trajectory into the future.

As always with complex situations, against to desertification it must be taken precautions without await complete knowledge of the circumstances.

Immediate efforts need to be made using our existing understanding, not only to stop the physical processes of desert encroachment, but also to create opportunities for the people especially to our country.

The harm done to fragile ecosystems and to provide them with better standards of living is possible witj the better architectural environment.

It is believed that architecture against to desertification could be part of such a programme and it is believed that the first stretches of the architectural scheme could be created following a rather brief period of research.

In the longer run, extensive research is needed. The examples about earthen architecture created against to desertification underlines the need for urgent short-term relief measures.

Architects create spaces that accommodate human activity. Earten architecture is not so much focused on the styling of that activity, as on the supporting of it. Earthen architecture is designed to visually, and at the same time, but a social, ecological, cultural one. Architects must find a way how are we to live with the desert, in the desert, within the desert?

Architects must have the understand and respond to such questions.Architects must have developed mechanisms and innovative design consisting various forms and accommodations of functionalities within the systems we design.

Earthen architecture as a conceptually striated system, built up in layers like a sedimentary stone is the self-organising, gregarious grains of sand that taking on different shapes as time passes. The intricate geometries and endless variety of the natural granular materials is consequences of the internal or external environment.

When interacting with biological agents of The morphologies of granule material, some of their properties and potentials have been inspiring for desertification settlements. This potential of granule material has suggested that microorganisms be employed as a construction element in our built environment. The aim has exploring formal, performative, algorithmical, material, and similar properties in addition to architectural solution for this settlements. At the same time, it is related to large-scale, mitigatory engineering projects. The resulting architecture becomes an infinitude relationships: solidified mass or excavated void, sand that's been precipitated or left untouched, that is fluid, sand or sandstone, very light or very heavy. The building speaks the evolution of villages and cities built on sand covered in granule.

A billion people live in arid or semiarid environments in the world often in substandard dwellings. But, we know that massive volumes of sand that how to turn into pioneering buildings. Mankind has already moved into the desert and will continue living into the desert because of desertification.

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8- Earth Architecture as Sustainable Samples and Its Potential

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ABSTRACT

Earthen material is one of the most common elements of the planet, the most available, the most inexhaustible, the most versatile, the least expensive, and the least harmful to the environment. In today's world, such earthen constructions are the first to be razed and replaced by a generalized type that neither respects the diversity of cultures nor the originality of the material. However, at the intersection of modern and architecture there are construction techniques from earth in order to keep the authenticity of local settlements especially for poor families. In this research, it is aimed to search architectural heritae and build it sustainably provided that the protection and maintenance constructions are combined using the earth material and architecture.

This research adopts a set of analytical tools conducive to the study objectives. The research method is divided into two main components:

Firstly, to analyze the ideology component, such as; understanding the architectural concept of the mud house as a life-style; explaining authenticity foundations of the community; reviewing the functional and formal image of earth houses.

Secondly, to analyze the technical component, suh as; understanding the architectural concept of the earth house, understanding traditional earth construction techniques and thinking,

Thirdly, to give earth architecture samples as to reviewing the appropriateness of the earth as building material in sustainable scenario.

To summarize, in this research, to revive earth architecture through the implementation of new project samples with togetherness of modern and traditional fully built from earth and to raise awareness.

Keywords: Earth architecture, sustainability, earth construction, material

1. INTRODUCTION

Earth is one of the most abundant, basic building materials. There are various building that constructed with earth or adobe material. In these buildings ,unfired, untreated, raw earth is used, that is the practice of construction using . It has been successfully used around the world for over 11,000 years, and it is estimated that around half the world's population today live and work in earth buildings.

Used continuously for millennia in most of the world, raw earth remains one of the most popular construction materials. In 1964, anthropologist Claude Lévi-Strauss drew attention to a duality at the heart of civilisations: the use of 'raw' and 'baked'. These are relate to architecture at the same time. [1]

Earthen material is one of the most common elements of the planet, the most available, the most inexhaustible, the most versatile, the least expensive, and the least harmful to the environment. This material builds, at least partially, the houses of more than a third of the World inhabitants[2]

Earthen construction encapsulates many different and varied forms of techniques and applications. As a vernacular solution, it has developed over many thousands of years in all inhabited continents of the world. Eart contruction as a predominant building solution is seen in many rural regions of Africa, Asia and South America. For example, In Morocco, many international attempts were engaged to save earthen structures in some distant villages [3]. These attempts have aimed to restore this heritage, while the real need for us is the re- adaptation of earthen architecture as a building system which is worthful.

Over the last 25 years, the most ancient and construction resources related to earthen construction has grown significantly. Because worldwide research and development work contunue. Scientific articles about earthen construction as a written resouces now appear in leading international journals.

Earthen construction has undoubtedly played a much wider and, arguably, a more significant role than concrete concrete construction.

The oldest, still widely adopted in many countries, uses solar heat to dry and harden earth.Raw earth has many virtues and advantages, in particular in terms of energy saving and ecology.Most varieties of soils can be adopted if they include appropriate granular substances: pebbles, shingle, sand, silt and clay. The three most common for load-bearing masonry are adobe, rammed earth used generally to construct monolithic walls, and its variant used without formwork[4]

The raw material of earthen construction is usually sub-soil material sourced locally and mixed together with water. These material is mixed occasionally other materials such as straw or animal dung.

This mixing provide to form materials ranging from sun-dried mud blocks (adobe), compacted rammed earth, moulded cob. Therefore, with this mixing material decorative plasters is applied to building facade.

Earth is most commonly used where other traditional materials, such as timber and stone, are not available or affordable. Consequently, earthen construction is often seen as primitive and is imagined associated with poverty.

However, there are many celebrated civilisations that are used earthen material such as ancient Egyptian pyramids, large sections of the Great Wall of China, the Alhambra Palace in Granada and the Great Mosque in Djenne, Mali. These buildings are the world's greatest structures and remain to this day.

A number of countries around the world now have national standards or design guidelines about earthen construction. Because some historic buildings needs conserve as authentically approach.

For this reason, the modern techniques devoloped for earthen construction can often find its origins and can be applied to historic buildings aimed conserve. Today, traditional techniques of earthen structures have been relearnt and provided stimulus for new-build applications for today and future. One of them of this developments, is in the search for lower energy (and carbon dioxide) alternatives. Consequently, materials practitioners and researchers have increasingly returned to earthen construction over the past 40 years.

2. ANALYZING THE IDEOLOGY COMPONENT

In earthen architecture, theaccessibility to a good earth material to build homes in very importantant components. Fort his reason, the choice of the location is based mainly on the water criterion. (Figure 1).

Figure 2. Ouarzazate, morocco, North Africa (most of these villages are settled in a given oasis near valleys) https://www. mediastorehouse.com

2.1. UNDERSTANDING THE ARCHITECTURAL CONCEPT OF THE MUD HOUSE AS A LIFE-STYLE

This earthen architectural settlements related with the mentality, culture and traditions of location. This life-style has always been a faith and a code of life and guides a specific life-style that we can easily read outside and inside houses. The founding principles of earthen architecture were basically derived from society's code of life.

- Privacy / Modesty: Narrow streets that enhance the private space are characterictic of earthen architecture. At the same time, central patios which represent "the outside into the inside" represents same idea. (Figure 3,4).


Figure 3. Marrakech arches, Old architecture, Morocco; Figure 4.Morocco 's narraw street (http:// morocco+street+earthen+architecture)

-Respect: Basically, the earthen architecture traces its limits and boundaries. All residential units multiply spontaneously according to community rules and within a total neighborhood respect (Figure 5).


Figure 5. Limits and boundaries of earthen architecture((http://morocco+street+earthen+architecture)

2.2. EXPLAINING AUTHENTICITY FOUNDATIONS OF THE COMMUNITY

The authenticity of this architecture remains in perfect harmony between a belief based on the principles of unity and modesty. This approach is a real sustainability in terms of architectural style as well as of community life.

2.3. REVIEWING THE FUNCTIONAL AND FORMAL IMAGE OF EARTH HOUSES

-Union / Centrality: Earthen architecture houses are built one next to another because of in gathering spaces with a minimum of space connection. This architecture is constructed next to central points that represent functional landmarks like the mosque or the well (Figure 6).

Figure 6. Functional landmarks of earthen architecture

3. ANALYZING THE TECHNICAL COMPONENTS

The analyzing the technical component is important issue as to understanding the architectural concept of the earth house, understanding traditional earth construction techniques and thinking,

One of them of techical components is aimed to take preservation measures for earthen architecture.Over the last years, significant efforts have been made in developing earthen architecture through preservation measures.

This progress made this construction sustainable. At the same time, this progress could be inter-linked in many ways to the approach of reintroducing earthen construction and continuity of this construction method. As a tradtional legacy, the tradition of building with earth facilitates promote this important architectural technicality and inspires its future use.

Technically and concerning the urban plan, the compactness of earthen village houses has ideally the requirement of eco-design. Changing economic conditions and shortage of energy must lead to a new evaluation of this historic buisling material. Only 20 years ago, adobe construction was dismissed as impartial or undesirable, because of the belief that it could be used by the very rich or the very poor. However, today, it is taken seriously and accepted as a logical building medium. It must again assume its place as an important, energy efficient building material[5]

This approach, compactness and the qualities of earthen architecture are effective eco-design, and which is necessary for reducing the heat losses in the building. there is a central open patio that acts as a skylight, as a thermal regulator, and which also ensures great ventilation for all interior spaces [6].(Figure 7,8)

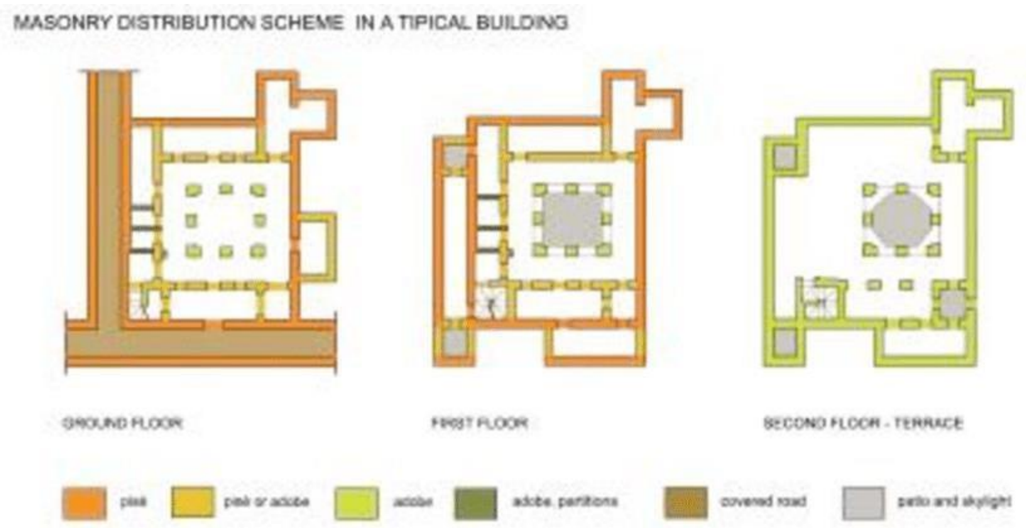

Figure 7. Earthen house typology (http:// morocco+house+earthen+architecture)

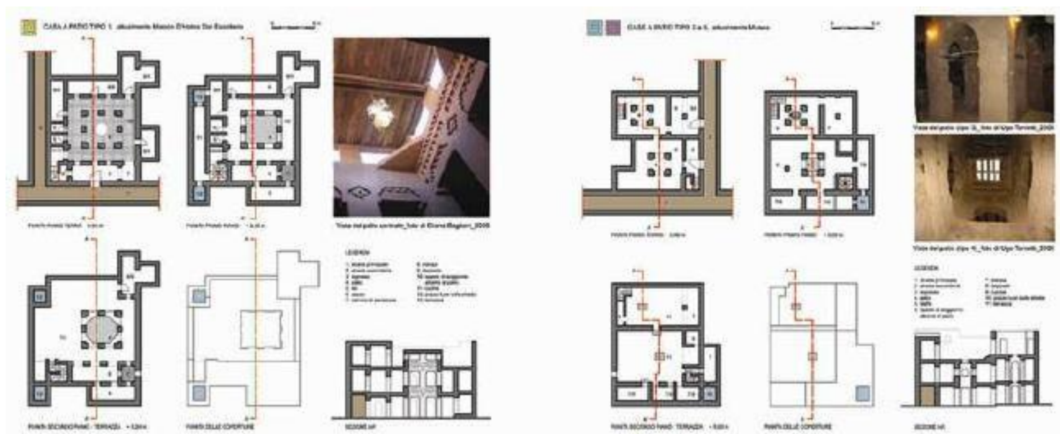

Figure 8. Earthen house typology- inner space (http:// morocco+house+earthen+architecture)

In addition to the design quality of this style of architecture, the characteristic of mud walls grant soundproofing, struggle against heat losses and gives real comfort even in bad climatic site conditions.

The characterics of this material that is 100% recyclable material is a renewable resource with a big potential to be reused without limits. At the same time, earten constructions have therapeutic caharacteric, It is worth mentioning that an earthen construction uses only 3 % of the energy used in modern construction.

In all its forms of earthen construction, it is convenient material during the life-cycle of the building.

The disadvantages of tha material such as low resistance to rain, earthquake, and thermal bridges can easily be treated for a low cost(7). It must not forgotten that in this proces that resistance to rain can be achieved through additives or via a periodical maintenance done by the inhabitants themselves quicly.

The earth material alone, is not an excellent material against great earthquakes because it is not a high pressure resistant material. It has however many high mechanical properties such as a certain deformability under compressive stress and shear. Consequently, earth becomes an interesting earthquake material. Practically, if we want to build in the ground in seismic regions, it is possible to combine it with another material resistant to tension like wood. [8]

But still, earthen material in its various forms and techniques is an excellent sustainable material and respects the environment. It has strong aesthetic value.

CONCLUSION

No matter how much considered that, soil construction often considers it substandard. However, adapting and improving the land structure is important conservation of soil surface. In contrary to these critics, It is the dual act of simultaneously "building with the natives" and "building for oneself".

This approach show that historically some traditional cultures have been how environmentally conscious. Especially the necessity of technically adept is seen this construction. This cultural world tradition has social codes ideologically deep and brings a new dimension to "living"

With some notable exceptions, there are a lack of reliable information about the future uses of this natural resource as a locally sourced and ecologically sustainable building material. Remedying this missing knowledge would allow a wide range of architectures to be built in situ, in both emerging and industrialised countries.

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9- From a Local to A Sustainable Building Technology; TheFuture of Adobe in North Cyprus

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ABSTRACT

It is known that small island developing states have vulnerable economies which are dependent on a narrow resource base and on international trade without the means of influencing the terms of that trade.[1] The island of Cyprus lies within the classification range for small island developing states[2] and hence has a vulnerable economy; a difficult situation which has worsened due to the additional negative impact of the Covid-19 pandemic. It has thus become more apparent than before that the island needs to develop strategies and policies for being sufficient in its basic needs such as food and shelter if it plans to have a more secure future. This paper is based on the premise that the conjecture is now right for pushing forward more systematically for the revival of the local adobe building technology which could in turn provide the islanders for self-sufficiency in their basic shelter requirements. Towards this end, the paper attempts to assess the current state of adobe building in North Cyprus and suggest a way forward for its popularization as a major building technology for homes.

Keywords: Adobe, North Cyprus, sustainable, local building technology, revival

1. INTRODUCTION

The adobe building technology has been practiced in Cyprus for thousands of years providing the islanders with a healthy indoor living environment; protecting them from heat in summer, maintaining warm inside temperatures in winter and regulating humidity levels in all seasons. Nevertheless, since the advent of the reinforced concrete construction technology and its popularization on the island, as in the rest of the world, the adobe building technology has been practiced less in Cyprus and may be on the verge of disappearing altogether. A series of interviews were conducted as part of the research for this paper which indicated that there is an apparent recent and growing interest on the island in this local building technology but there are also significant obstacles to its revival on a large scale as well as an absence of any organized effort to facilitate its popularization.

2. THE MULTIFACETED WORLD OF ADOBE IN NORTH CYPRUS

2.1. RISING INTEREST IN THE COMMUNITY

The various generations involved in driving this change seem to be based on different motivations.

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[1] United Nations (UN), *Global Conference on the Sustainable Development of Small Island Developing States,* United Nations, 1994, 3.
[2] Brookfield H. C., 'An Approach to Islands', in *Sustainable Development and Environmental Management of Small Islands,* eds. D'Ayala P. And Hein P., UNESCO, Paris, 13. North Cyprus's size surpasses Brookfield's somewhat "arbitrary" definition of small and hence is considered close enough to be classified as a small island.

The various generations involved in driving this change seem to be based on different motivations. The older generation who has at some point in their lives lived in an adobe building in Cyprus remembers the positive indoor environment they experienced; their motivation derives from lived experience and is hence mostly visceral in nature. The younger generation's motivations seem more ideological involving the search for a more ecological lifestyle and a reaction perhaps against a consumer society that has caused and continues to cause alarming climate change in the world. Regardless of the generation concerned however, there seems to be little or no dispute amongst the people regarding the ecological sustainability of adobe.

2.2. ENVIRONMENTAL IMPACT & HEALTH

In fact, a study conducted by the author herself in 1996,[3] compared the environmental impact of an adobe house to that of a reinforced concrete house of the same size within the context of North Cyprus and found out, based on the methodology of "a cradle-to-grave" materials analysis[4] that the concrete house used 84m3 more of local non-renewable rock-based materials,[5] consumed 24 times more energy,[6] and used 39% less labor.[7] While the local adobe technology is clearly much more environment friendly and would score well on any LEED or BREEAM evaluation scheme[8], there is also no disagreement about the superior indoor air quality that an adobe building provides for based on the older generation of islanders' experience in these buildings. The major obstacles to its revival on the island are primarily economic and social in nature confirming the validity of the three-tiered sustainability concept.[9]

2.3. LABOR

Traditional adobe building is a labor-intensive building activity and not only are labor costs high but the skilled labor required to build in adobe is also scarce. The older generation who knew this local building technology is passing away with each year gone by, which means that less of this local knowledge will be available to future generations. Tunç Adanır, present Director of the Cyprus Turkish Association of Architects and Engineers,[10] notes, regarding the restoration and renovation projects he is currently carrying out within historic Walled Nicosia, that the only

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[3] Atun, B., *The Appropriateness of a Construction Technology for Making Houses in North Cyprus (Master's Thesis),* 1996.
[4] Fordham, M., *Environmental Design for Architects,* Alden Press, Oxford, 1996, 80.
[5] The 84 m3 figure assumed a cement coating on the adobe, a common practice but one that is an inappropriate later evolution of the traditional lime mortar coating. If the coating is to be taken as lime mortar instead this figure would be even larger.
[6] The 24 times more energy figure does not take into account the energy savings that an adobe house would have compared to a reinforced concrete house and hence if this were also taken into account the figure would be much larger. The insulating properties of adobe walls are well documented in numbers in various academic studies. In the interview conducted with architect Metin Bilgiç as part of the research for this paper, he talked of a chicken shed they built out of adobe where they measured the inside air temperature as 29 C when it was 43 C outside on a hot summer day in North Cyprus.
[7] The analysis for the labor expended to build the house included all labor involved including that involved in the making of concrete in a factory. Hence, while the overall labor expended in the making of a reinforced concrete house was more, the local labor expended in the making of the adobe house was more.
[8] LEED (Leadership in Energy and Environmental Design) and BREEAM (Building Research Establishment Environmental Assessment Method) are two of the many schemes architects are increasingly using to evaluate the environmental impact of buildings with internal ratings. Such schemes are used increasingly as a demonstration of the environmental ethic/responsibility of the client/architect.
[9] Sustainability is most often described as having three tiers; economic, ecological and social. It is also often emphasized that it is not possible to attain sustainability unless all three tiers are simultaneously addressed in any endeavor.
[10] This association is called Kıbrıs Türk Mühendis ve Mimar Odaları Birliği (KTMMOB) in Turkish. Their official website is https://ktmmob.org/
[11] Adanır, Tunç, Interview by author. May 13, 2022.

builder he could find was a man from Hatay, Turkey, now in his 40s, who had learned the trade as a child from his elders in the village.[11] Ismail Cemal, experienced adobe and stone builder, states that because of the scarcity and expense of this specialized knowledge in adobe building, a new adobe house is likely to cost more to build in North Cyprus than a reinforced concrete house.[12] Disagreeing with this cost comparison, architect and academician Tuğşad Tülbentçi puts forth that he expects his recent adobe house design for which he has already received building permits to cost around one forth, if not less, than the same design if it were to be built in reinforced concrete. He adds, however, that they were very lucky that the appropriate type of soil was available on the site itself, saving them considerably on the cost of mining and transporting earth from elsewhere on the island.[13]

2.4. GEOGRAPHY

Given the importance of the proximity to the site of construction of the area from which the earth is to be extracted, it appears that there is a need for a map of Cyprus indicating those areas where such soil exists; a kind of geographical adobe building map for Cyprus. While this knowledge currently exists as the local and dispersed knowledge of the elders, there is a need for it to be documented and mapped systematically as it would be needed in any organized effort to revive this building technology.[14] A technologically altered variant of traditional adobe, a mix called Alker[15] is more flexible in terms of the type of soil to be used, hence making this technology potentially more readily applicable across the island regardless of geography.

2.5. TYPE OF EARTH MIX

Academician Ayşe Pekrioğlu Balkıs who has studied the properties of Alker points out that an 8-10% clay content in the earth is sufficient for the Alker mix compared to a 40-50% clay content for traditional adobe. She notes that this mixture is an improvement over traditional adobe because the high water content absorbed by the added gypsum not only increases the strength of the wall against earthquakes but makes it also more resilient towards the damaging effects of water. The wall thickness is also reduced down to 40 cm from 50-60 cm when using this technology.[16] Builder İsmail Cemal argues, based on the remaining older examples of adobe buildings on the island including the ancient ones found in the Tatlısu archaeological excavation site,[17] that if built properly traditional adobe walls are resilient towards the damaging effects of water. He expresses his hesitation about the Alker mix noting that due to the already high water content in the wall, its capacity to act as a "humidity regulating membrane" between the outside and inside is substantially

[12] Cemal, İsmail, Interview by author. May 11, 2022.
[13] Tülbentçi, Tuğşad, Interview by author. May 10, 2022.
[14] Regarding the availability of the right kind of earth for adobe building Ismail Cemal notes that there are two places in Kilitkaya, one place in Yedikonuk, one place in Büyükkonuk (all three are in the Karpasia Peninsula area) and the general Mesaoria Plain where it is most common. Nevertheless, a more systematic and detailed survey needs to be conducted covering the entire island.
[15] Işık, B. & Tülbentçi, T., 'Sustainable housing in island conditions using Alker-gypsum-stabilized earth: A case study from northern Cyprus', *Building and Environment*, 43, 1426-1432, 2007. Alker, which was developed at İTÜ as a research project by Ruhi Kafesçioğlu in 1980 is a mix of earth with an approximate 8% clay content added to which there is 2% lime, 10% gypsum, and 20-22% water (depending upon the method of building, rammed earth versus clay bricks) by dry weight of earth.
[16] Balkıs, Ayşe Pekrioğlu, Interview by author. May 13, 2022.
[17] Şevketoğlu, M., 'Early settlements and procurement of raw materials -New evidence based on research at Akanthou-Arkosykos (Tatlısu -Çiftlikdüzü), Northern Cyprus', *TÜBA-AR XI*, 63-72, 2008. The Neolithic site in the Northern coast of Cyprus currently being excavated has already re-dated the first settlement in Cyprus to around 8000 B.C., earlier than the well-known Khirokitia UNESCO World Heritage Site on the island. In this excavation, remains of the foundations and wall bases of six mud-brick buildings were found, further illustrating the presence of this local building technology on the island.

reduced as it is capable of absorbing less. This means, he argues, that the best characteristic of adobe walls, their breathability, is also decreased with the Alker mix. Both assessments about Alker are based on the same scientific principles and as such not necessarily contradictory in nature. Nevertheless, there does appear to be a difference in opinion about which characteristic of the wall is most important and what level of breathability is good enough vis a vis the indoor air quality of a building.

2.6. COMMUNITY

Such disagreements as the one above are more in degree than in kind and highlight the need for a holistic approach to the revival of adobe as many factors are involved and affected by each proposed alternative and variant of the technology. For example, while it is possible to apply Alker as rammed earth saving on labor costs, the making of traditional adobe involves more laborand related costs as each brick is made and laid separately on site. Nonetheless, the traditional adobe technology also provides for social cohesion, a sense of community and a sensual connection with the building process through its hand-based approach, akin perhaps to the citta slow and slow food movements which prioritize experience over results. When adobe buildings were built in Cyprus in the past they were built as the collaborative effort of the community, a method referred to as "imece"[18] in Turkish. Ismail Cemal talks of the feeling of community, helping each other and excitement that he experienced when building in adobe with his village community; an act that was part of daily life as opposed to the specialized professional domain ofthe building industry.[19] This "lived" aspect of traditional adobe building is worth reviving as it isa significant intangible cultural heritage of the island, an activity which simultaneously cementedcommunity bonds. Protecting this aspect of the building technology can help re-instill in the islanders a sense of respect for the limited financial and ecological resources of the island.

2.7. HANDS-ON ENGAGEMENT

The culture that collaboratively built adobe homes is no longer available, neither is the free labor associated with it. While it is unrealistic to expect the same social structure to re-emerge in Cyprus, this does not mean that another kind of collaborative culture is not possible. The Taliesin Fellowship established by Frank Lloyd Wright in 1932 comes to mind as a visionary organizationthat trained young architects to learn the profession through the hands-on collaborative activity ofbuilding.[20] Frank Lloyd Wright's vision may seem extreme to us now but in any case, the need for young architects to have hands-on experience in building is one that is increasingly being voiced by Schools of Architecture around the world. Tunç Adanır points out that more practical training in adobe building needs to be given to architecture students in Cyprus who will subsequently lean more towards designing with this technology because it will be more familiar to them.[21] Currently, architecture students graduate mostly unfamiliar with this local technology because Schools of Architecture teach design based on an a priori assumption that reinforced concrete is the building technology to be used. North Cyprus has many universities most of whichhave Departments of Architecture and hence there is a potential student population that can be re-

[18] "İmece", a Turkish Word means the performance of work for the community by the whole village.
[19] Cemal, İsmail. Interview by author. May 11, 2022. Ismail Cemal's description of the building process is also reflective of the "lived" nature of this intangible heritage. For example, in describing the appropriate clay content of the earth, for example, he does not use percentages as academicians do but notes instead, that if the clay content is too little the adobe wall will disintegrate and not hold together and if it is too much it will crack after drying. Likewise, when describing the earth type for the roof an adobe building he says that it needs to be "slippery" enough such that the water falling on it will "slide off" its edge as opposed to being absorbed by it.
[20] For a history of the Taliesin School of Architecture visit their website https://tsoa.edu/our-history/
[21] Adanır, Tunç, Interview by author. May 13, 2022.

directed to become part of a collaborative hands-on learning initiative in the local adobe building technology.

2.8. BUILDING CODES

While the economic and social dimensions involved in the revival of the local adobe technology will require substantial and coordinated planning, there is an additional obstacle to its revival that is more technical in nature; namely the restrictive nature of the building codes in North Cyprus as applied to adobe. Currently, due to the lack of any standards for the strength of adobe, calculations routinely done by structural engineers for load bearing structures cannot be done for adobe buildings. The building codes compensate for this lack of information by applying instead extra restrictive codes for adobe buildings so that their strength against earthquakes are guaranteed. For example, only one story buildings are allowed in adobe while up to four stories are possible in other load bearing structures. Furthermore, adobe building heights are restricted to 2.70 meters on the ground floor and 2.4 meters in the basement while unsupported wall lengths are restricted to 4.5 meters compared to an otherwise possible 7.5 meters in other load-bearing structures.[22] Besides these structural issues having to do with ascertaining the safety of an adobe building, the electrical building codes are also restrictive and even problematic as they require all wiring to be enclosed within the wall itself; an impractical proposition in so far as adobe walls are concerned. Another code-related current disadvantage of adobe building in North Cyprus is related to the allowable square meter area. In a typical suburb where two stories are allowed for homes,[23] the maximum allowable area is split amongst the two floors allowing only half of this area to be used on the ground floor. Given the one story restriction of adobe buildings, this means in practice thatthe allowable built area for an adobe building is automatically reduced to half. Moreover, traditional adobe walls are thick, around 50 cm, and this thickness is included in the calculation ofthe allowable square meter area, further reducing the livable space of an adobe building.

3. CHARTING A WAY FORWARD IN THE EVOLUTION OF ADOBE

3.1. STANDARDIZATION

If and when the building of adobe bricks becomes standardized, it will be possible for structural engineers and architects to design based on routine calculations done for other load bearing structures, enabling in this way more freedom in design. An entrepreneurial initiative by architect Metin Bilgiç may lead to such standardization. He hopes that the factory he is building with its 11 different adobe brick modules will help speed the uptake of the adobe building technology by standardizing the qualities of the adobe bricks produced, in the meantime also reducing the labor required to build in adobe. He notes that he is getting all of his brick modules tested for their compressive and tensile strength and hopes to be selling them in the market soon. Such future standardization may facilitate the larger scale use of adobe in North Cyprus.

3.2. EDUCATION

When the interviewees were asked how they thought it would be possible to popularize this technology in North Cyprus, they all agreed that educating the public at large as well as architects, engineers and builders about this local building technology was critical. There was also agreement that a shift in attitude was necessary, which could be facilitated through more built examples of

[22] KKTC Deprem Bölgelerinde Yapılacak Binalar Hakkında Yönetmelik 2015, 5. Bölüm Yığma Binalar, pp.90-101. Further restrictions to adobe involve other spans such as distance between openings, height of openings and so on.
[23] The two story building code stipulation was put into effect to leave more green area on a given site in the suburbs.

adobe buildings that cater to contemporary aesthetic sensibilities. Tuğşad Tülbentçi noted that he believed people understood the advantages of adobe but the more critical issue was that they were not convinced about its strength, hence clear demonstrations of its safety were needed.[24]

3.3. GOVERNMENT SUBSIDY

Should there be a hike in demand for adobe in the future, İsmail Cemal noted that there would arise the need for more skilled adobe builders, already a rare resource in North Cyprus. He also stated the need for an enabling financial environment in the form of government subsidies.[25] Reflecting a similar point of view present Director of the Board of Architects Kozan Uzunoğlu noted that unless the government got involved and created a demand for this local building technology, it would be difficult to kick start its revival. He noted that in such a scenario the Social Housing Unit of the Ministry of Interior could become a key stakeholder. [26] Cemal Serpek who has been working as a structural engineer in this unit since 1994 noted that they have built, up to date, more than 10,000 social housing units in North Cyprus but have not built any since 1997 because it was financially not sustainable to keep building them. He noted that there is no obstacle to building social housing units in adobe, the critical factor being workable financial and mortgage packages that will accompany any proposal to build wholescale in this technology.[27] The current social housing initiative of the Ministry of Interior where free land is given to needy youth in the suburbs for the purpose of building homes has the potential, as noted by Kozan Uzunoğlu, to kick start adobe building on the island on a larger scale.[28]

3.4. A HOLISTIC APPROACH

While there is an obvious need for a systemic approach to the issue of the revival of adobe involving the input of skilled adobe builders, architects, engineers, students, the government and local communities woven into an ecosystem that is beneficial for the livelihood of all islanders and considers all affected areas of life, further and extensive research is necessary for such a linked structure to be imagined and outlined. It is only through such holistic planning that the evolution of the local adobe building technology into a contemporary sustainable building technology will be possible. Nevertheless, there are some steps that can be easily taken in the meantime.

CONCLUSION

Some Initial Steps

As a first step, building codes could change in the suburbs to enable all the allowable square meter of a home in a two-story building to be used on the ground floor if a building is built in adobe. Such a simple legislative change would immediately remove the allowable area disadvantage this local technology currently has. This change would also increase the roof area of these homes providing an increased area to place solar panels sufficient for the entire energy requirement of such a home. This simple code change has the potential to begin shifting the perception of adobe homes into self-sufficient homes where the pleasures of one level living are explored in the landscape of Cyprus.

Simultaneously, cost comparisons between various versions of adobe and reinforced concrete could

[24] Tülbentçi, Tuğşad, Interview by author. May 10, 2022.
[25] Cemal, İsmail, Interview by author. May 11, 2022.
[26] Uzunoğlu, Kozan, Interview by author. May 8, 2022.
[27] Serpek, Cemal, Interview by author. May 13, 2022.
[28] Uzunoğlu, Kozan, Interview by author. May 8, 2022.

be carried out demonstrating in a clear and comprehensive way the differences between them. Any such cost analysis would need to also account for the energy expenditure of the different building technologies over their life time to account for the substantial savings that an adobe house will give its owner. Understanding the economics of building in adobe is crucial for its uptake as a major building technology as it is the only way people will be able to make choices that are appropriate to their circumstances.

Such steps as outlined above may be enough to speed up the process of exploration and experimentation in adobe building on the island creating a ripple effect for more research to be conducted in this area. Various versions of adobe building may simultaneously exist on the island enabling choices to be made based on economic, social, ideological and aesthetic preferences. In fact, the more these choices are the better the chances are that adobe will be appealing to larger sections of the population and experimentation in this area will increase. The objective of self-sufficiency and a greener society in North Cyprus, facilitated by adobe building, is a challenging one. It will only be through the combination of a sustained interest in the topic, an enabling financial environment and the accumulation of incremental positive steps taken, accompanied by more research and exploration into adobe building, that a holistic vision for a way forward will emerge over time through the collaboration and contribution of all parties involved.

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10- Drawing Connections to Archaeological Context: New Mudbrick / *Kerpiç* Designs for Tayinat / Kunulua on theAmuq Plain

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ABSTRACT

A 7th semester interdisciplinary architectural design studio at the Architecture Department of Mustafa Kemal University in Hatay brought together an architect, an urban designer and an archaeologist with architecture students. The project enabled the students to explore the archaeological site of Tell Tayinat on the Amuq Plain from different angles in order to create contemporary designs, aimed at research, preservation and presentation of the ancient site, while drawing inspiration from its historic context. Students determined the challenges that Tayinat presented as an archaeological setting for contemporary designs. They observed characteristics of mudbrick and addressed a variety of associated functional, logistic, topographical, climatic and protective requirements in their projects. Not all designs utilized mudbrick. Some preferred other natural materials, such as wood, though these designs could also be transformed into mudbrick. Those that relied on the vernacular focused on traditional mudbrick technology and were challenged by natural limitations, such as durability, strength and size. Others combined contemporary construction techniques with mudbrick, where mudbrick functioned only aesthetically as a finishing material, or utilized contemporary mudbrick technologies in accordance with current construction and spatial needs. Students explored uses and technologies of mudbrick at the site and elsewhere, addressing issues of climate-control and eco-friendliness, and scrutinizing the adaptability of contemporary designs to archaeological contexts. The results of this elective design studio, which presented the students with the challenges of an archaeological context, also provided on-site experience and research-by-design & design-by-research anddefined their experience in architectural learning. The variety in projects and results generated discourse and should be emphasized as it paved the way for addressing similar dynamics also found at other sites.

Keywords: Tayinat, Antakya, *kerpiç*/mudbrick, research-by-design, architectural design in archaeological context

1. INTRODUCTION

1.1. PROJECT TAYİNAT

Project Tayinat was an elective design studio in the 7th semester of the undergraduate programme in architecture, which aimed at introducing contemporary architectural design into an archaeological site. The archaeological and architectural heritage context of the site, as well as its landscape, were initially discussed as a source for inspiration in terms of concept, function, morphology, materials and technology to be associated with students' designs. The cultural landscape, generated through human-nature interaction in the past, was further enriched through the recent interaction of archaeologists, researchers and visitors, creating yet another layer of experience. Understanding the daily-life at the site and its urban-architectural morphology in the past and their reflections at the present formed an intriguing design problem: Some of the proposed functions included, but did not limit themselves to the needs of the current archaeological researchers and the visitors, thus not focusing entirely on the presentation and the preservation of architectural remains at the site. The prominence of the höyük in the landscape of the Amuq Plain, and especially on the historical route connecting Antakya with Aleppo, which continues to function in present day, was also a matter of consideration in design, in addition to its close distance to the current river bed of the Orontes (Asi) River. The design was to be an experimental building. Participants in the studio had the opportunity to adapt and experiment with old and new building technologies and materials. Kerpiç/mudbrick proved to be the most inspirational architectural element in all design projects of the students.

1.2. CONSTRUCTING A CHALLENGING INTERDISCIPLINARY FRAMEWORK

The archaeological site acts as a field library for architects and urbanists, where archaeologists become the librarians. Collaboration between an architect, an urban designer and an archaeologist creates a challenging interdisciplinary framework, opening up creative discussions on time and context. Project Tayinat opened up new perspectives of research for all its participants, both students and instructors, as this paper presents.

The course of the Project Tayinat presented opportunities for architects and urbanists to refresh their knowledge through new discoveries about the past and then present archaeologists new research perspectives in development and preservation through contemporary design. Discoveries on past cultural elements present architects and urbanists with new design tools. Information and inspiration derived from the past expand the consciousness of the designers in terms of understanding and creativity while understanding a design process can provide archaeologists determine ways to connect the past with the present and preserve their remains for the future. An interdisciplinary framework brings productivity and creativity from different angles, as it also helps to articulate challenges and generate processes of problem-solving. Archaeological research, combined with urban and architectural design in an interdisciplinary context, can address needs of preservation, development and communication of historical knowledge in creative ways.

2. THE RATIONALE

2.1. TELL TAYİNAT'S HİSTORİCAL BACKGROUND

Tell Tayinat functioned as major regional centre in the Early Bronze Age and the Iron Age, in the 4th and the 1st millennia BCE, respectively. Occupation moved during the Middle and Late Bronze Ages to neighbouring Tell Atchana, located about 800m southeast of Tayinat, also known from textual sources as the capital Alalakh of the kingdom of Mukish. The underlying reason of this movement appears to be the Orontes River, which changed its course numerous times on the Amuq Plain throughout history. [1, 2]

Identified as Kunulua, the capital of the Iron Age Syro-Hittite kingdom of Unqi/Patina [1, 2], Tayinat became famous with the discovery of the massive basalt statue of the Iron Age King Suppiluliuma in 2012. The ancient statue recently evolved into a symbol of the modern city of Antakya. The statue of Suppiluliuma, along with other monumental discoveries of stone, stand against the kerpiç/mudbrick architecture of this impressive ancient site on the Amuq Plain, forming an interesting juxtaposition of durability between stone and mudbrick. In order to simplify the context, the participants were asked to concentrate on the Upper City and the Syro-Hittite layer from early Iron Age, which contains the Temples II and XVI, the Royal Palace and the city walls and gates, the urban layout of which was clearer and easier to understand, rather than the remains that date to the Early Bronze Age. (Fig. 1)

The Oriental Institute of the University of Chicago had conducted excavations at Tell Tayinat between 1935 and 1938, while Sir Leonard Woolley, the excavator also of Ur and Carchemish, directed excavations on Atchana before and after World War II. Robert Braidwood, often cited as the inspiration for the movie character Indiana Jones, also conducted major systematic surveys on the Amuq Plain, setting the stage both for the future of archaeological survey techniques and for the regional chronological frameworks determined on the basis of pottery remains. [1, 2, 3] Current excavations were initiated as part of the Tayinat Archaeological Project by Timothy Harrison from the University of Toronto in 2004 following a series of regional surveys on the Amuq Plain and continue to this day.

2.2. THE DESIGN PROBLEM

The design problem presented to the students focuses on the fact that the project area is both a cultural heritage and an active archaeological excavation site. Archaeologists working on the site have been conducting excavations, during which precautions were taken to preserve immovable remains in situ. The studio participants were asked to select a building site on the höyük, with consideration of past, present and future excavation areas. They needed to understand how the process of archaeological research in an excavation project worked to ensure proper integration of their designs into an archaeological site. An alternative was to design a reversible and/or movable structure without underground foundations and using natural materials.

A fundamental problem identified during the studio process was the fact that the site is seldom visited by tourists or locals. Even the finding of the King Suppiluliuma statue has not been enough to increase visitor numbers or interest in the site. Many residents in the city confuse Tayinat with Atchana or do not at all know that the statue was found in Tayinat. Local, national and international tourists visiting the site are few in number even though the höyük is located on the main road from Antakya to Reyhanlı and Aleppo, only 25km from the city centre and can be reached by public transportation. A cotton ginnery that is constructed on top the archaeological site veils visual contact from the main road while obscuring the Assyrian Governor's Palace, which was excavated in 1930's. Similarly, a modern cemetery obscures the ancient city walls and ancient gates next to the main road.

Last but not the least, the students were asked to reflect on the interdisciplinary and innovative nature of archaeological research in their designs, generating a cognitive learning environment, like a living research lab that brings concerns of the specialists with those of the students, which could also be observed by the visitors. The aim was to generate a place for improved interactive and interdisciplinary learning as well as producing an authentic life experience. The expected final results could be more clearly described with the following examples: Paolo Solari's built vision and concept of "arcology" in Arcosanti in the middle of Arizona Dessert, which itself an experiment in 1960's on the combination of ecology and architecture [4], and the archaeological complex of the Karatepe-Aslantaş Open-Air Museum, yet another Syro-Hittite centre in Osmaniye on the north of the Belen Pass, designed by Franco Minissi and Turgut Cansever, and built by renowned archaeologist Halet Çambel, who also conducted research on the site, and her husband, Nail Çakırhan in 1957-1961. [5]

Design ideas were expected to lead the students to generate work far beyond receiving inspiration from authentic architecture. During the studio classes, the instructors invested effort more on the design concept than on the form, the program and the details of the projects. The instructors drew particular attention to three characteristic design elements of ancient architecture: The formation of ritualistic L-shaped movement pattern (processional route) in urban design (Fig. 1), the use of kerpiç/mudbrick in construction and the placement of orthostats on public architecture.

The process of interactive thinking was supported through presentations by the studio instructors: Berk Kesim focused on urban form and the significance or the spirit of place. Nilüfer Baturayoğlu Yöney focused on architectural design in different historic contexts and Elif Denel focused on the history and understanding of the urban form, architecture and daily life at Tayinat and at other contemporaneous sites. A guest speaker, architect Sinan Omacan of Atölye Mimarlık, İstanbul, presented his work on preservation and presentation strategies at different archaeological sites in Turkey and answered students' questions on context and specific requirements. In addition two field trips were organized, one to the Hatay Archaeology Museum to look at the finds and to collect information about the site, and the other to Tell Tayinat to observe the site and its environment.

2.3. URBAN MOVEMENT IN THE UPPER CITY

An L-shaped procession route is observed in the heavily damaged central part of the upper city, connecting the East Gate to the area south of the Temple XVI in a processional progression and culminating in the public space where the statue of Suppiluliuma and other monumental works of art were originally located. [1, 2] This area seems to have acted as a focal point in terms of urban design. (Fig. 1) Similar L-shaped ceremonial paths are recognized also at such contemporaneous sites as Carchemish. [6] The revival or repetition of movement, which culminates with a staircase at Temple XVI, was proposed as an inspirational beginning point for understanding and presenting the ancient city. Architectural and urban history literature generally draws attention to linear paths in terms of ritual processions or circular ceremonial paths around special buildings. However, archaeological literature depicts behavioural patterns based on different morphologies as well [7].

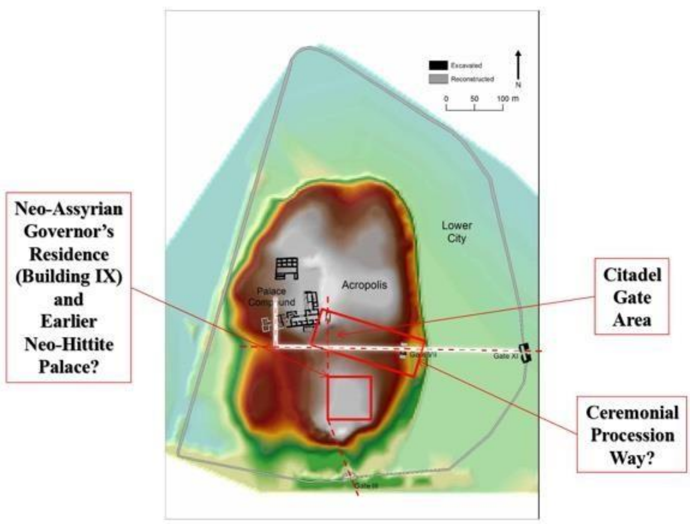

Figure 1. L-shaped Procession Route. Modified from Harrison, T. P., Denel, E., p.152, 2017 [8]

2.4. MUD, KERPIÇ/MUDBRICK AND ORTHOSTATS

Mud is one of the first and most widely used building materials in the world. The earliest examples of human settlements in the ancient Near East provide evidence for the use of mud as a binder and a finish as well as in the production of mudbrick and baked/fired bricks. Stone appears to be preferred where it was easily available, though brick stands out as the most important building material in Mesopotamia, where stone was scarce. [9] In addition to wattle-and-daub, mudbrick as a building material provided more elaborate, mass produced and processed techniques for public, ceremonial and residential architecture alike.

The extensive use of kerpiç/mudbrick in large cities, and the limited durability of the material against the effects of weathering, appear to be among the practical reasons for the introduction orthostats in urban areas. Orthostats not only protected the lower parts of mudbrick walls against water and weathering, but also formed a unified surface with the stone façades surrounding public open spaces, such as city streets and squares. As such, they eventually generated an additional opportunity in symbolic representation with artistic depictions of symbols and narratives that could be displayed on them. The in situ orthostats at Carchemish along the Processional Way and lining the side of the Monumental Staircase form some of the best-known examples of Iron Age architecture. The Iron Age limestone orthostats from Tayinat, now in the Hatay Archaeological Museum, may well have once adorned the base of a monument in the public square extending on the south of Temple XVI. Similarly, orthostats lined gates that controlled passage between distinct areas of cities at this time, marking them as distinctively liminal zones, defining important areas of settlement centres and controlling access. Such examples are found at Carchemish, Zincirli in addition to Tell Tayinat in southeast Turkey and Tell Halaf in north Syria.

3. RESULTS

3.1. DESIGN SCENARIOS: FAILED!

The instructors pre-determined three design scenarios based on the use mudbrick. The students were asked to select a design attitude each from the perspective of an architect, an architectural preservationist or an architectural historian. The first scenario was about designing a research and visitors' centre at the archaeological site. The second, which adopted a fictional approach, suggested that site was discovered with all its inhabitants and architecture intact. The students were in charge of intervening in this isolated, hypothetical and historical cultural geography. Thethird and final scenario was about integrating a new urban and architectural design to the city as itexisted in the past, in the 9th century BCE. However, only the more realistic first scenario was selected by the students with the other two only partially attracting interest. However, this lack ofinterest was not perceived as a total failure, but was considered as a studio phase, which opened new discussions and deliberations on the lack of knowledge about the past settlement structures.

3.2. USE OF KERPIÇ/MUDBRICK IN PARTICIPANTS' DESIGN PROJECTS

Structural systems to be adapted in design projects and material choices were left to the participants, who could make decisions on the basis of the environment and the particular characteristics of the archaeological site. However, 12 out of 20 projects preferred mudbrick in establishing a relationship between their designs and its context. Guest speaker Sinan Omacan's examples of new and interpretive mudbrick designs at sites that share similar characteristics might have provided a further inspiration for the students as well. As such, the students used mudbrick in different ways.

3.2.1. TRADITIONAL USE OF KERPIÇ/MUDBRICK

The use of mudbrick with traditional production and masonry techniques was the simplest approach. However, such vernacular architectural designs were, of course, challenged by the limitations the material presented for spatial needs, durability, and strength. Meanwhile, the reversibility characteristic of the material and the possibility it presented for superficial foundations provided an advantage for construction on archaeological areas and close to excavation trenches. Similarities that emerged between modern designs and original buildings, however, formed a disadvantage in that, it was not easy to differentiate between new designs or reconstructions, and remains of the archaeological walls. Furthermore, it became difficult to resolve issues involving infrastructural needs of modern designs that were physically so closely located to original archaeological remains. Traditional mudbrick masonry was already utilized by the current archaeological team of the Tayinat Archaeological Project at the site to form sacrificial layers on the remains of the original structures, so that the remains can be protected against decay and the plans of architecture can be observed clearly by visitors [10].

3.2.2. KERPIÇ/MUDBRICK FACING

Some of the student projects preferred contemporary construction techniques, providing only an aura and feeling of mudbrick, thus using it aesthetically as a cladding. The relationship of these projects to the archaeological setting was achieved through the apparent relationship of mudbrick with the surface of the site that consists entirely of dirt. As such, these projects displayed a sense of respect towards the heritage underneath their designs. In addition, some projects designed structures that were barely touching the ground, while others consisted of mobile, temporary or reversible structures, which also displayed a sense of respect and protection towards the ancient remains below the surface of the höyük.

One group created 'a Bronze Age skyscraper' standing on a steel frame structure, which was only faced with mudbrick. The motivation of this group generated from an aim to increase the visibility of their design and the ancient site. However, the final result approached a dystopia. (Fig. 2) This group emphasized that their motivation to use mudbrick, was based on not only the fact that it was the characteristic material of the site, but also the climate- and eco-friendly properties of mudbrick.

Figure 2. Images adapted from Hatay Mustafa Kemal University, Faculty of Architecture, Department of Architecture, 2001745 Renovation and Regeneration Projects in Architectural and Archaeological Sites, 2020-2021 Fall, project by Ali Kılıç, Oğuz Baran Akkurt, Enes Önal

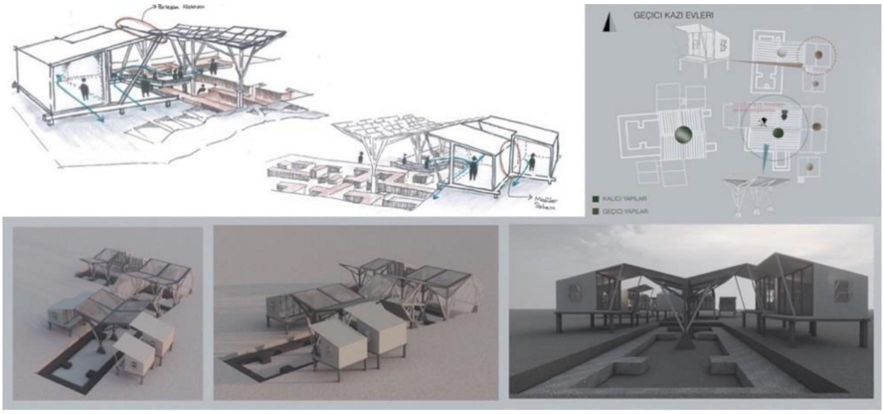

Figure 3. Images adapted from Hatay Mustafa Kemal University, Faculty of Architecture, Department of Architecture, 2001745 Renovation and Regeneration Projects in Architectural and Archaeological Sites, 2020-2021 Fall, project by Kadir İlik, Aycan Aydan, Aybike Yücel

Another group was inspired by the nature of mud itself. Mud is temporary when it is wet and permanent when it dries, always ready to be transformed. Hence, designs of this group involve removable structures, which become permanent shelters over the excavated areas when work is completed. (Fig. 3) In order to highlight the nature of 'old' that mudbrick represents at the site, this group preferred a building material, called "linit", a type of tempered u-channel glass, which is clearly 'new' and thus provides a contrasting effect for differentiating between the old and the new. Other groups also used similar approaches, but different materials. A common solution was providing a feeling of mudbrick with the use of temporary structures and other natural materials.

3.2.3 KERPIÇ/MUDBRICK ADAPTED

The projects of this group commonly preferred contemporary mudbrick technologies, such as monolithic systems produced *in-situ* or in frames and supported with modern structural systems in a response to current construction and spatial needs, while trying to adapt their designs to the characteristics of the archaeological site.

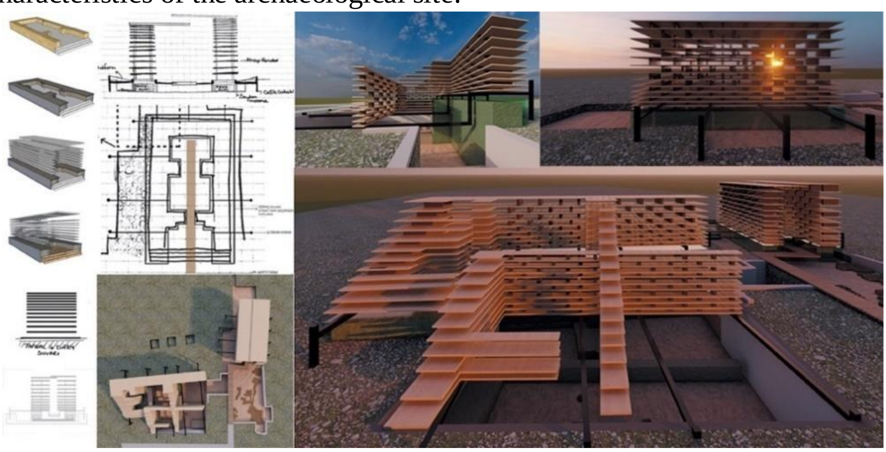

Figure 4. Images adapted from Hatay Mustafa Kemal University, Faculty of Architecture, Department of Architecture, 2001745 Renovation and Regeneration Projects in Architectural and Archaeological Sites, 2020-2021 Fall, project by Ceren Selçuk, Zeki Ünlükolukısa, Ahmet Emin Aslantaş

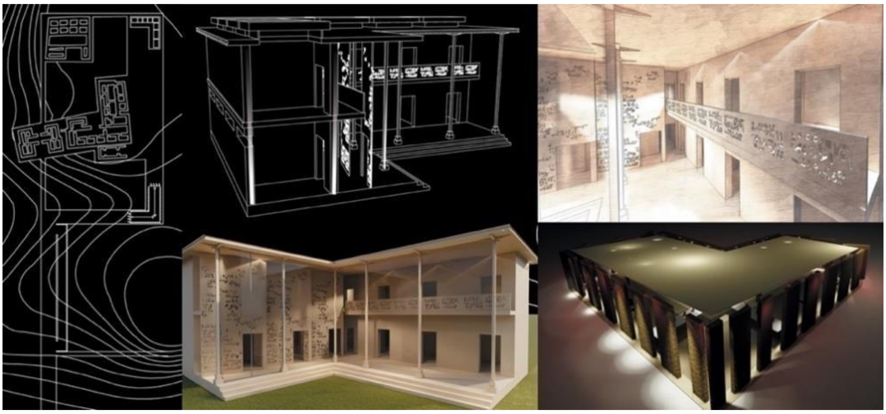

Figure 5. Images adapted from Hatay Mustafa Kemal University, Faculty of Architecture, Department of Architecture, 2001745 Conservation in Urban and Archaeological Sites, 2020-2021 Fall, project by İncinur Mutlu, Deniz Karlı, Berk Doğan

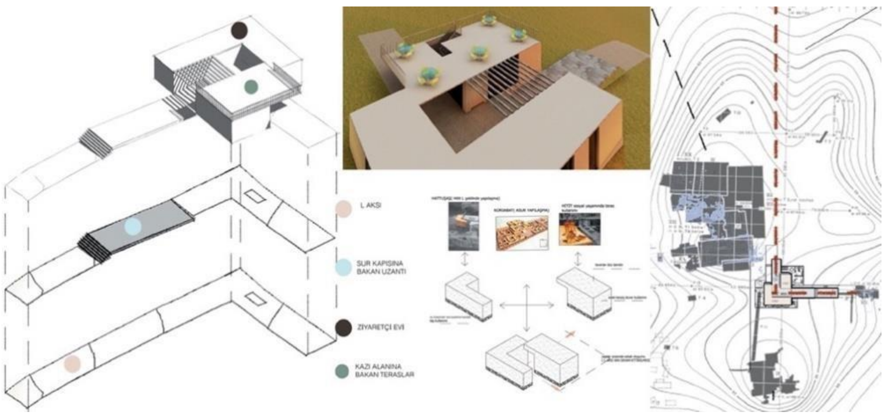

Figure 6. Images adapted from Hatay Mustafa Kemal University, Faculty of Architecture, Department of Architecture, 2001745 Renovation and Regeneration Projects in Architectural and Archaeological Sites, 2020-2021 Fall, project by Yasemin Şen, Bilge Pırıl Kavak, İbrahim Halil Tiryaki

A significant design achievement of these projects was to place emphasis on public space, re-interpreting the design of the ancient city and its buildings with emphasis on the present needs. One project attempted to interpret the volumetric perception of Temple XVI without touching the original mudbrick structure. (Fig. 4) This was an interpretation of the ancient architectural morphology achieved with a new structure built directly over the mudbrick remains, integrating the new with the old. The design became a three-dimensional installation. The sense of authentic space created inside the installation and its presence as a three-dimensional entity at the site, made the archaeological remains more visible and understandable. The design resembled adeconstructed building with a steel frame carrying wooden panels. Another project used mudbrick in a contemporary structural system as non-load-bearing infill walls, making it possible to meet the spatial needs for contemporary design while integrating it with the heritage site. (Fig.5) The morphology meanwhile presented re-interpretations of the architectures of the Royal Palace, the megaron (or deep/narrow-house) form of the temples and the L-shaped route. A third project presented a combination of the two previous examples in adapting and designing the building directly as a part of the L-shaped route. (Fig. 6) The different spatial combinations of Iron Age architecture are used to produce a contemporary building at the intersection of the L. The design also reincorporates the idea of using orthostats, and creates a new public space.

CONCLUSION

In general, the studio achieved its aim of introducing last year architecture students to designing in an alternative and challenging context. The archaeological site of Tell Tayinat with its urban and architectural heritage, and the aura of ongoing archaeological research, provided inspiration and challenge necessary for educational problem solving for architecture students. Both the instructors and the participants operated in an interdisciplinary and interactive learning environment, with some on-site experience and through research-by-design & design-by-research approaches. The results of the studio, presented in thematic groups above, reflect the main points generating from both inspiration and interpretation. As the authentic material in architecture, kerpiç/mudbrick became one of the focal points of design, addressing a variety of functional, logistic, topographical, climatic and protective elements in all projects. Not all designs utilized mudbrick while those that relied on mudbrick, did so from different perspectives and approaches. Students explored mudbrick uses and technologies at the site and elsewhere, discussing issues of climate-control and eco-friendliness, and scrutinizing the adaptability of contemporary designs to archaeological contexts. The variety of projects and results generated multi-levelled interdisciplinary discourse and, interestingly, paved the way for addressing similar dynamics also at other sites.

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11- Re-Thinking Earthen Architecture for SustainableDevelopment, VAN Field Project

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ABSTRACT

Earthen architecture is carrying knowledge from the history of mankind, as it is mostly used construction material. Living in earthen buildings is healthy. Indoor climate can be established with physical and mechanical property of earthen material. As a result, heating and cooling energy demand, up to the geographic living area, is minimized or not used. Today, demand for adobe structure can be identify in three ways: health living, little money for energy usage, 0-energy usage for sustainable environment. With the rise of global population and epidemic effect in recent years demand for widespread settlement gained importance. There is a need for re-thinking of earthen architecture: material durability, earthquake safety of loadbearing earthen walls, industrialized construction techniques. General usage of earthen material is for masonry or loadbearing structures. This study will summarize the findings on: *zero energy earthen buildings, *learning from earthen architecture heritage, *development strategy on earthen construction. With the field project in VAN province, the study will contribute for the demand on legal and administrative process using earthen architecture.

Keywords: Earthen Architecture, Zero Energy Buildings, Learning from Heritage, Development strategy, Development Strategy, Collaboration

1. INTRODUCTION

Architecture is carrying the knowledge from history and give definition for culture (Figure.1.1 and 1.2). Most of the world's population is living in earthen buildings (Figure.1.3 CRATerre). Half of the world population is living in earthen architecture.

Figure 1. Earthen Architecture 1.1. Mexica and 1.2. Iran 1.3. Global Map of Earthen Architecture

2. WHY RE-THINKING EARTHEN ARCHITECTURE

Earthen architecture is creating "healthy indoor" environment with mechanical and physical property of earthen material. Therefore, earthen construction material is "minimizing energy usage" for indoor climate of the buildings and finally "minimizes global pollution".

2.1. HEALTHY INDOOR LIVING WITH EARTHEN ARCHITECTURE

Indoor climate from buildings (Figure.3), constructed with earth is suitable for human health. The fever of the human body is 36'degree (Figure.2). If the environment temperature is lower than 18'degree, energy loss of the body is high. The immune system of the person is risky. If the temperature around is higher than 24 degrees, the body cannot release the energy that the body is producing. In this position the immune system is risky again.

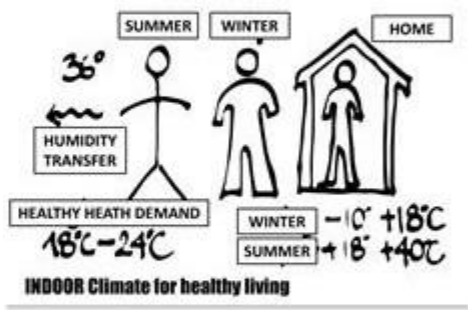

Figure 2. Healthy living temperature

Figure 3. Altınoluk, 1997, 280 m2 earthen house

2.2. HEALTHY ENVIRONMENT WITH EARTHEN ARCHITECTURE

Global energy consumption of the buildings in the last century is extremely high, resulting with environmental pollution. Energy is consumed almost the same rate by the sectors 1.Industry, 2.Buildings 3.Transportation (Figure.4). Earthen building consumes less energy because of the physical property of the earthen construction material [1]. For example earthen house 280 m2 in Altınoluk (Figure.3), constructed at 1997, is energy efficient. Since 25 years no energy is used for heating and cooling: So that we can use earthen material for "Zero-Energy buildings" in the climate change.

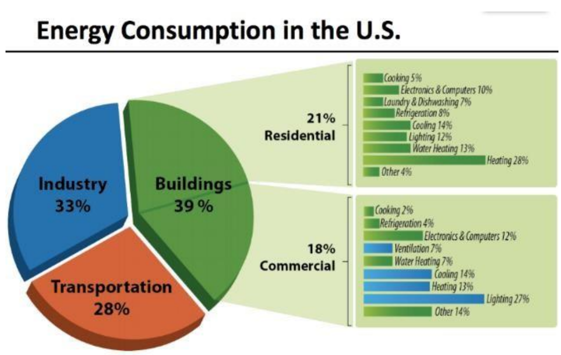

Figure 4. (eia-gov) Energy is consumed almost the same rate by the sectors

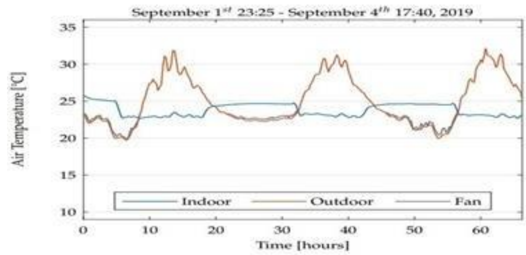

Figure 5. Murat Çakan + others [4] temperature: indoor +blue, outdoor +orange ; Figure 6. Temperature test on the R&D Project Building TÜBİTAK 622, constructed at 1995 [1]

The research on the building TÜBİTAK 622, constructed at 1995 shows: the daily temperature from outdoor(orange) is not changing the indoor temperature (blue) in September (Figure.5 [4]). The earthen walls of the TUBİTAK 622 projects are designed 45cm according to the Istanbul climate (Figure.6).

3. EARTHEN ARCHITECTURE WITH DEVELOPMENT STRATEGY

Traditional Earthen Construction

As it is mentioned in (Figure 1.3) half of the world's population is living in earthen buildings with mostly similar construction technique. Soil with the content of 30-40 % clay will be mixed with water and straw in the preparation pool. Mixture will wait in the pool min 8-hours or more (Figure.7). In that period extract of straw dissolves in the water. Extract of straw in the earth mixture creates durability of earthen wall during rain and snow. When the mortar is ready earth blocks will be produced and dried on the field (Figure.8). Wall masonry will start if the block production number is enough (Figure.9). All the level of production and construction of traditional kerpiç-house (earthen house) is time taking and labor intensive. If homeowner does not carry the construction, earthen construction (kerpic ev) is expensive.

To enable using the economic and healthy earthen construction technics, research developed: 1. Fast durability techniques 2. Fast earthquake safety 3. Fast contemporary construction technics.



Figure 7. Mortar preparation pool; Figure 8. Adobe production using the field; Figure 9. Adobe wall home, loadbearing wall system

3.1. FAST- DURABILITY TECHNIQUES OF EARTHEN CONSTRUCTION WITH GYPSUM AND LIME (ALKER)

To get the durability with fast and short stabilizing process, 10%Gypsum is mixed to the earthen wall material [3]. While adding water to the mortar, hydration period of gypsum is about 4 minutes, which is short for construction operations. Therefore, 5%lime is added to the earth and 10%gypsum mixture [3]. Hydration period with the water is about 20minutes, having enough time to finishing the construction process.

Clay content of the soil will be about 10-15%. "Clay+ Gypsum+ Lime" together will be about 30% binder in the mortar. During the new stabilization technique if clay content is more than 15%, demand for water will be high. If water content in the mixture is high, during drying of the material, shrinkage and finally cracks will occur. Table.1 shows the percentage of soil+ gypsum+lime and water to receive earthen mortar. Table.2 shows mechanical and physical properties of stabilized earthen material (Alker).

Ingredient	% by Weight	Practical Measures
Soil	100	2 full wheel barrow
Gypsum	10	4 shovel full
Lime	2	1 shovel full
Water	18-20	1 bucket full

Unit weight	1.6-1.7 kg/lt
Shrinkage	1.0-1.5%
Compressive strength	2.0-4.0 N/mm2
Shear strength	0.9-1.3 N/mm2
Water absorbtion	very low
Long term water exposure (except direct rainfall)	no erosion
Heat transfer value λ	0.4-0.5 kcal/mhC
Specific calorific	1.0 kJ/kgK

Table 1. Percentage of stabilizing material -gypsum -lime – soil -water called ALKER [1]; Table 2. Mechanical+ physical properties of gypsum-lime stabilized earth (Alker) [1]

3.2. FAST- DEVELOPED EARTHQUAKE SAFETY: LEARNING FROM HERITAGE

Architecture heritage is mostly load bearing system, (Figure.13) using stone, brick, or adobe (earthen bricks). In some countries loadbearing system is not in the curriculum from civil engineers and architectural higher education. That is the reason, loadbearing buildings in the last century generally does not have earthquake safety. During the earthquake, lateral force damages the building after diagonal crack (Figure.10). Upper part of diagonal crack slides down and the building collapse.

Figure 10. Diagonal cracks, no earthquake precautions

The aim of the research is to manage the lateral force, created by earthquake, to avoid the diagonal crack in the wall. Load bearing wall must have lateral energy dissipating surfaces to avoid the diagonal cracks. Masonry wall of the Heritage buildings are mostly constructed with horizontal stone& brick layers. Learning from Heritage: As the strength of brick is lover then stone, the horizontal force of earthquake will be dissipated by the brick masonry (Figure.13) and there will be no diagonal crack. The loadbearing building with horizontal energy dissipating surface in the walls is safe during the earthquakes.



Figure 11. Shaking table test 2009, ANKARA, General Directorate of Disaster Affairs; Figure 12. Labor test at Istanbul Technical University, Civil Eng. Labor; Figure.13 Stone-Brick Loadbearing Wall; Learning from Architectural Heritage-

The earthen walls of the test building on the shaking table (Figure 11) in Ankara 2009, (General Directorate of Disaster Affairs) is constructed with horizontal energy dissipating layers, from ground to the top every 50cm. After 8-times earthquake test, the walls do not have diagonal cracks. There can be only horizontal cracks where the horizontal friction layers are. During the test, building is not destroyed.

Figure 12. shows the element after the Laboratory test. If horizontal crack occurs the next force from earthquake will not affect other wall sections.

3.3. FAST- CONTEMPORARY EARTHEN CONSTRUCTION TECHNICS

Developing Construction Technology with Earthen Material at İTÜ (Istanbul Technical University), Since 1980 earthen material is subject for research to use earthen material for housing. As the rural and traditional earthen construction is time taking and labor intensive, industrialized earthen construction technology is developed and used. Table.1 gives the R&D list of earthen buildings, constructed as 1. Rammed, 2. Earthen block production for masonry, and 3. Shot-earth construction technology

3.3.1. RAMMED EARTH CONSTRUCTION



Figure 14. Concrete mixer for mortar: 100kg earth, 10kg gypsum, 5kg lime and water; Figure 15. Ramming mixed mortar in to the wall-form with Compactor; Figure 16. TUBİTAK 662- research building -rammed into the form.

Construction operation steps for rammed earth building are very fast: material supply, construction equipment -supply, construction worker. If construction is by hand 4worker can ram 5m3 wall in a day. VAN headman-office (Figure.23&24): rammed earth building 6x6m2 (25m3) has been constructed in 3 days, If mixer (Figure.14) and compactor (Figure.15) is used wall construction is faster (Figure.16).

3.3.2. EARTH-BLOCK CONSTRUCTION


Figure 17. Concrete paving stone machine, used for 60 000 earth block production; Figure 18. URFA- GAP four official residence, 400 m2, earth block construction at 2000

If the home owner is going to construct the building, 1. formwork for wall cannot be available or 2.expensive or 3.ramming needs some new knowledge. But mostly people know the masonry system. If there is support from government, that home owner get for a 3rooms building (like Figure.6). about 10 000 earthen blocks, they can make their houses. The earth block production is with Concrete Paving Stone Machine (Figure.17) which produces about 6000 pieces in a day.

In the city URFA, GAP Regional Development Administration Office is organizing the home supply FOR THE PEOPLE who are homeless after "Bilecik Dam" holds water. Before starting the project with "home supply for the homeless", GAP organization finished a pre-project, residence for GAP employee, each home100 m2 x 4home (Figure.18). Two storied, earthen building has been constructed with 60 000 earth block, produced by Concrete paving stone machine. The building, construction at 2000 is still in use in URFA.

3.3.3. EARTH-SHOTCRETE


Figure 19. Dilekkaya. Shotcrete -earth construction; Figure 20. Dilekkaya home 2012, organization: Değirmenlik municipality

Early signs from Cyprus history, date back to 10 000 BC. Since the late Bronze Age (1650 BC) Cyprus had the commercial relations with Aegean World, Sicily, and from 1489Venetians used

Cyprus as trade and fortified. From 1571to 1878, 300 years Cyprus was under Turkish rule. Just like the Mediterranean culture, architectural Heritage in Cyprus has earthen construction. Even people from Italy-Mediterranean region, went to USA-California for viticulture and wine culture, they used the Mediterranean earthen architecture. Today in Cyprus only reinforced concrete buildings are being built. For the indoor climate, air conditioner is in use. Cyprus buy the energy from overseas and it is expensive. "Les energy usage" in building sector must be the target. R&D project keeps:

1. Learning earthen architecture from Mediterranean Heritage and
2. Re-Thinking earthen architecture +durability, +earthquake safety, +fast earthen construction

If there is a need for FAST EARTHEN CONSTRUCTION: shotcrete machine produces earthen wall 7m3 in one hour (Figure.19-20). In 8hours-daytime, with a small shotcrete machine (7m3 per hour= daily capacity) wall construction can be 56m3. In Cyprus-Dilekkaya (Figure.20) shot- earth building 7x7m was a R&D project from CIU (Research and Development project -Cyprus International University) , carried by Değirmenlik Municipality. PERİ Wall-Formwork supply was from EMEK inşaat. Shotcrete machine supply was from IŞIK AŞ. When earthen mortar is injected into the wall-form (Figure.19), the new wall construction can carry in a short time. The formwork pieces can be removed and can be installed in a new location.

4. VAN - FIELD PROJECT WITH NEW KERPIC CONSTRUCTION TECHNOLOGY

The periods of Van According to the archaeological research extend before the written history B.C. 5000-3000, until the beginning of Chalcolithic period. The Hurrions established the first state in this region. Then the state of Urartu with its capitol Tusba was established in 900 B.C. Instead demolishing the architectural heritage,

1. Learning earthen architecture from central Anatolia and
2. Re-Thinking earthen architecture in climate change +durability, +earthquake safety, +fast earthen construction

The study is on VAN+ Tuşba province. Architectural Heritage is earthen load bearing wall system. Location of the city VAN is very east of Turkey. Continental climate prevails in Van. In a year 150days are under 0-degree. Following the historical background on indoor climate is important to use earthen architecture for healthy indoor with low energy usage (Figure.5).


Figure 21. VAN 5000 BC archaeological location, 900 BC. Tuspa – earthen arch Heritage; Figure 22. Tuşba recently – concrete buildings


Figure 23. VAN Tuşba earthen architecture headman's office - in snow-time – no damage; Figure 24. VAN Tuşba earthen architecture headman's office – construction in 3 days

R&D building in VAN Tuşba as Earthen Architecture Headman's office was built in 2019. People in VAN Tuşba, visiting Headman's office, will get the knowledge that:

-Today home-owner can build earthen construction
- indoor climate is healthy
- little energy for heating and cooling in a year

The building Tuşba, with 7x7 m is constructed in 3 days (Figure.24), with 5-workers and using mixer and compactor. Earthen Building is safe in winter and snow period (Figure.23).

CONCLUSION

COLLABORATION STRATEGY AND CONCLUSION

- The Turkish Earthquake Regulations are clear that: load bearing structures is not permitted
- The Turkish Earthquake Regulations If the building is made in rammed earth (cement / gypsum stabilized) the structure will be frame structure.
- The study and research on earthen architecture will contribute for the demand on legal and administrative process using earthen architecture.
- The "buildings permit" will be engineered and in frame structure
- Higher education must take the bearing wall system into higher education curriculum
- Governmental Authorities have to learn from earthen architecture = energy savings,
- Governmental Authorities have to learn from earthen architecture = Construction Industry

Collaboration is needed between : 1.governmental, 2.higher education, 3.local municipal administration, 4.local home builder etc. Table.1 shows list of R&D earth construction studies

	Years	Location	Technic	Research + OWNER	R@D
1	1995	İTÜ Istanbul	rammed	TUBITAK 622	B.IŞIK
2	1997	ALTINOLUK	rammed	Okan Tütnar	B.IŞIK
3	2000	URFA	Earthen block	GAP Idaresi	B.IŞIK
4	2009	ANKARA	Shot-earth	Shaking Table Test	B.IŞIK
5	2011	VİRANŞEHİR	Rammed	Home Builder	B.IŞIK
6	2011	KIBRIS Dilekkaya	Shot-earth	Değirmenlik Municipality	B.IŞIK
7	2015	KÖYCEĞİZ	rammed	BKM film Plato	B.IŞIK
8	2015	URFA-GÖBEKLİTEPE	Rammed	Visiting Center	B.IŞIK
9	2019	VAN- Tuşba	Rammed	Office for local authority	B.IŞIK
10	2020	ERZİNCAN	Rammed	Palanga Goat Shelter	B.IŞIK

Table 3. R&D project from B.IŞIK = fast and earthquake safe earthen technology

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2. Gypsum Producers
3. IŞIK AŞ Company
4. PERİ Company

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12- Understanding the change in construction technology oftraditional vernacular buildings of Dhulikhel

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ABSTRACT

The paper documents the traditional buildings with high heritage value to understand the changes occured in building forms, plans, construction technololgy and building materials. The methodology includes the firsthand data aqusition from the site. Two buildings with high heritage values are selected for the study. The existing condition of the selected buildings were recorded with measured drawings, photographs, and sketches. The information about the past condition of the building is discovered by the available photograps and interview with the house owners. The findings revealed that in all houses the external load bearing wall were left intact, while the internal non load bearing partition walls were added to meet the new functions. Toilet is added on the Ground floor. The two-way slope roof constructed from wooden truss and clay tile roofing was replaced with the corrugated metal sheet roof. In some cases, the two-way slope is even reduced to one way slope and the height of top floor was increased adding some layers of brick wall.

Keywords: Traditional building, construction technology, building material, vernacular buildings

1. INTRODUCTION

The traditional Newari towns and settlements hold the unique character of their own Architectural vocabulary. The settlements are divided by wide main routes in cardinal direction.These routes are also the festival and Jatra routes which again branches into narrow alleys. The main street and the narrow alleys are generally open and interconnected courtyards in which the daily activities and the rituals took place. The several storied brick houses and the temples on the higher plinth are built around the network of these brick paved alleys and streets [1]. Due to various factors such as modernization, migration, globalization these traditional settlements and buildings are undergoing changes in form, construction technology as well as functions. These changes need to be understood in a comprehensive manner, to be able to evolve a holistic view on the issue of changes and offer an opportunity to reinterpret the tradition while meeting the contemporary needs of the settlements. The traditional newari town Dhulikhel in the Kavre district has been chosen to understand these changes of vernacular buildings.

1.1. OVERVIEW AND HISTORICAL BACKGROUND

Dhulikhel is the administrative center of Kavrepalanchok District which is located 30 km east of Kathmandu (Fig. 1) and situated 1,550 m above sea level along the Araniko Highway. [2]

The town is situated on an ancient trade route to Tibet. Dhulikhel has been long considered the gateway to Tibet. Besides the spectacular Himalayan view, it is famous for its cultural heritage and traditional Newari settlement. In particular, it was the traditional domestic dwelling of the ethnic Newars- groomed to practical and symbolic unity of the purposes over the centuries.

The known history of the village has been traced back to the 5th century. Dhulikhel is said to have been a settlement established in the Palanchowk hills by goddess bijayaswori Bhagawati during Kirat period, in the region of the Licchavi King Mandeva (AD442-483). The evidence for this is found in an inscription from 481 AD (Kolligs, 2002). Another History ascribes the origin of the organized settlement in this region to Anand Dev, the Malla King of "Nepal Mandala", Who clustered together with the far-spread patchy habitation which led to the establishment of Banepa Saat gaun(seven valleys)about 700 years ago. Dhulikhel is incorporated as one of the valleys.Two centuary later son of Yaksha Malla split the Kingdom into three states, kathmandu, Bhaktapur and Lalitpur, in an attemp to region independently. Dhulikhel, which lies to the east of Bhaktapur,was included in this state (Glimpse of Dhulikhel, 2015). In October AD 1877, Dhulikhel was incorporated into the greater Nepal by King Prithvi Narayan Shah.

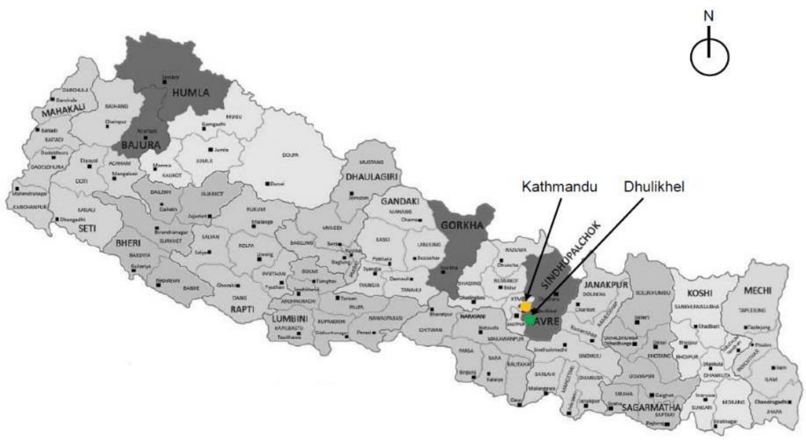

Figure 1. Map of Nepal, Location of Dhulikhel Source: http://www.holidaytoursnepal.com/nepal

1.2. THE URBAN SETTING

There are four main routes to enter the city (Fig. 2). Each route starts from four cardinal directions east, west, north and south and ends at a common place of Narayan Temple square. The route starting from each direction is believed to be an ancient philosophy of town planning.

1.3. MIGRATION, MODERNIZATION AND EARTHQUAKE

At present it has been a challenge to preserve the old traditional newari style houses in the old town. The damaging effect of rapid modernisation upon the physical cultural heritage of dhulikhel have been exacerbated by a lack of education and awareness. The local citizens feel little responsibility or inclination to preserve their historical buildings. In part this is due to the low level of cultural awareness. Unlike the temples, these dwelling do not fall under the existing government legislation on monuments. Thus, no attemps had been made by the government also to preserve it. Moreover; the recent earthquake of 2015 April 25th has made the buildings more vulnerable. So, the people have started to dismantle their old building and started to construct a new R.C.C structure.

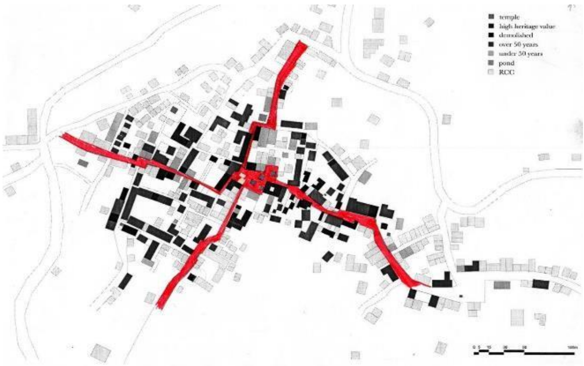

Figure 2. Map of old town Dhulikhel showing ancient route Source: Hari Bhakta Khoju

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Figure 2. Map of old town Dhulikhel showing ancient route Source: Hari Bhakta Khoju

Following are some of the challenges that are faced to conserve the old buildings:

- Earlier, most people of Dhulikhel engaged themselves in agriculture. As the population grew the agricultural produce was not sufficient hence the people travelled to various places for business which even extended up to India. Gradually the working age of Dhulikhel migrated to other cities for business and the elderly, women and the children remained back in Dhulikhel.
- The people of Dhulikhel are mostly businessmen who have their businesses in other cities and visit the town only during festivals. Nowadays some of the families have stopped visiting the town even during major festivals like Dashain and Tihar. Hence the old buildings in Dhulikhel are neglected as they are left uninhabited.
- The other factor is the separation of the joint family system. Once the joint family gets separated the old buildings also get divided amongst the heirs of the property. No member wants to sacrifice their ancestral property hence the buildings get vertically divided.

People of Dhulikhel though they are concerned about safeguarding the town but due to lack of resources both financial and technical they have not been able to preserve the old buildings.

After the devastating earthquake of 25th April & 12th May 2015, the people are scared to reside in the old structure and have started to demolish them and reconstruct in modern ways.

2. TYPICAL TRADITIONAL NEWARI BUILDING

The average newari house is rectangular in plan about 5-6 m in depth and 4-8 m in length.The universal feature of the building is vertical room arrangements, which is independent of the size of the houses. Generally the building is three storied with the two way slope roof along the longer side of the building. The two storied building is also found among the poorer inhabitants on the periphery of the town and four storied buildings are in the center of the city [1].

These houses are inhabited by nuclear or multiple family members. In most of the cases the front facade is connected to an alley or main street and the back facade opens up in a courtyard through the door. As the size, location and other facilities of the rooms offer certain limitations on their usages, the courtyard becomes a major component of the house itself. It became a playground, washing area, grain drying space and other various multipurpose spaces.

This rectangular newari house is divided into two bays by a middle spine wall parallel to the longer side. The rows of wooden columns frequently replace the part of the front wall, opening the ground floor to the street (Fig. 3). The back rooms are a storage room, workshop etc open to the courtyard. The ground floor is known as Chayali.

Generally a narrow single fight wooden staircase gives access to the upper storeys. The first floor (Matan = Middle section) is normally used as sleeping spaces. Depending upon the size of the house, the two rooms are further divided by either brick wall or light timber partition to form sleeping cabins for family members [5].

The second floor known as (Chota = Upper layer) in three storey houses are used as living and family areas. The central wall is replaced by rows of twin columns to create the larger hall space. The windows at the front and the rear wall, particularly the large SanJhya, provide enough light and make these areas the favorite space for various types of activities.

The third storey (Baiga = half or small storey) attic space in a three story house is used as kitchen and religious space. Family shrine normally known as a pooja room is also placed on this floor. The central spine wall is also replaced by the row of columns similar to the second floor to create more flexible spaces.

The water for drinking and for other various purposes are collected from public/private wells or fountains located in each sector of the settlement. The toilets,formally considered as the unhygienic and unclean space are not accommodated inside the house.The children used the street or open places, while womens and mens used the segregate place, which are the narrow alleys hidden behind the walls. These spaces are found in every town district or on the periphery of the bigger settlement.

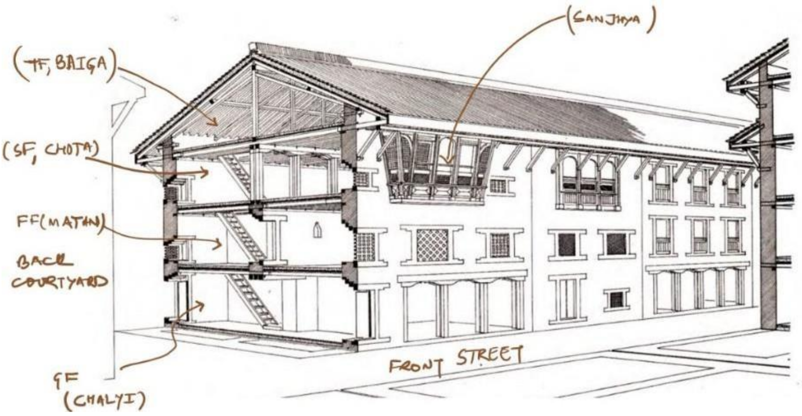

Figure 3. Sketch showing standard accommodation

3. THE TRADITIONAL DWELLING OF DHULIKHEL

A building (Fig. 4) located in the core of the traditional settlement is chosen to conduct this study. This building is chosen because it is more than 50 years old, and the architectural characteristics seem quite intact in the facade and planning well except some remarkable changes in the top storey. This building represents common building typology of that period which undergoes some changes later to accommodate modern facilities and requirements. The digitized replica shown in Fig. 5 represents the original form of the studied building.

Figure 4. Traditional building for study; Figure 5. Replica image of studied building.

A building (Fig. 4) located in the core of the traditional settlement is chosen to conduct this study. This building is chosen because it is more than 50 years old, and the architectural characteristics seem quite intact in the facade and planning well except some remarkable changes in the top storey. This building represents common building typology of that period which undergoes some changes later to accommodate modern facilities and requirements. The digitized replica shown in Fig. 5 represents the original form of the studied building.

4. OBSERVING THE CHANGES

The remarkable changes that are observed in the traditional building are the addition of a toilet in the ground floor. The toilet is added as a separate structure on the left side of the back of the house. The front facade and the inner layout of the ground floor were kept intact and the front bay toward the street is still used as the shop (Fig. 6)

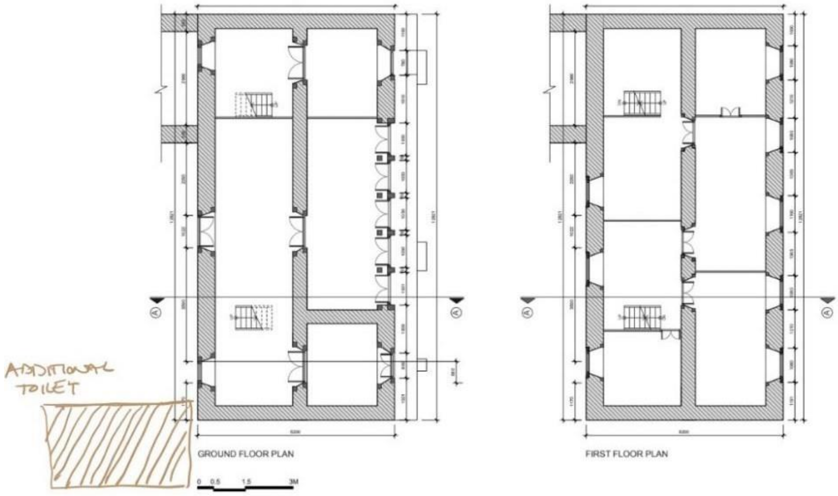

Figure 6. Observed changes in the traditional buildings at Ground and First Floor Levels

There were no changes observed in the first and second floor. The room and other spaces layout remain similar to the typical urban newari houses. (Fig. 6)

While major change was observed in the second floor. The function remains the same as the cooking space and pooja (worshiping) space.However, the two way clay tile (jhingati) [4] sloped roof was replaced by the single slope corrugated roof (Fig.). Moreover, the small balcony was also added for washing dishes on the back wall which was an unusual component for the traditional layout.

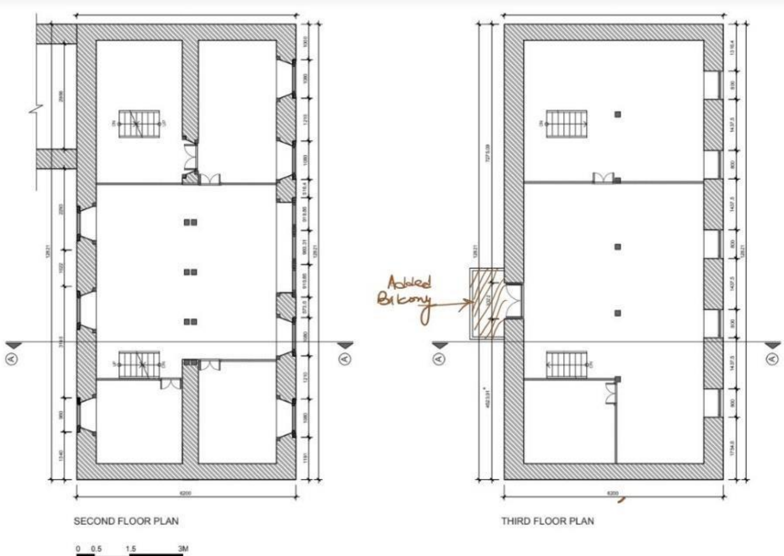

Figure 7. Observed changes in the traditional buildings at Second and Third Floor Levels

The height of the exterior wall was increased in order to achieve more head space and also to incorporate a small window on the front facade (Fig. 8). As the roofing clay tiled roof was replaced by the corrugated sheet roofing, the size and the span of the wooden members were reduced considerably.

Figure 8. Elevation and section of observed changes in roof and attic wall in the traditional building.

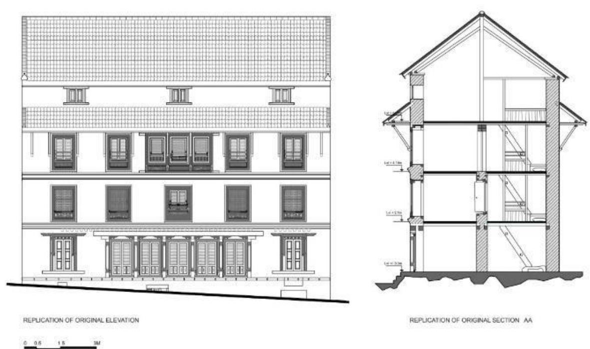

Figure 9. Original elevation and section in the traditional building.

CONCLUSION

As the lifestyle and the occupation changed, the traditional building were not able to meet the various spaces demanded by changed life style. So inhabitents started to transform their houses as per contemporary need and demand.There were not significant transformation observed in living and sleeping spaces. However, the addition and toilet inside or annex to house is the remarkable changes seen in the traditional building.

The major reasons behind replacement of the traditional two way clay tiled slope roof with single sloped corrugated sheet roof is due to change in cooking and dinning habit.In former time the food were prepared in primitive clay oven, locally known as *chulo* with fire wood by seating on wooden plank *(Pidka)*. Moreover, people ate the foods seating on the locally wooven floor mat.As the gas stoves and dinning table were introduced, the low height attic floor became inappropriate to do activities in standing position.So, the extra wall were added raise the height of top floor.

The rise in the height of wall also affect the roofing material and its construction technology. The clay tiles roof became very heavy and the increased height made it even unstable.There for it was replaced with the light weight corrugate sheet as the pragmatic solution.Moreover, the recurring small and large magnitude earthquakes became strong reasons to replace the two way claytiled slop roof.

Looking on these changes what what we conclude is the major changes are made in additing toilet and Kitchen spaces. This also shows the change of lifestyle and awareness of people toward sanitary hygiene. As we know that the changes are inevitable, thus these changes need to be understood in a comprehensive manner, to be able to evolve a holistic view on the issue of changes and offer an opportunity to reinterpret the tradition while meeting the contemporary needs of the settlements.

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13- Testing and Conservation Actions in the Hittite Mud Bricks Fortification of Porsuk – Zeyve Hoyuk (Southern Cappadocia,Turkiye)

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ABSTRACT

This paper will present the testings and actions of conservations lead in the archaeological excavation of Porsuk – Zeyve Höyük in Southern Cappadocia (Türkiye). The site of Porsuk – Zeyve Höyük is mainly characterized by its Hittite mud bricks fortification built in 1600 BC and repaired and rearranged after 1280 and in 837 BC, after wars and fires. It is the unique example of 8 meters of original mud bricks walls from the Hittite period in Türkiye. The first objective of the study is to understand the history of the fortification that means construction, destructions, reconfigurations, and restorations of the mud bricks fortifications of Porsuk – Zeyve Höyük during Antiquity. The second objective is the realisation of a mud bricks workshop, using the knowledge and know-how of Porsuk region local inhabitants (the mud bricks architecture is still used in this mountainous region of Türkiye). The third objective is to test techniques of encapsulation to protect original Hittite mud bricks structures. The fourth objective is a reflection about the valorisation of the conservation and preservation of the mud bricks Hittite fortification. The methods employed are research-action methods: archaeological excavations, mud bricks production, testing of the preservation and conservation actions of encapsulations.

The conclusions are the creation of a management plan for the conservation and valorisation of the mud bricks architectures of Porsuk – Zeyve Höyük, in relation with a project of mud bricks centre of interpretation from Antiquity to nowadays in the village of Porsuk (Niğde province), linked to sustainable tourism and development in the region.

Keywords: Mud bricks, Hittite fortification, Porsuk-Zeyve Hoyuk, conservation

1. INTRODUCTION

The archaeological site of Porsuk – Zeyve Höyük is situated in Southern Cappadocia, in the region of Niğde, near to the sub prefecture of Ulukışla, at the bottom of the Taurus Mountains (Bolkar Dağları) [1] [2], 40 km on the North of the Cilician Gates (Gülek Boğazı) [3], famous circulation pass between Anatolian Plateau and Cilicia from Antiquity, 'Fig. 1'.

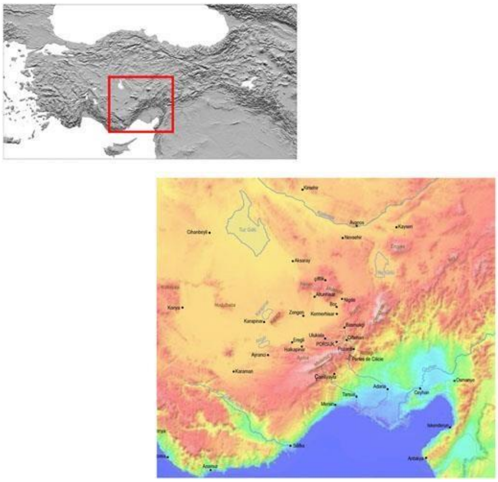

Figure 1. Map of localisation of Porsuk in its Anatolian environment (© Porsuk – Zeyve Höyük archaeological mission)

The site is a tabular höyük, 400 x 180 m in size, situated at an average elevation of 1300 m, with an area of 4 ha [1] [2], 'Figure 2'.

Figure 2. General view of the höyük of Zeyve (© Porsuk – Zeyve Höyük archaeological mission)

The English Geographer W.-M. Ramsay noticed the site in 1899, during his survey in the Cilician Gates region [4] [1] [5], but he proposed to identify it with the *Colonia Faustiniana* created in 176 AD by Roman Emperor Marcus Aurelius after the death of his wife Faustina. In 1926, the Swiss Assyriologist and pionnering Hittitologist E.-O. Forrer identified on the site the remains of a vaulted underground passage, dated, thanks to the ceramics, to the Hittite period. In 1937, in an article published in *Klio*, he proposed to identify the site to the Hittite Dunna, the Assyrian Tunna and the Ptolemee's Tynna, in the neighbourhood of the site of Faustinopolis, founded by Roman Emperor Marcus Aurelius [6].

No more archaeological survey was lead, and the site was really discovered after road works in 1960, for the construction of a track to access to the neighbouring gypsum quarry. A bulldozer cut off the western extremity of the höyük and considerably cut the top off it [1] [2]. A Neo-Hittite hieroglyphic inscription of the 8th Century BC was discovered in this occasion. It mentioned the General Parahwaras [7] [8] and was immediately transferred to the regional museum of Niğde. In 1961, the French Hittitologist Emmanuel Laroche saw this inscription in Niğde and went to see the site of Porsuk – Zeyve Höyük. He took steps to obtain excavation permission for the Turkish authorities, and, in 1968, a survey permission was given to Emmanuel Laroche, at this time director the French Institute of Archaeology of Istanbul [1] [2] [9]. In 1969, the archaeological excavations began, under the direction of Prof. Olivier Pelon (Lyon University), then under the direction of Prof. Dominique Beyer (Strasbourg University) between 2003 and 2015, and, since 2016, under the direction of Assoc. Prof. Claire Barat (Hauts-de-France Polytechnic University, Valenciennes) [10] [11]. Different excavation areas (called "Chantiers") were open on the höyük, but the more important to understand and to study the mud bricks Hittite constructive systems was in Chantier 2, where a defensive system were brought to light, with fortification walls and entrance system, known as the "Hittite postern".

The originality of the Porsuk – Zeyve Höyük archaeological remains in Chantier 2 is the original Hittite mud bricks conserved with an elevation going until 8 m in some parts of the fortification.

The aim of this paper is to study the ancient mud bricks constructive systems in Porsuk – Zeyve Höyük and to describe the mud bricks workshop started in 2018 in order to lead conservative actions on the original archaeological remains. This paper will also present encapsulation techniques tests used to protect the archaeological remains and to allow future visitors to see the Hittite fortification walls. Finally, a reflection will be lead about the valorisation of the conservation and preservation of the mud bricks Hittite fortification.

2. HISTORY OF THE ANCIENT CONSTRUCTIVE SYSTEMS IN PORSUK – ZEYVE HÖYUK

The excavations of the fortification system of Porsuk – Zeyve Höyük began in the Chantier 2 zone (1969-1970), then in Chantier 4 zone (1971-1972 and 1976-1977), and in parallel in both Chantier between 2005 and 2015 [9]. During these excavation campaigns, C14 analysis an dendrochronological analysis were lead in order to date the constructive systems in Porsuk- Zeyve Höyük [9] [12], 'Figure 3'.

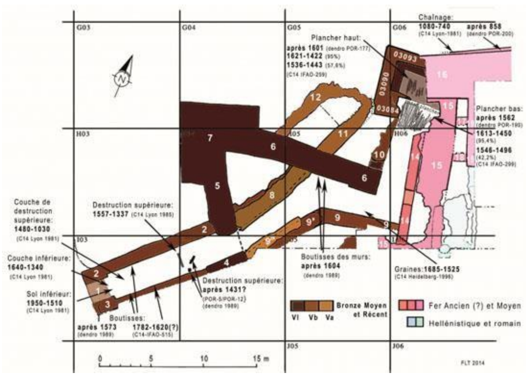

Figure 3. Map of Chantier 2 with principal dendrochronological and C14 measures (D. Beyer [13])

The foundation of the Hittite fortification seems to occur in the 17th Century BC. Mud bricks walls were constructed and a primitive gate allowed entering into the fortification. In the 13th Century BC, the fortification was attacked and fired, and the fortress was reconstructed with new mud bricks (another module, smaller). An advanced corridor was added, forward the primitive gate, forming the "Hittite postern" and this entrance became a secondary entrance. Under the reign of Salmanazar III, during his 22nd campaign (837 BC), the curved corridor in the "Hittite postern" system was obdurate by a mud bricks wall. Above this Middle and Late Bronze Age System, an Early Iron Age system of fortification was built [5] |9] [13] [14].

So the use of mud bricks appeared in Porsuk – Zeyve Höyük since the 17th Century, in the first state of the fortification. It seems that the first module for the first state of the fortification was slightly bigger (0,49 m x 0,44 m x 0,12 m) than the following one, discovered in the fire levels (0,49 m x 0,34 m x 0, 14 m and 0,49 m x 0,42 m x 0,11 m), but, nevertheless, the length remained constant. The mud bricks were used not only for the edification of the fortifications but also for private and public housing. In the implementation of the rampart, the apparatus is associating mud bricks in stretchers and bondstones. The whole of the structures constructed in mud bricks was covered with a layer of earth witch composition is identical of mud bricks ones, and on the earth mortar, a whitewash was applied.

The excavations and resumption of previous surveys allowed highlighting the remains of the Middle Iron Age rampart. It is composed internally by a mud bricks massif and in frontage by a facing of gypsum blocks tied by an earth mortar. This defensive ensemble was not fired. Manifestly, the construction of this rampart required in a first time a levelling of the Late Bronze Age cooked mud bricks ruined structures of the rampart, and the definitive obstruction of the corridor.

In order to prepare conservation actions on the Hittite fortifications of Porsuk – Zeyve Höyük, a mud bricks workshop was initiated in 2018 under the direction of Claire Barat.

3. MUD BRICKS WORKSHOP IN PORSUK – ZEYVE HÖYUK

During the 2014 campaign, testing mud bricks small walls were built, with four different compositions [15]. In 2018, it was possible to identify which combination was the more resistant to wind, rain and snow, and this combination was reproduced in the mud bricks workshop, 'Figure 4'. The composition of the mud bricks was the following one: earth, 20 % straw and water [10] [11].

Figure 4. Production line of 2019 the mud bricks of Zeyve Höyük (© Porsuk – Zeyve Höyük archaeological mission)

The archaeological mission of Porsuk – Zeyve Höyük could benefit from the knowledge and know how of the workers, all from Porsuk village. In fact, in the region of Porsuk, at the bottom of the Taurus Mountains, there is a still alive mud bricks construction culture. The old village of Porsuk (Eski Porsuk) abandoned in the beginning of the 1990s for the summer village, New Porsuk (Yeni Porsuk), show good examples of the use of mud bricks in vernacular constructions, 'Figure 5'.

Figure 5. Houses and constructive details of Eski Porsuk village (© CRAterre_C. Sadozaï)

The earthen material for the preparation of the mixture came from the rubble of the previous excavations. The straw came from old bale and was chopped in small pieces. The mix was then trampled underfoot by workers during one hour, and stayed rotting during twelve hours. The putty was moulded in wooden moulds on the next day. The mud bricks stayed outside to dry one week. Listening to the traditional knowledge, the normal drying time before using is forty days. The module chosen for the new mud bricks was 0,40 m x 0,18 m x 0,12-0,13 m, corresponding to the second state of the Hittite constructions.

4. CONSERVATION AND SITE PRESENTATION

During 2021 campaign, CRAterre undertook an assessment of the conservation methods in Zeyve Höyük, thanks to a grant from the French Ministry of Foreign Affairs promoting conservation of earthen architecture on all French archaeological missions abroad. Preliminary results are presented here.

The history of the conservation actions at Zeyve Höyük, as is often the case on archaeological sites, has been dependent on the will of its director. They were only thought for the Chantier 2, the Hittite postern, and to be presented to the public. D. Beyer initiated wall tests in 2014, he started works to have a trail for visitors, protected areas with a plastic roof and installed few boards. He left the project to C. Barat who took over from him.

The first mudbricks were molded in 2018, and implemented the next year. The technical choice to keep the earthen remains safe and understandable for the public has been the encapsulation, 'Figure 6'. The original volume of wall is covered by a layer of new mudbricks, on the sides and on the top, leaving a void of 5 cm fulfilled by dry soil from the rubble. On the top, mudbricks arelaid without mortar and covered by a layer of earthen plaster, 'Figure 7'.

Figure 6: Encapsulation of the original Hittite mud bricks (© Porsuk – Zeyve Höyük archaeological mission)

Figure 7: Conservation action of tower North-West, chantier 2, Porsuk – Zeyve Höyük (© Porsuk – Zeyve Höyük archaeological mission & © CRAterre_C. Sadozaï)

The mission being cancelled in 2020 because of the Covid-19 pandemic, only two campaigns of encapsulation were undertaken, in parallel with the excavations. Other technics of preventive conservation have been implemented such as stone wall consolidation (with earthen mortar), a cover of geotextile membrane and targeted paralloid consolidation for plasters, 'Figure 8'.

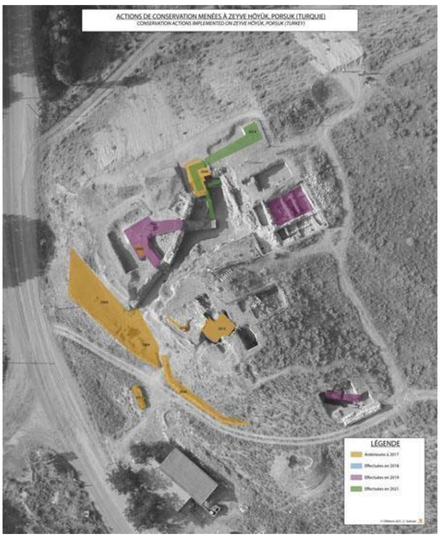

Figure 8: Localisation of conservation action in Chantier 2, Porsuk – Zeyve Höyük (© Porsuk – Zeyve Höyük archaeological mission & © CRAterre_C. Sadozaï)

CONCLUSION

The assessment showed that the site is in a good state of conservation, event after fifty years of research and exposure. The dry climatic conditions and the fact that most of the walls were fired allowed the remains to stay stable. Shelters of red corrugated plastic are efficient to slow down the decay process initiated by wind and rain, if they remain for the short-term.

The brick production is well mastered by the inhabitants of the region, but needs some improvements. Indeed, after two years the 2019 brick stock was partially broken and unusable. The inner quality of the materials has been identified as a possible weakness (grain size distribution and clay quality), as well as a lack of rotting time of the mix.

The choice of the encapsulation has also been questioned. This technic is hiding the original fabric to the public and is enlarging the original width of the walls. Angles are sharp and surfaces are new, the authenticity of the archaeological site could be affected.

Recommendations have been made for the next campaign. Technical adjustments will be tested, with new recipes of mix for mudbricks and more rotting time of the straw. Samples of other preventive measures will be implemented, such as sacrificial renders and targeted repairs. The scientific collaboration between archaeologists and conservators will continue with the elaboration of an action plan taking into account the objectives of both fields: the forthcoming excavations will be defined according to the needs of the site presentation, and to make the remains more understandable for the public. More widely, a discussion will be initiated to define a vision and the heritage values to be enhanced on Zeyve Höyük and a tentative management plan will be drafted in accordance with local authorities. They have shown a strong interest with the traditional building techniques of Zeyve Höyük and Eski Porsuk and want to enhance this know-how to the young generation, using the means of the Hittite fortress to build a Visitor centre made of mudbricks.

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14- Use of Soil Material with Sound Absorbing Feature

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ABSTRACT

For centuries, music and music venues have been closely related to architecture. Spaces are oriented and shaped according to the function, so spaces for listening need acoustic arrangements. Various methods have been developed for acoustic analysis from past to present. Methods and sound absorbing and reflective materials used have partially changed during the process. The first data that we know as written texts are included in Vitruvius' works. It has been observed that the theaters built with the information in the work exhibit high acoustic performance of similar quality to today's concert halls.

Since soil material is obtained from nature and can be used without requiring expertise, it has been used since ancient times. Examples of use for both structural and comfort purposes are available. In the Ancient Greek, Roman, Byzantine and Ottoman periods, there are examples of the use of soil material in the planning of the orientation and clarity of sound. In this paper, the use of soil material for acoustic planning purposes is examined and explained through examples.

Keywords: Soil material, sound absorption

1. INTRODUCTION

Soil materials are easily accessible materials that have been found in nature since the beginning of humanity. According to historical information, it is among the first structural materials used. It has been used more especially in regions where trees are scarce (Fındık 2017). It has become a material that can be used until today thanks to its features such as low production cost, no need for specialspace for production and good thermal insulation. Used in raw form or in combination with other materials. It is a material that can be used for both structural and decorative purposes and allows flexible design and has a wide range of uses.

The spaces where acoustic planning has been made in historical buildings are buildings for music, speech or religious purposes. Examples include amphitheater, church, cathedral and mosques. These structures were built to be symbolically important, to be open to the use of the majority of the people, to show the power of the current administration to the people and to leave a permanent work for the future. They are also carefully designed for visual, air quality, heat and lighting purposes. Structures with religious use should be considered as structures with both music and speech functions and appropriate acoustic analyzes should be made. Speech sound: d It occurs when sad or irregular sounds continue to follow each other over time. It consists of louder and quieter letters, and the intelligibility of speech depends mostly on the silent letters at high frequencies. The sound power of the voices is greater than that of the mute (Küçük 2000). Music sound: It is regular and harmonic, has a wide frequency range. It is shaped by many different parameters from the type of music to the type of instrument (Özkartal 2011).

The majority of vowels are in the low frequency range and the majority of consonants are in the high frequency range. Therefore, the quieter the letters, the harder it can be to hear as they move away from the source.

1.1. SOIL MATERIAL

Soil material is produced by consuming less energy and its use can be continued for a long time. It is economical, easy to access, recyclable and reusable, harmless to nature and human health (Özgünler 2017).

Soil material can be examined in two groups as concise and unsubstantiated with the raw materials it contains. When it is shaped with water and dried, the proportion of raw materials with extracts that do not disrupt its shape is high, even in the form of fine grain, the type of raw materials that is difficult to shape and whose shape is disrupted due to external factors is high. Non-extractable raw materials are not suitable for use on their own, but in mixtures and structures. Extractive raw materials are suitable for structural use on their own and can be sorted according to the intrinsic ratio they contain. It is an important factor that it can be shaped with water according to the ratio of raw materials used when sorting (Fındık 2017).

When soil materials are used in the form of mortar, the proportion of non-extractable raw materials is higher. In this way, surface retention is increased. It shows similar properties with the physical properties of the raw material it contains. For example, thanks to the coarse-grained sand used, the mortar applied to the wall creates a rough surface, and as the coarseness of the sand increases, the surface roughness increases.

1.2. SOUND ABSORPTION OF THE MATERIAL

Sound absorbing materials are divided into three: porous material, vibrating sheet and resonators.

Porous equipment works with the principle that the majority of sound energy is converted into heat energy by increasing the surface area. The increase in the number of pores, the change in the filled empty ratio of the material surface, the increase in the pore depth and size, and the homogeneity of the pore distribution increase the absorption of the material. It is more efficient in the face of low frequency sounds. The majority of natural materials are porous, the sound absorbing ones are porous. Therefore, it is possible to find examples in historical buildings.

Vibrating plates work with the principle that sound vibrates the material by hitting the material surface, that is, sound energy is converted into motion energy. Thus, acoustic sound prevents pressure fluctuations. The absorption value varies depending on the weight of the material, the surface area, and the distance between the material and the surface behind it. It shows better swallowing in high-frequency sounds. It is not often encountered in historical buildings due to reasons such as being mounted in front of the surface, not adjacent to the surface, and its service life may be shorter.

Resonators are both porous devices and vibrating plates. It can be produced with different types of materials. The sound absorption of the resonator varies according to the design, type, dimensions of the material, the dimensions of the space, and the distance of the source. In order for a material to be used as a resonator, its sound transmittance must be low. The earliest sound absorbing materials known are resonators. Examples of use have existed since ancient Rome. It has been used with different materials in different geographies.

When the use of soil material with sound absorption is examined, it is observed that it is mixed with additives (as a plaster) and used as a porous material or used as a resonator by shaping and cooking. There are examples of both in historical buildings. Heat and sound energies exhibit physically similar properties. The sound permeability of a material with low heat permeability is similarly low. The heat and sound permeability of the terracotta material is low. Suitable for use for acoustic regulation or insulation. The distribution of sound in concert, auditorium and speech spaces is examined in volume acoustics. For the clear and homogeneous distribution of the sound in the volume acoustics, the space should be in uniform geometric forms and proportional sizes, there should be no mutually reflective surfaces, and reflective surfaces should be used in the volume as fragments, not as a whole. Amphitheaters, opera halls, theater halls can be given as examples of these functional spaces.

2. BUILT SPACES FOR LISTENING IN ANCIENT TIMES

The first examples of places where acoustic arrangements were made and documented in history are Ancient Greek theaters. These theaters have characteristic features. They are in the form of semicircles with a seating area of just over 180 degrees. The scene is symmetrical in the middle, visible from every angle. In order to provide visual and acoustic comfort, seating areas increase by 1 to 2(Glass Sabah 2013). Ancient Greek theaters were built for both different musical genres and theatre purposes and are still an example for today's halls (Long 2006). The slope of the slope where the theater sits was determined by acoustic principles (Öz 2017). Roman and Late Hellenistic Period theaters were also built on the plan scheme of Greek theaters. The most important difference is that the stage has been raised and shadow elements have been added for the various backstage areas called backstage and the audience. While the backstage wall added in this period hid the backstage part, it increased the power of the sound on the stage and enabled it to reach the audience better (Glass Sabah 2013).

There are examples of stone resonators in theaters from the ancient Greek and Roman periods. Vitruvius mentions the bronze cubes used in Roman theaters to reach the back rows of sounds. The cubes are placed in niches that open between the seating areas. The cubes do not touch any edges of the niches and only the part of the niche facing the stage has an opening. In this way, while the niche itself acts as a resonator, the outer surfaces of the cubes form a reflective surface. Layout plans and niches were calculated mathematically. It is known that each niche and cube is placed for different notes and planning is made according to the principle that even the back row can detect all notes. However, these cubes were not found in the excavations, only niches carved from stone were found. Vitruvius stated that these bronze cubes were used in the Hellenic city states rather than Rome and that various climatic data were used when designing theaters(Vitruvius 2015). For example, the positioning of the theater to be protected from the wind is for ventilation, health and acoustic purposes. The wooden shadow element added to the theaters in theRoman period reflected the sound and strengthened the theatre acoustics. It is known that the shadow element adversely affects the acoustics when placed without calculation (Öz 2017).

In the Ancient Greek and Roman periods, resonators made of earth material for acoustic regulation, especially in indoor spaces, were encountered.

2.1. USE OF SOIL MATERIAL FOR SOUND ABSORBING PURPOSES IN ANCIENT GREEK AND ROMAN PERIODS

Ancient Greek and Roman resonator samples are empty boxes obtained by carving the stone. These are examples of the hollow resonator type, highly developed acoustic systems although they have a simple structure. The mouth of the boxes is narrow and the middle part is wider square and rectangular. Due to the fact that it is a stone material, some examples have survived to the present day. Large volumes of low frequencies increase the likelihood of resonance and ringing time. Porous materials and vibrating plates may not be sufficient alone in these areas. Cavity resonators provide the optimum acoustic solution for such spaces.

Other examples known to be used in the Roman period are narrow-mouthed, thin-necked jugs produced from soil with a wider bottom, called "Amphora" (Figure 1). The main purpose in the production of these jugs is to transport water or store wine, which is also known to be used to regulate acoustics.

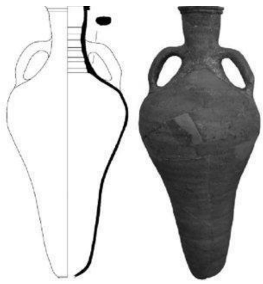

Figure 1. Roman Amphora

The sound of narrow mouth and neck parts is to prevent the sound coming in and coming out. After the thin neck part, the surface area where the sound reaching the large diameter and long body part can reflect is larger. Thus, sound energy is trapped in a small confined space and converted into heat energy.

3. USE OF SOIL MATERIAL IN TURKEYS FOR SOUND ABSORPTION PURPOSES

Turks experienced the period of principalities after the culture of nomadism in Central Asia and their settled lives were finalized during the Anatolian Seljuk period. Planning examples made by the Turks in Anatolia have been encountered since the Seljuk period. It is thought that Turks with no settled life experience were inspired by the artifacts they found in the lands they settled in in their structural arrangements. Because although there are traces of Roman works in the buildings from the Seljuk State, there is no perfect geometry and detailed planning in Rome. Examples of hollow resonators have been seen in Turks since the Seljuks. Water cubes made of soil were used. It is located in caravanserai, mosque and complex structures. However, as in the case of the Great Mosque of Manisa, the jugs (water cubes) in the brick wall in some buildings from the Anatolian Seljuk period were used only for the purpose of lightening the structure, not resonator. Basically, the jugs placed for acoustic purposes were placed in the structure with a certain order and geometry, while the jugs placed for lightening the structure were placed according to the stability of the brick wall (Gök 2021). There are examples of the method of alleviating both the top cover and the walls of the building with empty jugs in the Roman, Byzantine, Seljuk and Ottoman periods.

In the Ottoman Empire, in the 19th century, Mimar Sinan made acoustic analyzes using water cubes similar to Roman Amphora. He applied these acoustic analyzes especially in mosque structures. Mosques and religious structures are mixed-functional structures. It is an example of listening and speaking spaces in terms of preaching, sermon and mawl recitation functions and religious structures in terms of worship function. For this reason, the only purpose of the space is not to swallow the sound, but to ensure the homogeneous distribution of the sound within the space without reverberating. From the moment the sound comes out of the source, it is subjected to friction and its energy is reduced thanks to material surfaces and listeners, especially air. In addition, the energies of high-frequency sound waves are low, and as the distance between the source receiver increases, it becomes difficult to reach the receiver. Therefore, the individual who is close to the source hears the fine sounds more clearly than the one sitting far away. In terms of speech, vowels remain intelligible even over long distances, while consonants become inaudible as they move away from the source. It is necessary to use acoustic planning and various reflective, absorbent surfaces to solve this problem.

Rectangular and square plans in mosque structures cause resonance of sounds at similar frequencies, especially at corner points. Mimar Sinan used pendant or muqarnas in the corners to solve this problem in Selimiye (Kayili 1988). In this way, sounds with similar frequencies were reflected away from the surface at different angles. After solving the problem in the places where the sound reflects the most, it is easier for it to spread homogeneously and make acoustic planning. In addition, he made internal planning by taking care to prevent the formation of acoustic shade between the pulpit, altar and the pulpit and the congregation.

The most obvious examples are found in Sinan's work Süleymaniye Mosque. The cubes used by Sinan in Süleymaniye Mosque are short (50 cm height), narrow-mouthed, thin-necked, oval section. Ağızları içe bakacak şekilde kubbeye 60 adet ve kubbe ayaklarına 4 adet toplamda 64 adet küp yerleştirilmiştir. There are a total of 45 cubes in the Sokollu Mehmed Pasha Mosque, 36 in the dome and 9 in the quarters outside. The mouth parts of the cubes are 1.5 cm in diameter. Thereare 35 cubes placed on the walls outside the dome in Şehzade Mosque. There are 40 cubes in totalin 3 intertwined rings in Sultan Ahmet Mosque. The mouth parts of these cubes are 3 cm in diameter on the one hand and 6 cm on the other hand and can prevent resonance at different frequencies. The cubes were placed inside the stones, leaving only the mouth parts as openings, so that they did not have any visual effects on the interior. Since the inner surface of the dome is smoothly concave, the direct sound coming out of the source and reaching the dome tends to meetat a single point. The dome is an acoustically undesirable form due to this feature. Meanwhile, thetime that may occur between the sounds reflected at different distances may also cause different echoes (Kayili 1988). The fact that Mimar Sinan was placed in accordance with the dome geometry of the cubes ensured homogeneous distribution of the sound and reduced the ringing time. 16 of this detail. The fact that it was thought and implemented in the 21st century shows that a technology and engineering were used beyond its time.

Mimar Sinan has reduced the ringing time with the materials he uses in mosques that have acoustic problems in terms of geometric form. These are Khorasan Mortar and its derivatives. Horansan mortar, soil

Uskudar Mihrimah Sultan Mosque, Istanbul Rüstem Pasha Mosque, Kadırga Sokollu Mehmed Pasha Mosque, Canabi Ahmed Pasha Mosque have used Sinan Khorasan Mortar to absorb the sound reflected from the dome on the surfaces. Khorasan mortar is a binder consisting of lime, aggregate, gravel, sand and broken soil pieces. It is of mineral origin, porous and soft structure. It shows better swallowing at low and medium frequencies. When Khorasan mortar is used as plaster, it is mixed so that 50% by weight is lime and it is preferred to use smaller granular aggregates. Flax and wool pieces are added to the classical Khorasan mortar and scarce Khorasan mortar is added. It is known that Sinan used this mortar in some of his mosques (Kayili 1988).

Sound absorption values of lime-added plasters vary over time. The material varies to different degrees for the swallowing it shows at all frequency values (Nursal, Tavukçuoğlu, and Çalışkan

2016). Therefore, the comfort of the buildings where these plasters are used is different from the current acoustic comfort.

Apart from using direct resonators or materials for acoustic analysis, Sinan also arranged the orientation of the carriers, walls or the niches, enclosures and large surfaces where the sound was dispersed.

CONCLUSION

Mankind has built places for listening since the Ancient Greek Period. Over time, space comfort has been increased by making additions and changes in these spaces. Ancient theaters can offer acoustic, climatic and visual comfort conditions and give almost similar results to today's structures.

In ancient times, natural resonators were used for acoustic arrangements in theaters. These resonators are double-layered and planned to reflect or swallow according to the note of the music. It allows the sound to reach the rear most. These resonators, which are obtained by carving stones and placing bronze cubes in them, show how advanced the technology and acoustic knowledge of the Roman period is. Other resonator types used in the Roman period are amphoras. Roman amphoras are long water jugs made of terracotta. Although its main purpose is to store wine, it has also been used for acoustic purposes. The mouth parts are placed facing the sound source in accordance with the geometry of the space.

The beginning of Turks leaving permanent artifacts in Anatolia is based on the Anatolian Turkish Seljuk State. The Seljuks are in the beginning phase of the transition of the migrating Turks to the settled life. Therefore, the buildings in this period were originated from ancient Anatolian civilizations. Structures were built by taking only physical elements as an example, without knowing their main purpose. An example of this is the use of the jugs in the structure, except for the purpose of the resonator. In the Roman period, jugs were also used to alleviate the structure, and in the Seljuk period, jugs were used to alleviate the structure. However, contrary to the Roman period, there are differences between both the dimensions and the ratios of the jugs used. In addition, the amphoras used for resonator in the Roman period were also used as water cubes in the Seljuk period. Similar practices continued to be developed in the Ottoman Period. The most obvious examples are seen in the rise phase of the Ottoman Empire during the period of Mimar Sinan. Sinan guided the sound with the technology of that day, absorbed it where necessary, and enabled it to make an echo and create an acoustic shadow. As the volume grew, it caused the sound to break down more to prevent it from resonating, and used reflective surfaces in the right places to reach the rear. While making these acoustic plans, natural resonators made of water cube, plasters and mortars made of soil material were used. Süleymaniye Mosque, Üsküdar Mihrimah Sultan Mosque, Sokollu Mehmed Pasha Mosque are examples of structures where water cubes are used as resonators, soil additive mortars are used and passive acoustic guidance is made.

Throughout history, various types of structures have been built that require acoustic planning. Although the materials and construction techniques vary over time, the acoustic planning and the working principle of the materials remain the same. Soil material was also used for acoustic regulation for a period of time and some samples have survived to the present day. It has been determined that the soil material is mixed with additives for acoustic purposes and used in plaster form and as a test by cooking and shaping. In this way, different properties of the soil material were utilized and the same material exhibited different sound absorption. The material, which has the feature of porous material in the form of a plaster, has the feature of a resonator while being tested.

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15- Preservation and Reuse of Traditional Rammed-Earth Houses, Floating Cloud Township Villa in Qinglongwu, China

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ABSTRACT

Historical buildings serve as historical documents that reflect the urban and architectural style of their own period, built upon the social, cultural, and economic accumulations of the society, to which they belong. Today, the method of choice in the preservation of historical buildings, which as a cultural and historical heritage represent the societies' bond with both the past and the future, is to furnish such buildings with a new function.

The rammed-earth construction technique is one of the systems of construction that found effective use throughout the human history. Today, the rammed-earth technique has come to the fore in the midst of increased concerns about the environment as an alternative construction technique due to the fact that it is easy-to-apply, relies on abundant natural resources, and meets both structural comfort and sustainability and aesthetic concerns. The extant examples from different regions of the world and different time periods are indicative of the fact that the rammed-earth construction technique can adapt to different geographies and conditions, and furthermore, the structures built upon the said construction technique also provide a great potential for the re-functionalization practices.

The present study aimed to draw attention to the reuse potentials of the rammed-earth construction technique and rammed-earth buildings and to increase awareness thereof. In this context, first, the rammed-earth construction technique was discussed based on a review of relevant printed and digital literature. Subsequently, the process of re-functioning of the Floating Cloud Township Villa, i.e., the subject of the present study, and the interventions carried out in the context thereof were examined based on visual sources. A general assessment of the present study and the inferences were included in the conclusion section.

Keywords: Rammed-earth technique, preservation, reuse, historical buildings, China

1. INTRODUCTION

It has been suggested that the use of earth structures appeared with the first agricultural communities, corresponding to a time period between 12000-7000 years BC. The earth structures were preferred, produced, and used for different purposes throughout the history. [1] Upon a review of the thousands-of-years-old structures or ruins, it is evident that earth structures could remain surprisingly robust compared to today's structures. [2] Despite the fact that the interest in the earth construction technique was declined upon the discovery of cement and the construction of the first reinforced concrete structures, the use of earth as a building material came back to the agenda in the 21st century thanks to the development of environmentally friendly design awareness, and the interest in the use of earth material in building construction increased due to its sustainable features, including the use of local material, low embodied energy, and low waste generation compared to modern construction methods. The rammed-earth technique has a great potential for the future as much as it was a part of the past, because the same is an environmentally friendly, strong, and even aesthetic material today. [3] Different techniques are used in the construction of earthen buildings, including poured earth technique, light earth technique, compressed earth block technique, adobe technique, in-situ poured earth technique, wattle and daub technique, and rammed-earth technique. Of these, the rammed-earth technique is one of the most preferred earth construction techniques. [1]

2. RAMMED-EARTH CONSTRUCTION TECHNIQUE

In its most basic form, the rammed-earth construction technique is a type of load bearing masonry construction system, in which earth is used as the main material, bearing element, and non-bearing divider system element. It is based on the principle of compressing uncooked soil into molds with the necessary equipment. [2] Rammed-earth, which is the most durable of the earthen construction forms, can also be used to produce the building elements or to build all the walls in situ layer by layer. [4] The technique is also commonly referred to as “Pisé” and “Pisé de Terre” in French. [5,6] The first examples are from China and its near abroad, dated as early as the 2000s BC.[2] Widely preferred in China, the technique was used in both the ancient monuments and local architecture, where the rammed-earth technique was also utilized during the construction of the Great Wall of China. [3] The thickness of the walls made with the rammed-earth technique reaches up to 2-4 meters with their length reaching up to 70 meters. Standard 400 mm thick rammed-earth walls can be used as bearing elements in structures up to four floors high. The technique is generally proliferated in hot and moderate climate regions, and has no example either in Antarctica, due to the arctic climate and weather conditions, or in the desert regions due to the soil characteristics. The aforementioned construction technique is more prevalent in regions, including India, Mediterranean coast, Brazil, and Nepal. [2,4]

As regards the traditional examples, the technique was preferred, where the soil composition was not suitable for producing sun-dried clay bricks and where stone and wood materials were limited. For a long time, no binding material was used to hold the soil together, relying on the combination of the minerals in the soil with water and moisture. [2,5] However, in some regions, lime or animal blood were used as a binder to increase stabilization. [4] There was no limitation in the use of technique by building type in the traditional examples, but it was noted that it was mostly used in the construction of residences, palaces, and city walls. Although there were periods, when the technique was considered old and outdated, the interest in the earthen structures continued in every period due to the limited resources used in the construction sector, the costs and difficulties associated with the transportation, procurement, and personnel training of newly construction materials. The housing problem that emerged in Germany especially after the First World War can be said to have revived the interest in the soil material, which was easy to provide, cost-effective, and simple to work with. Institutes were established and relevant training was introduced to the public during the 19th century with an aim to further improve the earthen structures. Since the 1970s, the use of rammed-earth as a sustainable construction material has been promoted in Europe and the United States in the midst of increased environmental concerns. Today, rammed-earth technique is used for construction purposes pursuant to the respective technical construction codes in many developed countries, including Canada, the United States, and Australia, and the same is also incorporated into the reinforced concrete construction codes in combination with steel elements and cement additives to ensure stabilization in the current practices. [2,5]
The ease of supply and processing of the material and fitness to practical experimental studies has

enabled the improvement of material properties. As a result, having been adapted to today's conditions in terms of structural engineering and building physics, the uses of the material expanded especially during the last 20 years, yet the construction principle of the elements made with this technique has not substantially changed compared to the practices in the past. In this context, the rammed-earth construction technique consists of certain stages, including soil selection, binder addition, mold installation, mix placement, compression, curing, and surface finishing.

The soil to be used in the construction of the building is sourced in situ, where due care should be taken that the selected soil layer is free of organic components, rich in minerals, and no harm is inflicted to the agricultural land during the process. After the first layer intended for agriculture uses is removed, soil with brown and red minerals, which accumulated upon rainfall over time, should be selected and used in the production of building elements and walls after having been left to dry for a certain period of time with an aim to balance the moisture content. During the said stage, upon sifting the soil, the dry mixture should be well mixed and the particle sizes should be evenly distributed within the soil material. Soil must have a ratio of 70% by volume in the mixture, with 30% spared for additives and sand to be included in the mixture. Another important element of the mixture is to determine the amount of water. There is no definite ratio, while the parameters, including the type of soil, mineral content, and sand content serve as determinant factors as regards the amount of water to be added. [2]

In general, a number of field tests are conducted on the samples collected from a depth of 0.5 meters on site to ensure that the soil is free of organic matter. In the drop test, a handful of unscreened soil is taken, moistened, and balled, held in the hands and left to dry for a few minutes, and then dropped on the ground. If the ball breaks into a few pieces, this means that it has a good mixture. In the jar test, on the other hand, two-thirds of a bottle is filled with soil collected on site and the rest of the bottle is filled in with water. The bottle is left to rest for a few hours after being shaken until all soil particles are suspended. [5] As the water becomes clear, humus, water, clay, silt, sand, and gravel settles down to the bottom of the bottle from light to heavy, respectively. Subsequently, it is necessary to measure the whole part of the mixture consisting of solid particles, and then to measure each layer separately. Although the mixture depends on the type of soil available in the field, it should be proportioned to 100 if the clay layer measures 2 cm thick out of roughly 7 cm thick solid mixture with an aim to achieve stabilization. [2] Another ratio is suggested as 2.5 gravel, 2 rows of sand and 2.5 clay based on field study. Thereafter, the mixing stage is the most necessary process to ensure the homogeneity of the soil in use. After the full dry mixing process (using the drum mixture), water that will make up about 10-15% of the mixture should be gradually added, but the effect of the field conditions must be taken into consideration due to water evaporation especially in hot weather. [5]

After the preparation, the soil mixture should be stored until it is poured into the formworks in a way that it is not affected by the weather conditions. The formworks should be prepared in the desired wall thickness and the soil is compressed up to approximately 50% of its original volume after poured into the formworks. While wooden formworks were preferred in the traditional method, plywood, steel, and concrete formworks are used today along with wood. While a long compression pole was used in the traditional method, electric or air compression guns are used today. [2,4,5] The time-to-removal of the formworks depends on certain variables, including the thickness and volume of the wall and humidity rate. In order to dry the wall, it should be covered and dried in the shade instead of direct exposure to the sun, and the walls should be kept moist for at least 7 days after the formworks are removed in order to prevent shrinkage cracks due to likely rapid drying. Upon achievement of complete dryness, various coating elements of choice can be used or the surfaces can be left as is. [2]

In many examples, wall thicknesses of at least 30 cm generally create high thermal capacity and improve indoor conditions in geographical areas with high temperature differences between night and day. Today, plaster, bitumen, or flaxseed oil is applied to the wall surfaces to increase the resistance to weather conditions, especially in rainy climates.[4] In addition, the walls can be insulated internally or externally during the construction phase and the foundations are laid at a height of at least 225 mm from the ground level in order to prevent potential water damage. In the current practice, cement is added to the conventional soil mixture as a binder to both eliminate insulation deficiencies, and increase the load bearing capacity of the rammed-earth, and steel elements and reinforcements are also used to increase the bearing capacity of the walls. [2,3] The above technique is rather called stabilized rammed earth (SRE) construction due to the ingredients in the mixture. Especially preferred in Australia, the SRE method creates less sustainable buildings due to the high embodied energy of cement, although it promotes the rammed-earth construction technique. However, here, the designer needs to decide the method of choice upon an assessment all the parameters including, climatic and structural requirements, and requirements with regard to durability and sustainability. [3]

Today, the rammed earth technique and stabilized rammed earth technique are not only used in the construction of new buildings, but also the traditional rammed earth buildings are preserved by contemporary restoration interventions based on the said techniques with an aim to have the old buildings acquire modern and diverse functions. Today, preservation by re-functioning is the most preferred method in the preservation of historical buildings, which represent the societies' bond with both the past and the future, as a part of the cultural and historical heritage. In fact, history not only tells the past, but the history of the future generations is created right now by us.
[7] The reusability potential of the contemporary earthen buildings are important for the protection and perpetuity of the cultural heritage thanks to the fact that the earthen buildings with all their ecological benefits can decelerate the urban sprawl and that such buildings can be handed down to the future generations as the historical documents of the day. This is as important as adopting reusability in preserving the traditional rammed-earth buildings, which serve as the historical documents that represent the social, cultural and economic accumulation of their society and reflect the urban and architectural style of their time. [7,8] The reuse potential is remarkable basedon its lower construction cost, faster construction, and the potential to transform the historical buildings into new and unique symbols by preservation. [8]

3. FLOATING CLOUD TOWNSHIP VILLA

A recent example of the preservation of the rammed-earth buildings by re-functioning was introduced in Zhejiang Province of China by the More Design Office, a Shanghai-based Architecture Office. The project involved in a housing cluster consisted of six buildings as transformed into a series of contemporary guesthouses called Floating Cloud Township Villa and included in daily life (Figure 1). [9] The design phase started in 2017 and the project was completed in 2021. [10] The project that was realized on an area of 1300 m2 with the re-functionedrammed-earth houses located in Qinglongwu village, which was transformed into a cultural and touristic center known as Fangyukongxiangsu Cultural and Creative Complex in Tonglu County. The houses, which were refunctioned as guesthouses would meet the accommodation needs of the tourists, who were expected to visit the village within the scope of the transformation project in the region (Figure 2). [9,10]

Figure 1. Floating Cloud Township Villa project, views [9]

Figure 2. Floating Cloud Township Villa project, plans and sketches [10]

Figure 3. Views of the traditional rammed-earth houses in original status and in their novel use [10]

The six existing earthen buildings in the village were modernized upon preservation of their characteristics during the re-functioning process (Figure 3). Two concrete buildings with certain functions, including reception, bar, and recreation area were added to these buildings considering the new touristic use of the settlement. [9] The design concept was to create an out-of-town retreat, where the users could feel the history and material culture of Qinglongwu, and where they could feel themselves as a whole with the nature. [10]

Figure 4. Interior views of the reuse of traditional rammed-earth houses [10]

Figure 5. Reused traditional rammed-earth houses and contemporary concrete buildings [12]

All of the buildings in the project had their time-bound and patina features and relations with the landscape were preserved, and they were located in a valley very close to each other along a cobbled street, each facing the bamboo forest surrounding the village. [11] The project aimed to provide visitors with an exclusive experience apart from traditional luxury hotels. And accordingly, the marks and defects on the surfaces of the original walls and windows of the earthen buildings, which qualified as the historical documents of their time, were preserved upon repairs by the help of the craftsmen so that they could continue telling their past history. [12] The project made an endeavor for preserving the original materials and finishes on the earthen structures as much as possible, and the contemporary annexes were added as a distinctive layer onto the structures so that the guests could clearly differentiate the original parts and the contemporary annexes. [9] The original wooden roofs were damaged beyond restoration, thus a new steel structure was built inside the existing walls. [11] In this way, both the ceiling height of the buildings could have been increased and the roof windows were created to enrich the atmosphere of the space. Guests could see the bamboo forest through these windows, and stay in constant contact with the bamboo forest landscape. New window openings inspired by original square windows were created with an aim to provide more light into the gloomy spaces of the traditional buildings. In this process, contemporary windows were designed with thin metal frames so that they could be distinguished from the original wooden framed windows. The windows were positioned so as to display the unique forest view in a picture frame as seen from the sofa and the shower (Figure 4). [9, 12] The contemporary structures added to the original structures at the foot of the mountain road were built of rough concrete to create a contrast with rammed-earth structures. [9] This design approach strengthened the distinction between the private and common spaces as well as the original and new spaces (Figure 5). The two reinforced-concrete structures replacing the two soil structures beyond repair as located nearest to the mountain road were considered an opportunity to strengthen the connection between the rural and the nature. The form of the buildings was inspired by the appearance of the rocks that burst out of the slopes as a result of the erosion of water and wind. The sharp contrast in the surfaces between the new buildings and the traditional structures was created as a result of the desire to emphasize the old and new distinction of the overall design. Accordingly, it was expected that the rough concrete surface coating would gain natural patina in a short period of time due to the effect of rain, sun, and snow, and thus the reinforced-concrete buildings would have the appearance of a natural rock as desired, softening the boundary between architecture and nature. It was also contemplated that the contemporary buildings would serve as beacons to guide travelers and invite inside people, who approach from any direction, as inspired by the traditional lighthouse culture. [12]

CONCLUSION

The earthen structures that emerged with the first agricultural communities were constructed and used in many different cultures throughout the history and called with different names. Once lost their importance for a period due to the use of cement and steel as building materials, the rammed-earth structures, the first examples of which were seen in China as early as the 2000s BC, came to the agenda again by the 21st century thanks to the increased environmental concerns and consciousness. Upon a review of the traditional rammed-earth structures that survived to the present day, it was seen that such structures were extremely durable and were used across a wide geography without limitation to building type, except for Antarctica and the desert regions, where climate and vegetation constituted obstacles. The traditional rammed-earth structures are ecologically beneficial thanks to their low water and material requirements, ease of supply and recyclability of soil material obtained on the construction site, sound and thermal insulation, fire resistance, low greenhouse gas emission, reusability of the formworks, and preservation of agricultural soil during the construction. Furthermore, they are also beneficial thanks to their high endurance and the fact that they ensure that the architectural features that shed light on the social, economic, and social life of their period reach the present day, ensuring and maintaining cultural perpetuity.

In contemporary applications, there are no major modifications to the traditional construction technique, and the soil is basically compressed and used as the main material, bearing structure, and non-bearing divider system element. However, in contemporary practices, chemical additives were used to ensure that the said technique can easily be used in non-hot climates and to increase the structural resistance to external factors, including rainfall and earthquakes compared to traditional examples, with partial withdrawal from the use of completely recyclable materials in molding, compression, curing, and surface finishing processes. The interventions, including the transportation and production of cement used as a binding element in the stabilized rammed-earth structures and similarly the transportation of certain insulation materials can greatly increase the greenhouse gas emissions compared to the traditional method, although these buildings can still be considered ecological on the grounds that they do not have negative characteristics such as the use of 100 percent chemicals and the supply of materials away from the construction site. Given that history not only tells the past, but also the history of future generations is created right now by us, stabilization of today's earthen structures is beneficial despite certain ecological disadvantages thanks to the ability to use the technique in a broader geography compared to the traditional technique and the fact that the examples of contemporary earthen architecture built even in less favorable climates can be handed down the future generations, thus ensuring cultural perpetuity. Both the traditional and stabilized rammed-earth techniques are suitable for reuse applications, i.e., the most valid contemporary conservation approach. This aspect helps to ensure economic and cultural continuity thanks to the said techniques' lower construction cost and faster construction, and the opportunity of preserving buildings that have historical value today and will also have in the future, and the potential to transform them into new and unique symbols as admired by the society. As a result of the study, it was seen that new employment opportunities were created for local workers, who mastered the traditional technique, in the repairs of the traditional buildings in the Floating Cloud Township Villa project, which envisaged the reuse of six earthen structures located in the Zhejiang Province of China. Furthermore, the design interventions intended for the parts of the buildings beyond repair or modification to the interior living, which utilized different materials for different periods thanks to the very characteristic of the rammed-earth structures, which allows the use of diverse materials, improved the extant historical value of the buildings and incorporated the aspects of the day. The stabilization and renewal processes carried out in earthen buildings are essential for the safety of the buildings so that they can host the guests. In this context, despite the fact that the greenhouse gas emissions of the original buildings have increased, ensuring the survival of those culturally valuable buildings in contemporary use and being experienced by the new generations is positive as regards cultural continuity. Although the contemporary reinforced-concrete buildings added to the six original buildings were not ecological in terms of construction materials, they were in compliance with the contemporary preservation approach based on the emphasis that the old and the new could be perceived as distinct layers and the contrast between them could be differentiated. The similar contrast created between the original walls and contemporary partitions and the furniture in the interiors of the traditional buildings strengthened the said sense of historical layering and its readability.

As a result of all these inferences, it was concluded that the rammed-earth method, which was considered as a historical technique and mostly associated with hot and moderate climates, could be built in very different climates, that the rammed-earth buildings could be reused by preserving the features of different historical periods in accordance with the contemporary conservation approach, that this method and the reuse of the structures built with this method could greatly contribute to ecological, economic, and cultural continuity today as it did yesterday, and notwithstanding above, the designers should make design decisions upon an case-specific assessment especially in terms of the ecological, economic, and cultural dimensions of continuity.

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16- Palanga Goat Shelter

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ABSTRACT

Palanga Art and Architecture Farm (PAAF) is located in the northeastern part of Turkey and the Goat Shelter is part of the sprawling property of the farm. It has been designed in line with goat physiology, geographical features, local climate and seismic demands of the land. The project entails a structure with high earthquake resistance designed by using two semi-circular rammed-earth walls of different diameters on a deep stone foundation. Project design (by Erginoğlu & Çalışlar Architects) was initiated with approaches such as seeking sustainable solutions, adapting to current conditions, using natural materials and traditional stone-earth-timber craftsmanship as a construction technique, communicating with the craftsmen in the region and producing collective knowledge, coordinating with academic parties, putting materials to the test and questioning technical decisions. An age-old technique called khorasan was recreated and used to build the foundation and the surrounding walls. The structure is a successful experimental example of zero-impact construction. It has the feature of completely dissolving back into nature without leaving any trace or impact.

Keywords: Palanga, local, architecture, multidisciplinary, goat, shelter, rammed-earth, wooden structure.

1. INTRODUCTION

Palanga Art and Architecture Farm (PAAF) is located in the northeastern part of Turkey and falls approximately 1200 kilometers to the east of Istanbul. The PAAF project is first of its kind in Turkey. PAAF'S motto is "from agriculture to culture". The owner of PAAF is Kutluğ Ataman, who is a Turkish filmmaker and contemporary artist. He lives in Istanbul, Erzincan and London. The Palanga of Mehmet Ali Bey, where he started his experimentation, is nearly two hundredth of its original sprawling size, now down to only 100 hectares. The land was administered by his family since 1473. Since then, wars, revolutions, earthquakes, massacres and economic downfall reduced the land to its current size. He acquired palanga in 2014 with the aim of turning it into a hideaway for himself and his friends. Later on, Ataman decided to run it as a profit-making holistic ranch that would create employment for the locals.

The word "Palanga" means small fort in the Turkish language. In time, the word came to indicate a large semi-communal ranch, where working families were employed by the local bey responsible for their economic and social needs including, but not limited to, the administration of justice, healthcare and, to a lesser degree, education. The families were entitled to half of a Palanga's generated income. During the Republican Era, this system was abolished, but entire areas of land continued to be referred to as palangas.

The farm contains several projects such as KA House, House of Chicken, Goat Shelter, Semi Open Cattle Barn etc. (Figure 1) When the main building received critical acclaim, as well as two international design prizes, Kutluğ Ataman mustered the courage to turn Palanga into an architectural collection documenting contemporary Turkish architecture. As a result, he decided to knock down the workers' buildings in subsequent years and commission established and young architects to rebuild them. Once the house project designed in collaboration with Erginoğlu & Çalışlar Architects was completed and he began living on the farm, he came to notice the need for a number of different structures in varying sizes. [1]

Erginoğlu & Çalışlar Architects is an Istanbul based, independent firm of architects founded in 1993 by Hasan Çalışlar and Kerem Erginoğlu. The firm specialises in urban planning, architecture, and interior design projects together with providing assistance for planning applications. In addition to architecture and design services, the partners also give lectures and organize architectural workshops in universities across Turkey.

In due time, Erginoğlu & Çalışlar Architects put together a selection of young, promising and up-and-coming architects capable of undertaking such a project and Kutluğ Ataman and his team evaluated them together. The curator, Hasan Çalışlar, also suggested inviting several renowned Turkish architects to the project to motivate their young colleagues. This proved highly effective, giving PAAF the opportunity to observe how different generations of architects treated the subject with their respective experiences on the same terrain.

Figure 1. Aerial view of PAAF, PAAF 2021

1.1. PURPOSE

When looking at reference projects for rammed-earth construction technique, which have survived to the present day, it is understood that it is a technique that can easily adapt to changing conditions. The aim of this project is to analyze the basic principles of the rammed-earth construction technique, which stands out as an alternative to existing construction techniques, with drawings containing simple experimental setups and to examine the interaction of the technique with other disciplines. In this project experience is shared on how a masonry building with a wooden roof structure was built in Erzincan climate and geological conditions. The priority principle of this constructionis avoiding the usage of concrete, cement and chemical additives.

1.2. SCOPE

Palanga Goat Shelter started as an architectural project to take place in PAAF. The project has been shaped by research conducted before and after construction, additionally was presented at national and international conferences and platforms.**[2]**, **[3]** In 2020, it was awarded in the project category of the national architecture awards.**[4]** The construction process, which started at the end of 2019, was completed at the end of the summer of 2021 after the pandemic.

1.3. METHOD

Palanga Goat Shelter project started with the design of Erginoğlu & Çalışlar Architects. Later advanced by receiving multi-disciplinary consultancy such as; vernacular architecture, archaeological restoration, civil engineering, agriculture and art. Progress has been made by conducting material tests in university laboratories. During the entire construction period in Erzincan flow of information continued between the consultants, PAAF and Erginoğlu&Çalışlar Architects. All these recorded data have been archived. This study was prepared by compiling in a certain cause and effect relationship.

2. PALANGA GOAT SHELTER

Palanga Goat Shelter (Figure 2) designed within the framework of the requirements in PAAF and Erzincan; goat physiology, geographic attributes, local climate and seismicity. In a region where there is a shared earthquake memory based on the second strongest earthquake recorded in 1939 in Turkey. For this reason, it is of great importance that the structure to be proposed here is highly resistant to earthquakes.

The architectural design phase has been advanced by taking all the geographical features of the land into account. The prevailing wind direction, the snow load on the roof, etc. Another aim of the project is to minimize the carbon footprint by producing the goat shelter using completely local materials and local labor. In addition, local materials and construction technique do not contain any chemical additives. Attention has been paid to ensure that the materials to be used are durable and maintenance-free. Another important point is to choose the kind of materials that the goats cannot eat.

Figure 2. Aerial view of Palanga Goat Shelter during construciton, *PAAF 2021*

The earth material near PAAF was tested for earthquake resistance before the construction. According to laboratory test results, the type with the highest strength was obtained. In order to obtain the required strength without using concrete, cement-free hydraulic lime is used as a binder in the stone foundation. After laying the foundations, in order to slow down and control the strong winds coming from the northwest, the construction process continued by creating a wind barrier with pile of earth that rose and damped in a curvilinear direction around the shelter walls. (Figure 3)

The purlins and rafters of the roof that will cover the shelter are made of poplar wood. The coating is made of twigs, jute and covering materials and is detailed with a high degree of inclination against snow load. It is planned to make a non-hydraulic natural mortar using archaeological restoration techniques on the roof surface. Thus, a durable roof that will need less maintenance and high impermeability will be created. Floor purlins are placed instead of reinforced concrete beams where the purlins sit on curved earth walls. (Figure 4)

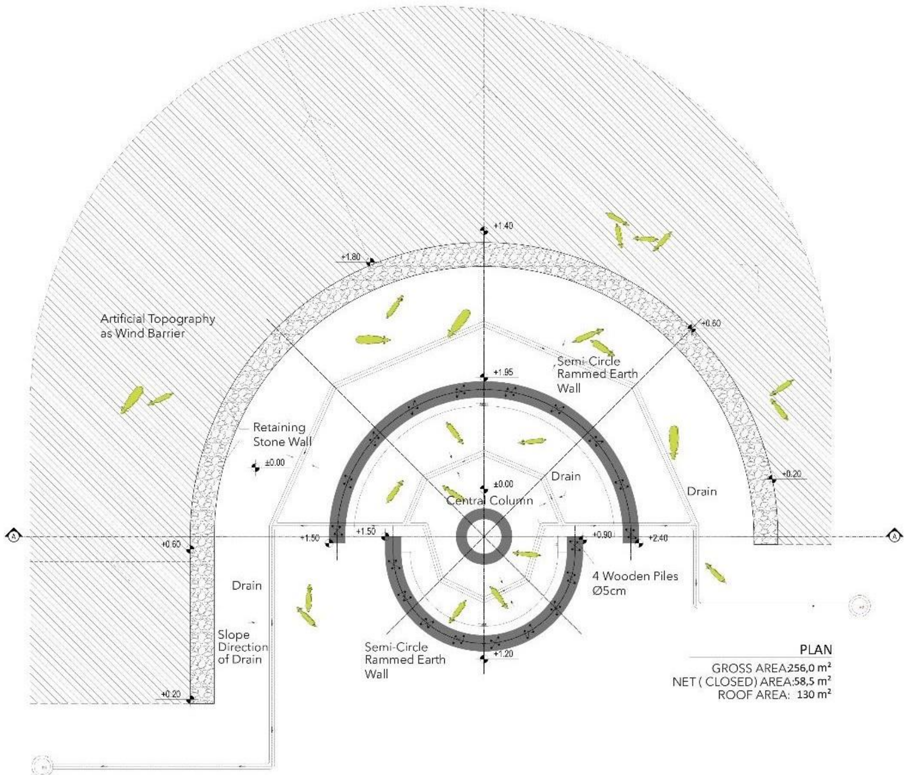

Figure 3. Floor Plan, Dilara Demiralp, 2019

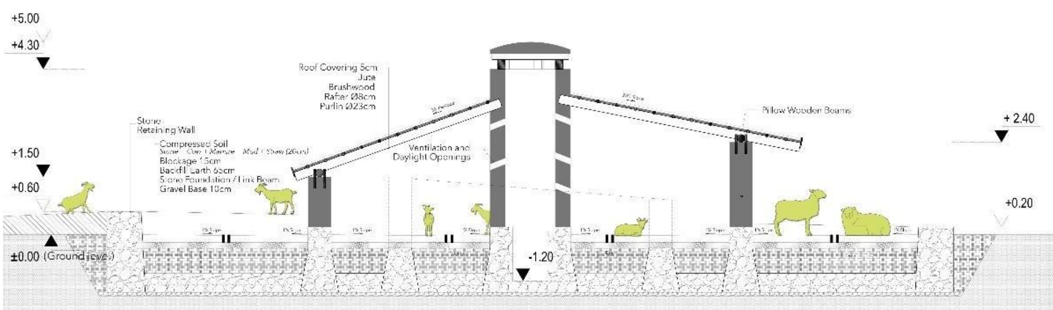

Figure 4. Section, Dilara Demiralp, 2019

2.1. PRE-CONSTRUCTION MATERIAL ANALYSIS

2.1.1. LABORATORY EXPERIMENTS

In Palanga, Prof. Bilge Işık has determined the suitable points for earth alternatives. The soils extracted from the selected points were tested in ITU and Erzincan Binali Yıldırım University. The contents of the samples, consisting of gravel and sand, were determined by "sieve analysis".

(Table 1) and (Table 2) Consistency limits have been determined for universal nomenclature of samples with the combined soil class system.

Excavated soil from the construction of the PAAF cattle facility, the E1 sample, performed best in these "sieve analysis" and "compressive strength" tests. (Figure 5) The soil to be chosen as a source must be devoid of organic components, rich in minerals. In addition, damage to agricultural lands must be avoided during the process. At this point, the first thing to do is to strip the first layer of soil rich in organic components and devoid of minerals to be used for agriculture. Layer underneath is needed.[5]

Numune Adı =	E1	E2	K1
Numunenin Çakıl İçeriği (%) =	2,4	10,8	14,8
Numunenin Kum İçeriği (%) =	88,0	23,6	33,7
Numunenin Silt İçeriği (%) =	8,9	62,8	48,3
Numunenin Kil İçeriği (%) =	0,7	2,8	3,2
Numunenin Silt + Kil İçeriği (%) =	9,6	65,7	51,5
D10 =	0,090	0,009	0,007
D30 =	0,600	0,045	0,025
D60 =	1,800	1,800	0,400
Üniformluk Katsayısı, Cu =	20,0	*	*
Derecelenme Katsayısı, Cc =	2,2	*	*
Likit Limit Değeri, LL =	17	37	34
Plastik Limit Değeri, PL =	*	23	21
Plastisite İndeksi, PI =	*	14	13
Zemin Sınıfı =	SW-SM	ML	ML
SW-SM =	İyi derecelenmiş siltli kum		
ML =	Düşük plastisiteli silt		

Table 1. Sieve analysis results of E1, E2, and K1 Samples, Istanbul Technical University, 11 September 2020

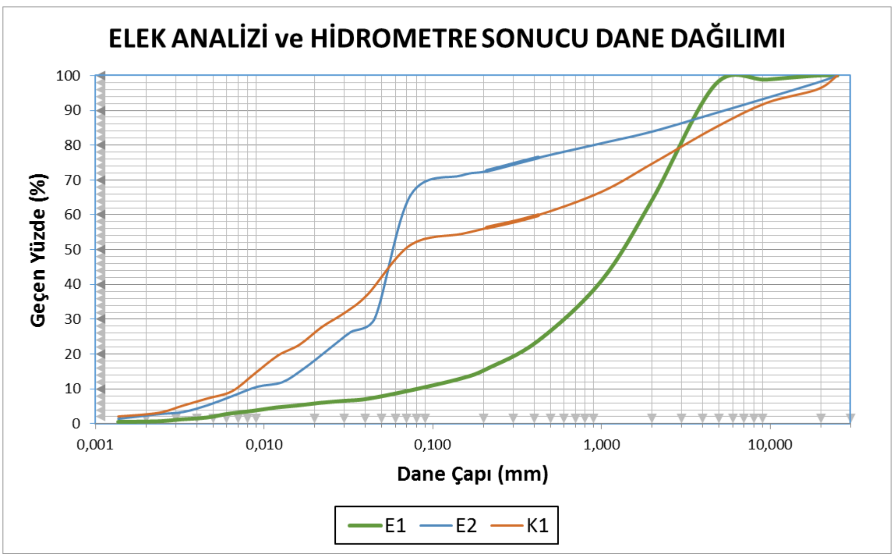

Table 2. Grain distribution as a result of Sieve Analysis and Hydrometer Measurements of E1, E2 and K1 Samples, Istanbul Technical University, 11 September 2020

Excavated soil from the construction of the PAAF cattle facility, the E1 sample, performed best in these "sieve analysis" and "compressive strength" tests. (Figure 5) The soil to be chosen as a source must be devoid of organic components, rich in minerals. In addition, damage to agricultural lands must be avoided during the process. At this point, the first thing to do is to strip the first layer of soil rich in organic components and devoid of minerals to be used for agriculture. Layer underneath is needed.[5]

Figure 5. E1 soil sample (in the middle) was tested for compressive strength and passed, Erzincan Binali Yıldırım University, 22 October 2020.

2.1.2. RAMMED-EARTH WORKSHOP

As of May 2021, construction process has began with a workshop held in Istanbul with the consultants. (Figure 10) The soil mixture was prepared according to the following formula: 10% Gypsum + 5% Lime + Earth from Erzincan

Figure 6. Rammed-Earth Workshop with the sample soils from Erzincan, 26 May 2021, Participants: Prof. Dr. Bilge Işık, Suat Işık, Suat Güvenç, Dilara Demiralp

3. CONTENTS OF PALANGA GOAT SHELTER

3.1. STONE FOUNDATION AND RETAINING WALL

The construction of the project started with the construction of stone foundation and retaining wall in the winter season of 2019. Due to the fact that Erzincan is an earthquake zone, the depth of the foundation reached 150 cm. (Figure 7)

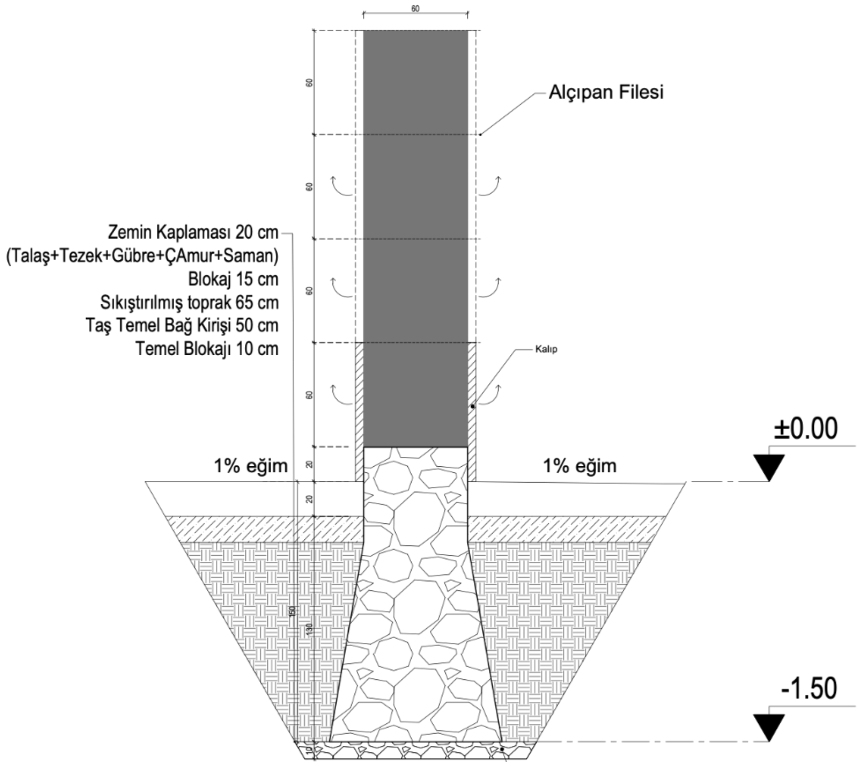

Figure 7. Principle section for rammed-earth wall and stone foundation, Dilara Demiralp, 2019

An age-old technique called khorasan was recreated and used to build the foundation and the surrounding walls. In order to obtain the required strength without using concrete, a mortar of hydraulic lime and Khorasan mortar, which does not contain cement, was used as a binder on the foundation. The foundation level was left 15 cm above the 0.00 level and the wall level was kept above to prevent water intake (Figure 8).

After the foundations were laid, a wind barrier was created around the shelter walls with an earth filling that rises and dampens in a curvilinear direction in order to slow down and control the strong wind coming from the northwest (Figure 9). Soil was piled up behind the stone masonry retaining wall and the pile was expected to settle and turn green for 1 year.

Figure 8. Stone foundation upper level is 20 cm above ground, November 2019

Figure 9. Retaining wall as a wind barrier with horizontal wooden beam inside, December 2019

3.2. EARTH WALL

Erzincan has a continental climate with cold, snowy winters and hot, dry summers. Spring is the wettest season whilst summer is the driest. The lowest temperature recorded was −32.5 °C (−26.5 °F) in January 1950. The highest temperature recorded was 40.6 °C (105.1 °F) in July 2000. The highest snow thickness recorded was 74 cm (29.1 inches) in February 1950. Use of adobe is common in such climates. In order to ensure Erzican is an earthquake zone, structure with high resistance was constructed by using two semi-circular planned rammed-earth walls with different diameters on a deep stone foundation.

After the foundation construction, the wall construction couldn't be possible to start immediately. Due to COVID-19 pandemic construction has stopped for a year. In order to ensure Erzican is an earthquake zone, structure with high resistance was constructed by using two semi-circular planned rammed-earth walls with different diameters on a deep stone foundation.

According to the mixing ratios of the sample made in the workshop in Istanbul, a sample was made in Erzincan according to the following formula, 10% Gypsum + 5% Lime + Earth from Erzincan, then the first 60 cm of the two main walls were built.

Figure 10. The first 60 cm of the two main earth walls were built., 10 June 2021

Expected results could not be obtained. Problems were detected in the bonding of the mortar due to ruptures and rapid drying on the wall surface.

Figure 11. Soil mixture samples at different ratios were prepared and poured into the mold, 20 June 2021

Unlike the mixture in the workshop in Istanbul, a new formula was tried by considering the hot weather conditions and soil type in Erzurum. Since gypsum is a material that absorbs water, it was removed from the mortar. There are breaks and cracks in the surface.

Tile powder (or crushed ceramic) as an aggregate can be found in mortars associated to water-bearing structures from the early Hellenistic to the early Byzantine periods. Tile powder can also be found in mortars that aren't immediately related to water-bearing structures, such as those used to keep the inside of a wall dry. [7]

The aggregate used is volcanic material, which was added to mortars by both Greeks and Romans to improve their quality since it increased the hardness of the combination and generated mortars that hardened even underwater (Vitruvius, De architectura II, 4–5, VII, 4 and VIII, 6 and 14). Mortars including volcanic stones were utilized in construction projects requiring higher compressive strength, such as the masonry of the Roman Baths. [7]

Considering these studies [7] shared by Mustafa Çakalgöz; During the casting process, hydraulic lime, cream lime and tile powder were added to prolong the drying time and increase water resistance. The mortar was prepared according to the following formula:

16 kg Hydraulic lime + 14 kg cream lime + 150 dm3 Earth + 12 kg tile powder

1- Mix tile dust and soil (45 shovels) for 5-10 minutes
2- 2- Add hydraulic lime and mix for another 10 minutes
3- 3- Add cream lime
4- 4- Add water until you get the consistency of mud

Figure 12. The earth wall mortar was prepared and applied gypsum additive, 30 June 2021

3.3. CENTRAL RAMMED-EARTH COLUMN

Essence of the historical design with the opening on the top is that the building functions like an atrium, and the opening modifies the indoor climate passively. It gives the user orientation in the space and focuses to bring them together. Also, it creates the smoke escape of the fire place in the center. [6] The rammed-earth column in the center where the purlins are set is also designed to function as a chimney that facilitates the discharge of the methane and gas accumulated in the space, openings on the surface large enough to not reduce the static strength of the overall structure (Figure 13).

Figure 13. The rammed-earth central column with the openings on the surface, 31 August 2021

3.4. WOODEN CONSTRUCTED ROOF

The purlins and rafters of the roof that will cover the shelter were obtained from the poplar trees in the region. Purlins with an average diameter of 23 cm were covered with rafters with a diameter of 8 cm. Poplars were dried for a long time (19 months) with the timber drying technique, as the construction was suspended during the pandemic. It has been cleared of its bark by the timber drying method without being subjected to chemical treatment and made ready to turn into purlins that would form the structure (Figure 13). After the wall construction was completed, the roof purlins began to be placed on the wall (Figure 14). The piles, which were burned with a blowtorch, were left in the drying wall and pillow wooden beams were used to connect the purlins with the wall and were connected to each other with nailed wires (Figure 15). The form of the roof, which will cover the semi-circular walls of which slopes change, also consists of variable slopes. Curvilinear artificial topography is made behind the shelter to protect goats, roof and walls from being exposed to the wind.

Figure 13. Timber drying technique, October 2019

Figure 14. All poplar purlins were carried by the central earth column and attached to certain points on the semi-circle earth walls, 27 June 2021

Figure 15. Poplar purlins and pillow wooden beams joint detail, 27 June 2021

3.5. THE ROOF COVERING

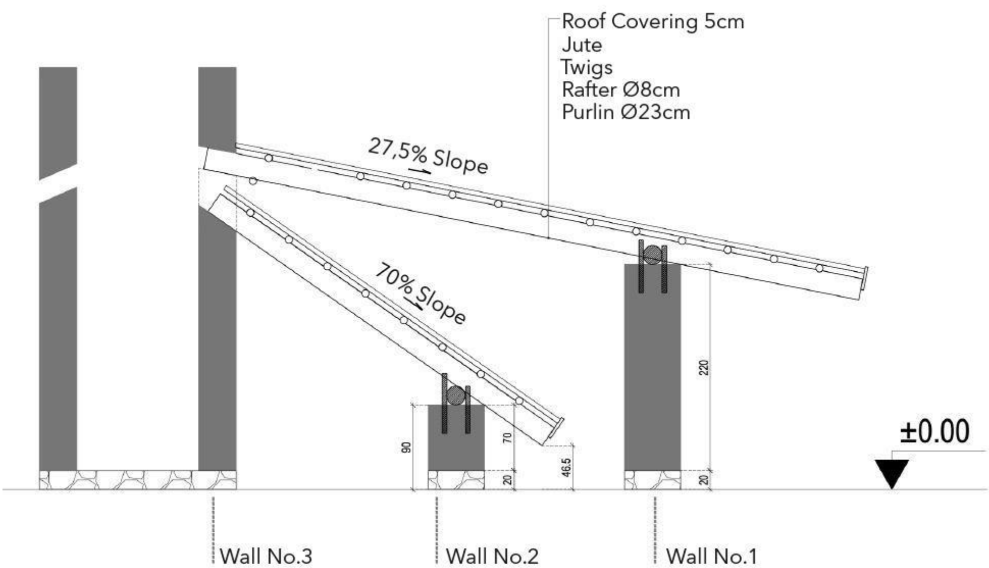

Figure 16. Variable slopes of roof, Dilara Demiralp, 2019

The form of the roof, which will cover the semi-circular walls of which slopes change, also consists of variable slopes (Figure 20). A maintenance-free roof finish material was needed to find that could work in harmony with these slope grades, was resistant to climatic conditions and the movement of goats on it. The coating is made of twigs, jute and covering materials.

The roof covering is made of brushwood, jute and earthen materials and is detailed with a high degree of slope against snow load. A water-proof and maintenance-free layer was created with the archaeological restoration technique. The mortar includes hydraulic lime, cream lime, perlite sand, gypsum and tile dust.

On the basis of archeological restoration technique research; the strength of the mortar can be improved by adding limes to the mix. The grain size distribution of this aggregate, on the other hand, is a critical aspect in this process. The mortars with tile powder (or crushed ceramic) are suited for situations where frost resistance is not a concern but waterproofing is. [7]

The mortar which was prepared based on archeological restoration technique, has created a waterproof, maintenance-free, long-lasting roof layer. There is no soil in the mortar. The roof covering mortar was prepared according to the following formula:

5 units of Hydraulic Lime
2.5 units of Cream Lime
1.5 units of Perlite Sand
2.5 units of Tile Powder

Figure 17. Samples prepared for roofing mix, 16 July 2021

The reed grass was laid on the rafters. A plaster net placed over the reed grass. Then, the mortar for the roof poured on top of them. Perlite was sprinkled on the top surface to make it hardened (Figure 18)

Figure 18. Layers visible during roofing, 31 August 2021

The current situation of the shelter and the roof covering is under control by PAAF. Necessary repairs will be applied after the control to be made in summer 2022 regarding how the building and especially roof covering is affected by the winter and spring climate.

CONCLUSION

PAAF is a privileged, multi-disciplinary and experimental attempt taking place in Turkey. Palanga Goat Shelter is also an experimental project created by an architectural team (Erginoğlu&Çalışlar Architects) with the guidance of consultants from different disciplines. Competent people from academia, art and architecture came together and created a contemporary collective knowledge. The foundations of this knowledge are based on experience, vernacular architecture, culture, animal physiology, geographical features and local climate.

Palanga Goat Shelter project has principles related to using local and natural materials and reducing carbon footprint. These principles have been tested with issues such as climatic conditions, pandemic restrictions, budget and material supply in the Erzincan region. Air temperatures of up to 40 degrees, low humidity accelerated the drying time, causing direct damage to the wall. Breaks and cracks were observed on the wall surface. Therefore, the gypsum-containing formula, which gave good results in sample testing in Istanbul, was reviewed. Instead of gypsum, cream lime and hydraulic lime were added. The consultants cameup with this idea and they suggested this change in accordance with the ancient-age archaeological restoration technique. Water was added until the powder mixture became yoghurt-like. Since the water absorbency performance of gypsum causes fast drying, hydraulic and creamer lime with high water resistance prolonged this drying time.

This intervention, which was made with a multi-disciplinary decision, yielded good results. This also shows that rammed-earth construction technique can adapt to different geographies and with different mineral additives. People who have been informed about the rammed-earth construction technique can build without the need for large machinery and technologies by using natural and easy-to-procure materials. This shows the sustainability of the rammed-earth construction and the project. As a technique with high adaptability and sustainability, the rammed-earth construction method can be used much more widely and effectively.

The earth structure, which is natural and lives in interaction with nature, is real and in this aspect, it is like any living thing on earth. Prolonging the life of an old-age knowledge with trial-error and spreading this collective knowledge is an important contribution to both humanity and the world.

Design Team: Hasan Çalışlar, Dilara Demiralp
Client: Kutluğ Ataman
Consultants:
Prof. Dr. Bilge Işık (Academician, Architect)
Istanbul Aydin University · Department of Architecture
Mustafa Çakalgöz (Archaeologist):
Ege University, Bergama Vocational Training School / Head of Department 2019-
Suat Güvenç (Civil Engineer)
Construction Date: October 2019 - September 2021
(construction was suspended during the pandemic)
Location: Erzincan / Turkey
Land Area: 8000 m²
Constructed Area: 256 m²
Construction Type: Masonry Wall (rammed-earth technique) – Wooden Structured Roof
Funciton: Goat Shelter
Supplier: Palanga Art and Architecture Farm (PAAF)

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17- Earthen Squinches as a Sustainable Element in IranianArchitecture

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ABSTRACT

A squinch is an architectural element that fills the upper angles of a square space as a base for a dome. The dome's weight or forces are transmitted to both sides of the corner by squinches. The earliest squinches in Iran can be seen in the architecture of Sasanian. Based on available architectural evidence, Iranians introduced this element to the world of architecture. Later, this element was used in Iranian-Islamic architecture and has continued its development. This research investigates the development of the Iranian squinch and how it became a sustainable earthen architectural element. In this paper, a historical descriptive method was employed. The results of this study indicate that the sustainable development of squinches involves two aspects, including materials and techniques. Wood, stones, and adobes were used in the early squinches, but bricks eventually took over. Squinches were first built in pre-Islamic buildings in Iran with four different techniques, including, Patkin, Filposh, Sekonj, and shouldered arches, eventually developed into one more form, namely, Patkaneh as a three-lobed squinch. Earthen squinches with their various techniques could now be employed as a sustainable architectural element.

Keywords: Squinches, Iran, sustainable development

1. INTRODUCTION

Due to a scarcity of sturdy and stretched wood in Iran, vaults and domes were built to cover spaces rather than flat ceilings,[4] employing masonry materials, such as, stones, adobes, and bricks. The circular cross-section of the dome cannot be directly placed on the square space, thus interface elements must be used to get the square shape closer to the circle. The squinch was invented by Iranian master builders to address this architectural challenge, and it was later improved using diverse methods such as corbeling, a little arch, and so on. Figure 1 illustrates the squinch. The dome was frequently built on square planned spaces during the Sasanian era [5] and afterward in Iranian-Islamic buildings. The oldest surviving squishes may be seen in Dokhtar Castle, which was constructed during the Sasanian period. This research employed hisa torical descriptive method and existing squinches in Iran were used as data.

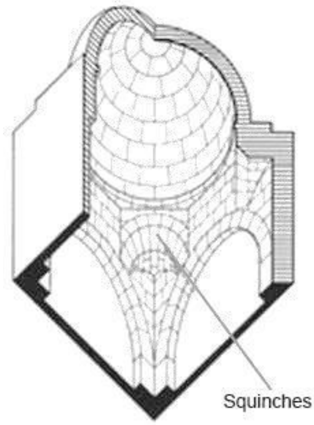


Figure 1. Squinches [6]

2. DEVELOPMENT OF SQUINCHES

The Iranian squinch was created in response to the needs of the time and has evolved over time. The long-term sustainable development of squinches is determined by two factors: materials and techniques. In the following parts, each factor was investigated.

2.1. TECHNIQUES

Building squinches to withstand loads of domes is based on the structural and static logic of the building, which is the result of many years of experience and practical expertise. SAndré Godard, Mohammad Karim Pirnia, Gholamhossein Memarian, and Hadi Safaeipour are among researchers who investigated and categorized the various techniques of Iranian squinches. Filposh, Patkin, Sekonj, and shoulder arches were used to construct earlier squinches in Sasanian buildings, and later Patkaneh was created in Iranian-Islamic structures. There are also instances where two techniques were combined as a transition zone to construct a dome on a cubic space.

2.1.1. FILPOSH

Filposh is a vault with a conical shape. The dome is constructed on top of four half-cones that are created in the corners. Dokhtar castel, a Sasanian construction, has the oldest example of this method [4]. Ardeshir palace, which has three square chambers that are covered with domes built on conical vaults, is another example of this form from the Sasanian era. Filposh could also be found in a number of Sasanian fire temples, such as Siyahgol Ivan. Early Sasanian Filposh were built with stones, but in succeeding eras adobe and bricks were used as the primary building materials.


Figure 2. Filposh in Dokhtar castel(left) and Ardeshir palace (right)

2.1.2. PATKIN

Patkin is a technique whereby construction materials are placed overlapping each other in corners. According to Pirnia, this method is known as Encrobellement in French, which translates as moving the wall forward gradually [8]. The Bazeh Hoor fire temple contains the earliest surviving example of this technology, which is made of wood [1]. Instead of wood, adobes and bricks were used to construct Patkin in Iranian-Islamic buildings.

Figure 3. Patkin in Bazeh Hoor fire temple(left), Damghan Zangule Dome (right)

2.1.3. SEKONJ

Sekonj is made up of two curved triangles in space that are shared by a middle side [4]. Two square chambers in the Sarvestan Sasanian Palace are covered with domes supported by sekonj. This method was developed in Iranian-Islamic constructures, such as, the Sekonj of Zia – eyeh School in the city of Yazd.

Figure 4. Sekonj in Sarvestan Sasanian Palace

2.1.4. SHOLDRED ARCHES

The downward thrust of the dome is carried by the rib in the squinch of the sholdred arches [2]. In kooh-e-khaje, the earliest example of this type can be found (Uschidā) [8]. This form of squinch was discovered and developed during the Sasanian period [2], and it was developed throughout the Iranian-Islamic period, for instance, by adding one or two ribs behind the shoulders.

Figure 5. Sholdred arches in kooh-e-khaje[8](left), Se Gonbad tomb (right)

2.1.5. PATKANEH

Patkaneh is made up of multiple rows of niches that are stacked one on top of the other [8]. In Iranian-Islamic architecture, the technique was first used and Iranian squinches reached their pinnacle with this technique.

Figure 6. Patkaneh under the north dome of Jameh Mosque of Isfahan

Iranian master builders were challenged in ancient Iran to create an architectural element that functions as a transition zone to carry a dome on a square chamber. Squinches were invented by them and developed over time as a result of their extensive expertise. A squinch is a sustainable architectural technology that has little negative effects on the environment. Furthermore, the development of squinches occurred as a result of making this element more resistant, which implies the construction can stand for a longer period of time, saving money and decreasing waste.

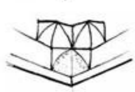
Title	*Sketch*	*Earliest example*
Filphosh		Sasanian architecture
Patkin		Sasanian architecture
Sekonj		Sasanian architecture
Shouldred arches		Sasanian architecture
Patkaneh		Iranian-Islamic architecture

Table 1. Different teqchniques of squinches (by authors)

2.2. MATERIALS

Wood, stones, and adobes are the main common materials to construct squinches in Sasanian construction. The Bazeh Hoor fire temple contains the only remaining wooden squinches from this dynasty's structures. In numerous examples, for instance, Ardeshir Palace, Dokhtar Castle, Sarvestan Palace, and various fire temples, such as, Niyasar fire temple, the upper corners of chambers are filled in with stone squinches. In addition, squinches are made of adobes in kooh-e-khaje. In Iranian-Islamic architecture, squinches were made of air-dried brick and, in most cases, bricks. Table 2 lists the names of a few examples of squinches made of various materials found in

Sasanian and Iranian-Islamic structures. Making squinches out of adobes and bricks rather than wood and stones demonstrates a sustainable development. Adobe is mainly made from earth and it is affordable, renewable [1],vernacular, and environment-friendly. Bricks are fired adobes that are more durable than adobes and brick-built squinches will last longer than adobe-built squinches.

Table 2. Different materials of squinches

Periods	Materials	Examples
Sasanian buildings	wood	Bazeh Hoor fire temple
	stones	Firozabad palace Dokhtar Castle Sarvestan Palace Fire temples, such as, Niyasar
	adobes	kooh-e-khaje
Iranian- Islamic buildings	adobes	Jame mosque of Fahraj
	bricks	Se Gonbad tomb

CONCLUSION

The ancient architectural invention of covering a square plan space with a dome occurred in two different main forms, including pendentives by the Romans and squinches by the Iranians. Early squinches were created during the Sasanian era, and they were developed in Iranian-Islamic architecture. Although the concept of sustainable development in architecture is a new one that has received considerable attention in recent years, it existed in ancient architectural practices, such as squinches. As a result, earthen squinches with five distinct techniques could be used as a sustainable structural element in contemporary structures.

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18- Revealing the Potentials of Earthen Shell Design Using FormFinding Techniques

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ABSTRACT

While construction technologies and building materials are developing continuously, providing users' comfort requirements for the cities and buildings we live in, being in harmony with the natural environment and how the constructed environments will or will have to change in time after they are built also how they will affect the natural environment during the construction processes are crucial issues to be considered.

Although it is possible to create or modify a construction material like polymer-based materials these kinds of materials are neither adequate for building healthy spaces nor degrade, while aging, in a desirable way. Therefore, the aim of this study is to discover the potential of natural materials, by considering earthen structures, which have great importance in terms of designing healthy spaces and ecological sustainability.

This paper demonstrates the possibility of generating examples of earthen architecture, which can be built by blocks or pouring, using different construction systems, or by adding different additives in order to improve the structural or thermal performance of the material, through architectural form-finding methods. These methods are can be followed using computer-aided design programs and enabled innovations in construction technologies.

Keywords: Earthen architecture, shell design, form-finding, computer-aided design

1. INTRODUCTION

Computer-aided design programs and innovative production techniques (for example 3D printing) have the potential for the design and construction of earthen architecture. Even earthen structures have known as weak to seismic actions; it has been changed in time thanks to innovations in formwork and material technology. There are only a few studies about earthen shell design (a shell constructed from compressed earth blocks exhibited at La Biennale di Venezia, the 15th International Architecture Exhibition in 2016) which designed considering vertical loads of the structure [1], the other example found on the literature investigates again the masonry shell structure but considering also the lateral loads by using computer-aided design programs [2] but it is obvious that considering the environmental challenges we have been facing since the industrial revolution, we should and will rethink earthen architecture and there is still a lot to discover about. Before discovering the future possibilities, we should reconsider the state-of-art of earthen architecture to reveal this potential; so this paper discusses how to design an earthen shell through a form-finding method by handling the formwork and reinforcement techniques since it is necessary to know for any architectural design; how it will be constructed and will come into existence.

2. FORM FINDING TECHNIQUES

There are many ways to generate a form; by creating continuous surfaces (soft meshes, double-curved shells or hyper paraboloids), using modularity and accumulation (interlocking units, irregular units), deformation and subtraction (twisted blocks or porous spaces), creating algorithmic patterns (tesselated planes or Voronoi surface) or triangulation (Penrose patterns or faceted lofts) [3] (Fig. 1). These techniques are being used by designers along with each other or separately but when it comes to designing a shell it should be considered that shells are form-active structures while transferring their loads to the ground [4]. In ancient times people have discovered the load-bearing behavior of shells by creating arches, vaults and domes. These basic forms are being used even today because of their durability and beauty also their limitless variations and being researched about the basic principles behind them. The earliest research was about these form-active structures' main element; the arches. In the 16th century Stevin illustrated how a chain takes the shape of the forces that affect it by using hanging weights on and later in the 17th century Hooke and Wren used the inversion of this hanging chain model to design a non-funicular form, a dome [5].

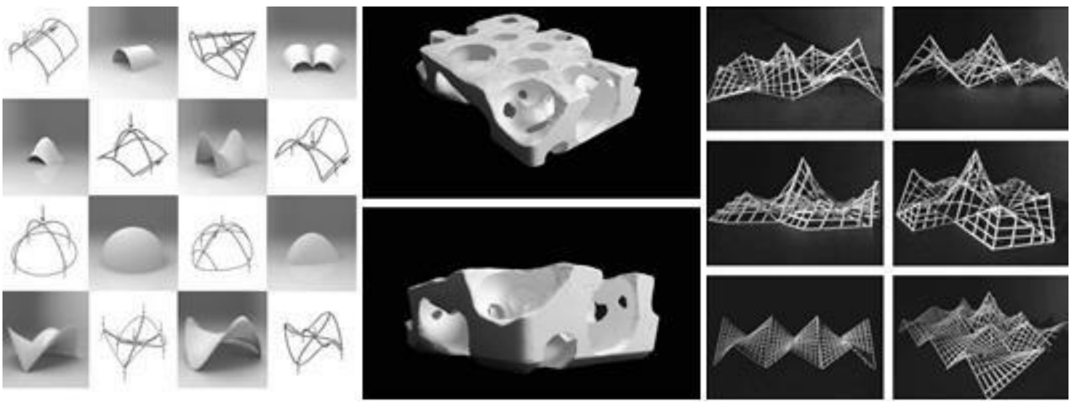

Figure 1. Some examples to generative form finding techniques; creating continious surfaces, deformation and subtraction (Agkathidis, 2015).

Since the inversed hanging chain modeling was discovered in order to design non-funicular forms, they have been used by many architects including Antoni Gaudí one of the masters of all times and a great example of it can be the basilica he designed in 1883, La Sagra da Familia (Figure 2). However this technique hasn't been improved in order to resist lateral loads yet, only one research [2] found in the literature that considers seismic loads using the hanging-chain method in two planes while designing a masonry shell structure and shows that; it is possible to estimate the lateral load will affect the structure so finding a form will resist it in the same way just like it resists to gravity by using computer-aided design programs (Figure 3).

Figure 2. Hanging chain model of Gaudi and the modeling of La Sagrada Familia both from the exhibite in Casa Milà (From personal archive).

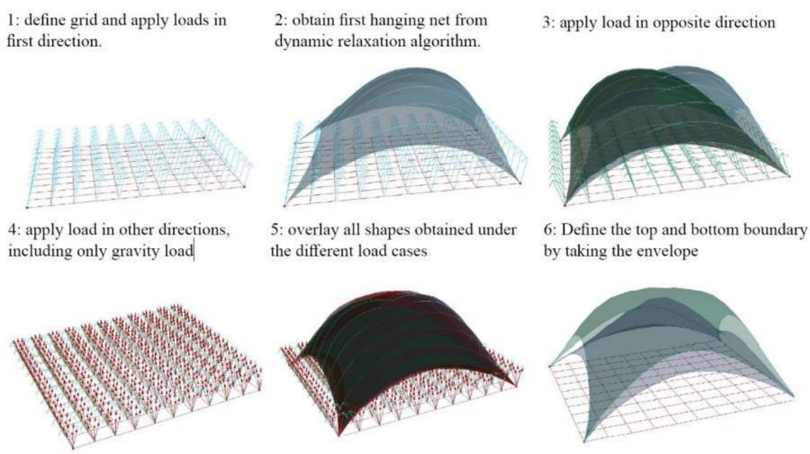

Figure 3. Form finding process step by step for a shell with square plan simply supported on the four corners (Michiels et al., 2017).

3. FORMWORK AND REINFORCEMENT IN EARTHEN ARCHITECTURE

3.1. FORMWORK

Despite there being a vast variety in the production of earth and construction techniques differing to the cultures also the chemical composition of earth depending on the place, the majority of the earth-building techniques can be grouped, considering the manner of forming and strengthening the material as; sculpted earth, molded earth, rammed earth, and compressed earth (the technique used in preparing the blocks) [6]. The rammed earth process begins with soil selection that has an appropriate ratio of sand, gravel, and clay; the soil is usually being provided directly from the site and then poured into usually wooden formwork that can resist forces caused by the compaction of the soil [7].

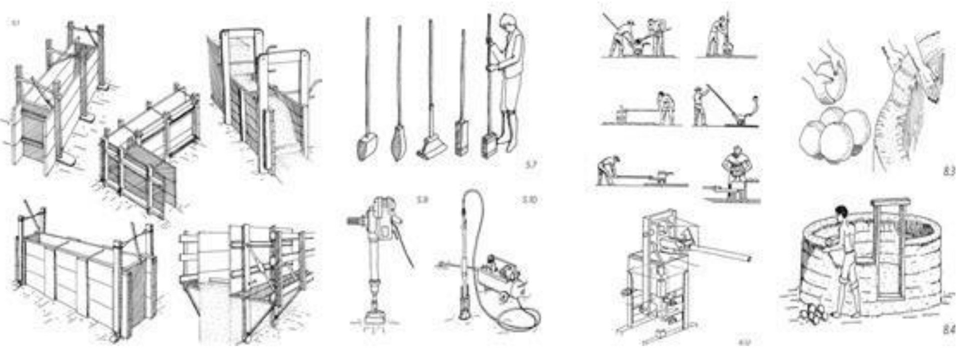

Figure 4. Earthen architecture's construction techniques; rammed earth formwork and tools, production of compressed earth blocks and sculpting earth by hands (Minke, 2006).

The compressed earth block production has started with manual and motor-driven mechanical presses with heavy iron lids that presses the earth into molds and today these mechanical presses have electric, diesel, or gasoline-powered engines that make use of hydraulic compression to produce thousands of blocks per day and have attachments which include earth-blending machines, hoppers, and loaders [7]. Another technique that can be more efficiently used for earthen shell construction is wet sculpting. It is a primitive technique thus it is simple cause no tools are required to work with earth (especially for the kind of earth that includes more clay and is called "loam") [8].

Figure 5. Houses constructed with wet sculpting technique in Ghana (left), a ceiling design to molded earth which can be constructed pouring mineral loam in formwork of textile stressed by cables (Minke, 2006).

The easiest way to make a wall of lightweight mineral loam is to simply pour it into a formwork by preparing the mix in a forced mixer (it is even possible to use an ordinary cement concrete mixer in which the loam is being poured over the aggregate while it is turning) then the formwork is being simply left open on one side for the upper portion of the wall, the mix is being thrown into it and tamped and the surface of the walls made with this technique need only be plastered with a single thin layer [8]. These two techniques (molded earth and wet sculpted earth techniques) (Figure 5) have more potential to use in shell structures since compressed blocks are usually more proper to use for masonry structures and rammed earth is a technique that works by applying vertical forces to the earth. Besides these two techniques have more potential to use different kinds of formwork like textile formwork which is cheaper and more flexible to use even though there is a designed example to it (Figure 5), still it is not found another or applied example in the literature. Also, despite there is a study that investigates the performance of adobe bricks using the 3D printing technique and since 3D printing can be used with computer-aided design programs, there is no other example in the literature that investigates the potential of additive manufacturing in earthen architecture yet [9] (Figure 6).

Figure 6. 3D printed cob cylinders' production from a robot arm.

3.2. REINFORCEMENT

As mentioned before earth is being reinforced; with various types of aggregates or fibers in various proportions, different shapes, chemical compositions, capacities for water thermal or mechanical properties. A decrease in density is being observed with the increase in aggregate or fiber content, as reduction of shrinkage cracks. Ductility is always being improved with increased plant aggregate or fiber content (dependent on Young's modulus) and both tensile and flexural strengths depend on the shape of the plant particles: they are being improved when fibers are used. Earth has a high capacity to balance air humidity, and this capacity is also being increased by the addition of plant aggregates or fibers. Thermal conductivity decreases with the addition of plant aggregates or fibers and because of the decrease in density of the material [10] (Table 1). So all of these properties of the material are modifiable, can be optimized to correspond to the users' needs and there are also studies to improve the seismic behavior of the material by using bamboos, polymer meshes or ropes [11].

Type	Composition (%)			Elastic modulus (GPa)	Tensile strength (MPa)
	Cellulose	Lignin	Hemicellulose		
Hemp fiber	64	4	16		
				21	1077
				34	900
Wood aggregates	50	16–33	7–29		
Flax fiber (Harakeke)	61	8	27	21	805
	81	3	14		
	60	3	16		
Jute fiber	72	13	13		
				10–30	400–800
Kenaf fiber	70	19	3	136	1000
Diss fiber					100
Coir	43	46	0.25		
				3	150
	41	27	22		144
	21	47	12	10–40	73–505
Oil palm fiber	49	23	21		
Date palm fiber				5	233
Sisal fiber				18	580
	65.8	9.9	12	15.5	472
				15	363
	73	11	13	15	347–378
Banana fiber	26	25	17		

Table 1. Chemical and mechanical properties of plant particles used in earth construction materials (Laborel-Préneron et. al., 2016).

CONCLUSION

Rethinking the earthen architecture has great importance by the means of both ecological sustainability and providing users' comfort in today's and future environmental conditions. Future possibilities of earthen shell design are waiting to be discovered through computer-aided design techniques and innovative production or material technologies. Considering the form of a shell, wet sculpting and molding are two production techniques that are utilizable and developable since they also offer more than compression-only structures unlike the compressed block technique. Especially the molded earth has the potential to use different formworks like textile which has the advantage to create a form; flexibility. These potentials can be used, as mentioned above, by strengthening the earth's structural or thermal performance using reinforcements like; plant aggregates and fibers, bamboos, polymer meshes or ropes. Also it is possible to use computer-aided design programs that can predict the behavior of the structures so the principles of form-finding techniques that have been used to create shells since they have been improved can be useful to design a shell that is resistant to both vertical and lateral loads will affect it. So all the advancements in architectural or computational methods of design and construction are available today and can be used considering also the things been learned from the past.

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19- Comparison of Masonry Construction and Reinforced Concrete Systems with Cost-Benefit Analysis in the Process of Determining the Construction System of an Internship House Project

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ABSTRACT

The Covid-19 Pandemic has necessitated many changes in the education system all over the world. Due to the inexperience in preventing a global epidemic, it is aimed to reduce the spread of the virus by switching to distance education in Turkey as in many countries. Internships that need to be done face to face have been postponed for one year. In the process called new normalization, the sanctions were eased and the hybrid education model, in which the theoretical lessons were made remotely, and the practical lessons face to face, was adopted. Within the scope, an internship house project consisting of modules in which one-person rooms and one bathroom-toilet are provided for two rooms has been developed in order for the students of architecture and engineering department to do their internships within the university campus. The aim is to analyse the performance of the masonry construction system with pumice concrete, an earthen material and reinforced concrete system within the framework of the scenario developed above. The efficiency of construction techniques will be compared with the Cost-Benefit Analysis method, which is a numerical analysis method that takes part the themes of the conference as 'Structural behaviour; static, dynamic and numerical analysis methods'. This method consisting of different steps that will be explain comprehensively. Ultimately, it is aimed to determine which of the two construction systems is more suitable.

Keywords: Cost & benefit analysis, masonry construction system, pumice concrete, reinforced concrete system, covid-19 pandemic

1. INTRODUCTION

There are many epidemic diseases that have occurred throughout human history. One of these, the Covid-19 epidemic, has caused many changes all over the world since its emergence in 2019. This epidemic, which affects many areas in society as economic, socio-cultural, health, has made it necessary to apply a method called distance education in higher education. Practical lessons could not be done face to face as in the past. It was decided to postpone the internship, which is the subject of this paper and which is a practical education, and the student dormitories were turned into quarantine and a year was gained for the solution of the problem. In the second year of the pandemic, in the process called new normalization, the sanctions were eased and a hybrid education model was introduced, where theoretical lessons are held remotely and practical lessons face-to-face [1].

Within the scope of this model, an internship house project has been developed by us, where the students of architecture and engineering departments can do their summer internships in university campuses and scientists who participate in scientific activities on campus in other seasons can stay. Considering Turkey's economic conditions and the pandemic process, "What should be the construction system of the internship house? Is it more suitable to be built with a reinforced concrete construction system, like many buildings around us, or with another construction system?" An attempt was made to find answers to the questions.

Various calculations have been made assuming that this internship house was first built with a reinforced concrete construction system, and then with a traditional construction method, a masonry construction system (with pumice concrete). According to these calculations, it is tried to decide which construction system will be more suitable.

1.1. PROBLEM DEFINITION

Many diseases have been occurred throughout the history of humanity. These unavoidable diseases have turned into a pandemic and affected the whole world from different perspectives. Covid-19 has also affected the world in case of not only socio-cultural, economic but also health and education system. Within the framework of the hybrid educational system, the need for a sterile place where internships can be held has arisen.

1.2. PURPOSE OF THE STUDY

The internship house project is designed using masonry and reinforced concrete construction systems. Pumice concrete, a natural building material, is used for masonry system. Also, brick is used as filling material for the reinforced concrete system. The aim of the paper is to analyse the performance of the construction systems within the framework of the scenario developed above. As a result, it is aimed to determine which of the two construction systems and construction materials is more suitable for this scenario.

1.3. CONTEXT OF THE STUDY

Performance analysis and comparison of all construction systems can be done with the Cost-Benefit Analysis method. Within the scope of the paper, the reinforced concrete system, which is the most widely applied construction system in Turkey, and the masonry construction system in which pumice concrete material is used are compared in terms of many criteria.

1.4. METHODOLOGY OF THE STUDY

The method used in this study is the Cost-Benefit Analysis method, which has been used in various studies for a long time. In Tapan's book "Mimarlıkta Değerlendirme Aracı Olarak Fayda-Değer Analizi " published in 1980, the Cost-Benefit Analysis method is explained as a method that is used when choosing among many alternatives and aims to determine the value provided by these alternatives. The benefit value is formed by evaluating the benefits provided by the system parts of an alternative one by one. It is a method that depends on a value system related to the goal system and the preferences of the decision maker, not as a tangible size of goal-related utility [2].

In this context, each construction system is analysed in terms of its positive or negative features. The data with different units obtained at the end of the analysis are converted into a single value system. This method consists of determining the necessary criteria for comparing the construction systems with each other, ranking these criteria according to their importance, calculating the success points of the construction systems against each criterion and the result value obtained by the construction system 'Figure 1'.

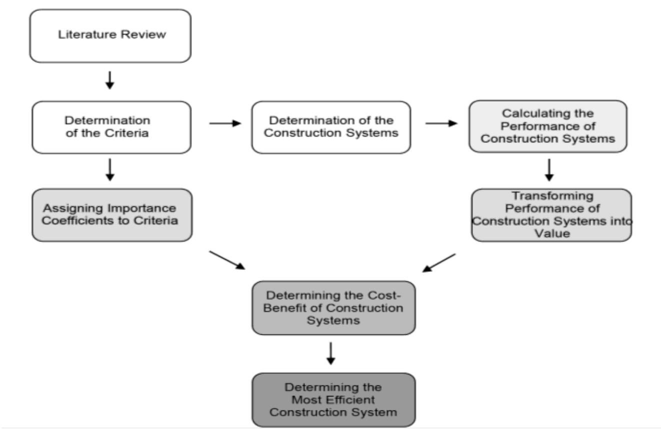

Figure 1. Methodology of the Study

2. FINDINGS

The architectural project was created in modules where each student stays in single rooms and a bathroom-toilet is used in two rooms. Each module is 3 meters x 7 meters in size and designed to have a net usage area of 21 sqm. During the summer months, the architecture students will stay for 6 weeks and the engineering students for the other 6 weeks; during the academic year, an accommodation unit that can host up to 100 people is designed to be used by the academic staff attending the scientific meetings on the campus. 25 of these units, which have ground floor and first floor, are located in an area close to the cafeteria within the campus 'Figs. 2 and 3'.

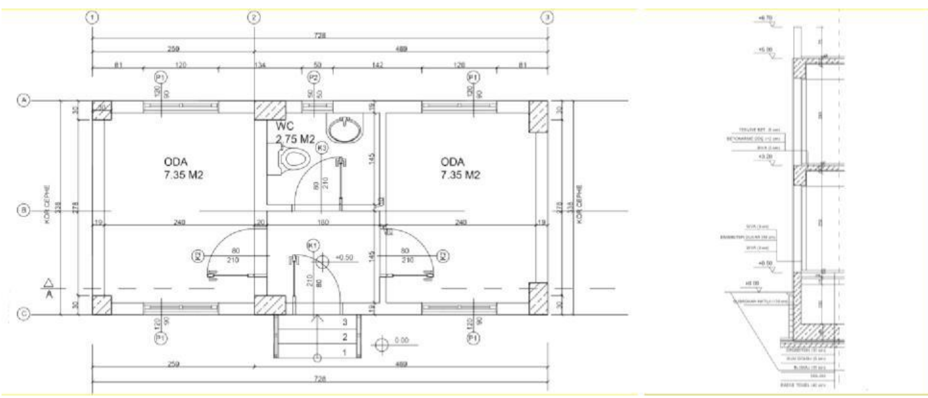

Figure 2. The Internship House Project Reinforced Concrete System Plan and Section

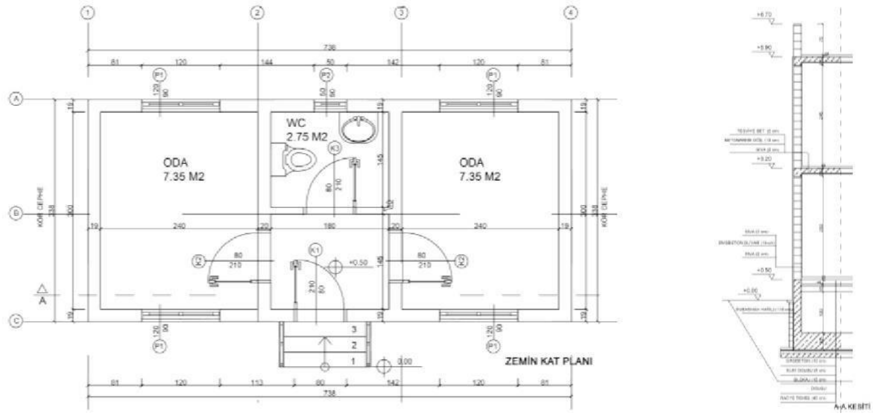

Figure 3. The Internship House Project Masonry System Plan and Section

2.1. CRITERIA

It is foreseen that the construction of the internship house, which will be built within the framework of the architectural project, will start at the end of February, the beginning of the 2020-2021 spring term, and will be completed by the start of the internship period in July (approximately 4 months). In addition, since the cost of construction is covered by the Rectorate, choosing a low-cost construction system should be among the priorities.

Two different projects of the internship house project, both masonry and reinforced concrete construction systems, were drawn by keeping the net usage area constant at 21 sqm, and the calculations were made according to these projects. The buildings designed with these two construction systems were compared within the framework of 8 criteria seen in Table 1 in the context of Cost-Benefit Analysis. Since a raft foundation was used for both structures, calculations were made considering the structure above the sub-basement level in the context of comparison. At the same time, cost calculations were made taking into account the rough construction.

C_1- Cost of the Project	C_5- Ease of Production of the Material in Turkey
C_2- Construction Time	C_6- Ease of Transportation
C_3- Need for Skilled Workers During the Project	C_7- Ease of Instalment
C_4- Equipment and Vehicle Need During the Project	C_8- Sustainability of the Construction System

Table 1. Main Criteria Determined within the framework of Cost-Benefit Analysis

2.2. IMPORTANCE OF COEFFICIENTS

After the criteria were determined, their importance levels were determined by considering the pandemic conditions. In this process, a discussion with 16 participants, including the senior undergraduate students of the Department of Architecture, was held and the arithmetic average of the results was taken and the importance coefficients were assigned [Table. 2]. Within the framework of the prepared scenario, the most important of the 8 criteria was given a maximum of 4 and the least important one was given a minimum of 1 and the other six criteria were given points between these numbers and the importance coefficients were determined.

Importance Coefficients (1<I.C. <4)	Main Criteria (The most important 4 point, the least 1 point)
$I.C._1$=3.75	C_1- Cost of the Project
$I.C._2$=3.70	C_2- Construction Time
$I.C._3$=2.10	C_3- Need for Skilled Workers During the Project
$I.C._4$=2.10	C_4- Equipment and Vehicle Need During the Project
$I.C._5$=2.40	C_5- Ease of Production of the Material in Turkey
$I.C._6$=2.00	C_6- Ease of Transportation
$I.C._7$=1.40	C_7- Ease of Instalment
$I.C._8$=3.30	C_8- Sustainability of the Construction System

Table 2. Importance Coefficients of Each Criterion

2.3. PERFORMANCE CALCULATIONS AND SCORING

In the third stage, scores were made on the basis of criteria, taking into account both systems. There are two types of criteria, main and sub. Sub-criteria were created by detailing the main criteria. The value of each main criterion is found by the formula in Table 3. This formula contains the importance coefficients and values of the sub-criteria of the main criterion and is used within the scope of Cost-Benefit Analysis [Table 3].

$B_j = \frac{\sum_{i=1}^{m}(V_{(i,j)} \times IC_i)}{\sum_{i=1}^{m} IC_i}$ [j=1,2,…,n; (i=1, 2,…,m)]	
B: Benefit of Main Criterion	I.C.: Importance Coefficient of Sub Criterion
In this study m=8 (Criteria), n=2 (construction system) was taken.	V: Value of Sub Criterion

Table 3. The Formula Used Within the Framework of Cost-Benefit Analysis [3].

2.3.1. COST OF THE PROJECT

For the rough construction cost criterion, all the construction stages of the superstructure are written. The total cost was reached by taking the quantities and using the pose numbers for 2021 and the unit price list published by the Ministry of Environment and Urbanization. [4]. The masonry construction system made using pumice concrete is 22% cheaper than the reinforced concrete construction system in terms of cost. [Table 4].

C_2- Cost of the Project	Reinforced Concrete System Total Cost	Masonry Construction Total Cost
	48,964.46 ₺	38,343.31₺

Table 4. Comparison of the Costs of the Systems

2.3.2. CONSTRUCTION TIME

For the construction time, the Gantt Diagram was created by us using the working times in the same pose numbers. Rough structure construction times were found for both building systems. Coatings with fine construction materials are excluded from the cost. In this study, a total of 6 craftsman crew, including one carpenter, cold blacksmith, concrete worker, mason and two plasterers, were used. As a result of the Gantt Diagrams, the construction period with the masonry construction system took 40 days and the reinforced concrete system took 43 days. The masonry system with pumice concrete can be built in 7% less time than the reinforced concrete 'Fig. 4'.

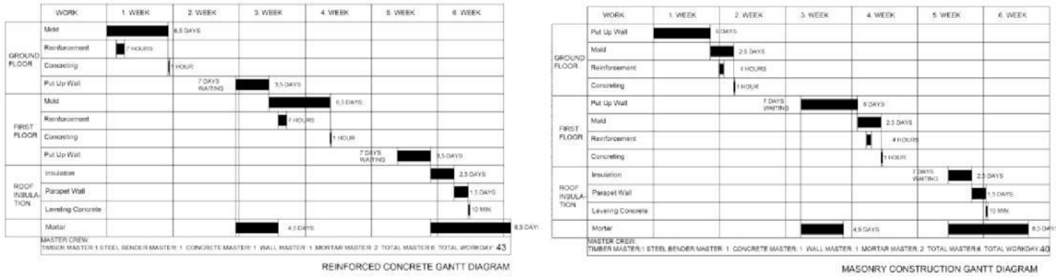

Figure 4. Gantt Diagrams of Reinforced Concrete and Masonry Construction Systems

2.3.3. NEED FOR SKILLED WORKERS DURING THE PROJECT

Three sub-criteria were created to determine the value of this criterion. These criteria are 'No need for specially trained workers', 'Availability of skilled workers across the country', 'Unskilled workers ability to learn the work done skilled ones'. The importance coefficients of three sub-criteria were created with the study group of 16 people. Comparative values were determined for both systems. In the context of the definition of the criterion, 1 was given to the one with the lower performance from the two construction systems and a comparative value was determined for the other [Table 5]. Values are also determined based on performance for each criterion. Values in Table 5 are substituted in the formula in Table 3 and the value for the main criterion is calculated.

C_3- Need for Skilled Workers During the Project	Importance Coefficients of Sub criteria	Values of Sub criteria (Reinforced Conc.)	Values of Sub criteria (Masonry Const.)
$C_{(3.1)}$- No need for specially trained workers	$I.C._{(3.1)}= 1.8$	$V_{(3.1)}= 1.0$	$V_{(3.1)}= 1.6$
$C_{(3.2)}$- Availability of skilled workers across the country	$I.C._{(3.2)}= 1.1$	$V_{(3.2)}= 1.35$	$V_{(3.2)}= 1.0$
$C_{(3.3)}$- Unskilled workers ability to learn the work done skilled ones	$I.C._{(3.3)}= 1.4$	$V_{(3.3)}= 1.0$	$V_{(3.3)}= 1.6$
Value of the Construction Systems		$V_{(3.r)}= 1.08$	$V_{(3.m)}= 1.44$

Table 5. Third Criterion's Value for Reinforced Concrete and Masonry Construction Systems

2.3.4. EQUIPMENT AND VEHICLE NEED DURING THE PROJECT

Five sub-criteria were created to determine the value of this criterion. These criteria are 'Obligation to use mold', 'Obligation to use working scaffold', 'Obligation to use special construction machinery', 'Intensity of using truck mixer and concrete pump', 'Obligation to use lifter'. Values are also determined comparatively [Table 6].

C_4- Equipment and Vehicle Need During the Project	Importance Coefficients of Sub criteria	Values of Sub criteria (Reinforced Conc.)	Values of Sub criteria (Masonry Const.)
$C_{(4.1)}$- Obligation to use mold	$I.C._{(4.1)}= 1.5$	$V_{(4.1)}= 1.0$	$V_{(4.1)}= 2.5$
$C_{(4.2)}$- Obligation to use working scaffold	$I.C._{(4.2)}= 1.3$	$V_{(4.2)}= 1.0$	$V_{(4.2)}= 2.0$
$C_{(4.3)}$- Obligation to use special construction machinery	$I.C._{(4.3)}= 1.7$	$V_{(4.3)}= 1.1$	$V_{(4.3)}= 1.0$
$C_{(4.4)}$- Intensity of using truck mixer and concrete pump	$I.C._{(4.4)}= 1.6$	$V_{(4.4)}= 1.0$	$V_{(4.4)}= 2.5$
$C_{(4.5)}$- Obligation to use lifter	$I.C._{(4.5)}= 1.7$	$V_{(4.5)}= 1.0$	$V_{(4.5)}= 1.0$
Value of the Construction Systems		$V_{(4.r)}= 1.02$	$V_{(4.m)}= 1.76$

Table 6. Forth Criterion's Value for Reinforced Concrete and Masonry Construction Systems

2.3.5. EASE OF PRODUCTION OF THE MATERIAL IN TURKEY

Two sub-criteria were created to determine the value of this criterion. These criteria are 'Production prevalence of building components throughout Turkey' and 'High annual production capacity of building components' [Table 7].

C_5- Ease of Production of the Material in Turkey	Importance Coefficients of Sub criteria	Values of Sub criteria (Reinforced Conc.)	Values of Sub criteria (Masonry Const.)
$C_{(5.1)}$- Production prevalence of building components throughout Turkey	$I.C._{(5.1)}= 1.4$	$V_{(5.1)}= 2.6$	$V_{(5.1)}= 1.0$
$C_{(5.2)}$- High annual production capacity of building components	$I.C._{(5.2)}= 1.4$	$V_{(5.2)}= 2.1$	$V_{(5.2)}= 1.0$
Value of the Construction Systems		$V_{(5.r)}= 2.35$	$V_{(5.m)}= 1.0$

Table 7. Fifth Criterion's Value for Reinforced Concrete and Masonry Construction Systems

Five sub-criteria were created to determine the value of this criterion. These criteria are 'Ease of transportation from the production site to the construction site', 'Simple to replace building materials and components', 'Difficulty in transporting building components within the construction site due to weight and quantity', 'The possibility of breakage of the building components during transportation to the construction site or when they are unloaded to the construction site' and 'Road transport difficulty due to the dimensions of the components to be transported' [Table 8].

2.3.6. EASE OF TRANSPORTATION

Five sub-criteria were created to determine the value of this criterion. These criteria are 'Ease of transportation from the production site to the construction site', 'Simple to replace building materials and components', 'Difficulty in transporting building components within the construction site due to weight and quantity', 'The possibility of breakage of the building components during transportation to the construction site or when they are unloaded to the construction site' and 'Road transport difficulty due to the dimensions of the components to be transported' [Table 8].

C_6- Ease of Transportation	Importance Coefficients of Sub criteria	Values of Sub criteria (Reinforced Conc.)	Values of Sub criteria (Masonry Const.)
$C_{(6.1)}$- Ease of transportation from the production site to the construction site	$I.C._{(6.1)}= 1.6$	$V_{(6.1)}= 1.0$	$V_{(6.1)}= 1.1$
$C_{(6.2)}$- Simple to replace building materials and components	$I.C._{(6.2)}= 1.5$	$V_{(6.2)}= 1.0$	$V_{(6.2)}= 2.5$
$C_{(6.3)}$- Difficulty in transporting building components within the construction site due to weight and quantity	$I.C._{(6.3)}= 1.5$	$V_{(6.3)}= 1.0$	$V_{(6.3)}= 1.0$
$C_{(6.4)}$- The possibility of breakage of the building components during transportation to the construction site or when they are unloaded to the construction site	$I.C._{(6.4)}= 1.9$	$V_{(6.4)}= 1.75$	$V_{(6.4)}= 1.0$
$C_{(6.5)}$- Road transport difficulty due to the dimensions of the components to be transported	$I.C._{(6.5)}= 1.3$	$V_{(6.5)}= 1.0$	$V_{(6.5)}= 1.1$
Value of the Construction Systems		$V_{(6.r)}= 1.18$	$V_{(6.m)}= 1.32$

Table 8. Sixth Criterion's Value for Reinforced Concrete and Masonry Construction Systems

2.3.7. EASE OF INSTALMENT

Two sub-criteria were created to determine the value of this criterion. These criteria are 'Easy laying of plumbing under construction' and 'Easy to make plumbing repairs during use' [Table 9].

C_7- Ease of Instalment	Importance Coefficients of Sub criteria	Values of Sub criteria (Reinforced Conc.)	Values of Sub criteria (Masonry Const.)
$C_{(7.1)}$- Easy laying of plumbing under construction	$I.C._{(7.1)}= 1.3$	$V_{(7.1)}= 1.75$	$V_{(7.1)}= 1.0$
$C_{(7.2)}$- Easy to make plumbing repairs during use	$I.C._{(7.2)}= 1.3$	$V_{(7.2)}= 1.75$	$V_{(7.2)}= 1.0$
	Value of the Construction Systems	$V_{(6.r)}= 1.75$	$V_{(6.m)}= 1.0$

Table 9. Seventh Criterion's Value for Reinforced Concrete and Masonry Construction Systems

2.3.8. SUSTAINABILITY OF THE CONSTRUCTION SYSTEM

Six sub-criteria were created to determine the value of this criterion. These criteria are 'Whether it is harmless to the environment', 'Whether thermal insulation is needed (on the wall/ceiling)', 'Insufficient amount of residual product at the end of production', 'Low cost of demolition', 'Whether the material is reusable after demolition' and 'Whether the demolition process harms the environment' [Table 10].

C_8- Sustainability of the Construction System	Importance Coefficients of Sub criteria	Values of Sub criteria (Reinforced Conc.)	Values of Sub criteria (Masonry Const.)
$C_{(8.1)}$- Whether it is harmless to the environment	$I.C._{-(8.1)}= 2.8$	$V_{(8.1)}= 1.0$	$V_{(8.1)}= 2.75$
$C_{(8.2)}$- Whether thermal insulation is needed (on the wall/ceiling)	$I.C._{-(8.2)}= 1.9$	$V_{(8.2)}= 1.0$	$V_{(8.2)}= 2.0$
$C_{(8.3)}$- Insufficient amount of residual product at the end of production	$I.C._{-(8.3)}= 1.6$	$V_{(8.3)}= 1.1$	$V_{(8.3)}= 1.5$
$C_{(8.4)}$- Low cost of demolition	$I.C._{-(8.4)}= 1.1$	$V_{(8.4)}= 1.0$	$V_{(8.4)}= 2.25$
$C_{(8.5)}$- Whether the material is reusable after demolition	$I.C._{-(8.5)}= 2.1$	$V_{(8.5)}= 1.0$	$V_{(8.5)}= 1.0$
$C_{(8.6)}$- Whether the demolition process harms the environment	$I.C._{-(8.6)}= 1.8$	$V_{(8.6)}= 1.0$	$V_{(8.6)}= 2.25$
	Value of the Construction Systems	$V_{(6.r)}= 1.01$	$V_{(6.m)}= 1.99$

Table 10. Eighth Criterion's Value for Reinforced Concrete and Masonry Construction Systems

2.4. DISCUSSION

For the first criterion, the project cost, the values of the reinforced concrete and masonry construction systems were found with the help of quantity and unit price calculations. It has been concluded that the one built with reinforced concrete system is 22% more costly than masonry. For the second criterion, the construction time, Gantt diagrams were created according to the quantity. It has been concluded that the construction speed of the reinforced concrete system is 7% slower than the masonry. For the third criterion in which the need for skilled workers is compared, the masonry system is more advantageous. The masonry system is more advantageous than reinforced concrete for the fourth criterion, equipment and vehicle needs. Contrary to the first 4 criteria, it is seen that reinforced concrete is more advantageous in the comparison of the criteria of ease of production of materials. For the sixth criterion comparing the ease of transportation, the masonry system is more advantageous. It is seen that the reinforced concrete system is more advantageous for the ease of laying the installation system. For the last criterion, sustainability, it is seen that the masonry system is advantageous with a significant difference [Table 11].

Main Criteria	Importance Coefficient	Values of Reinforced Concrete System	Values of Masonry Const. System
C_1- Cost of the Project	$I.C._1 = 3.75$	$V_{(1.r)} = 1.0$	$V_{(1.m)} = 1.22$
C_2- Construction Time	$I.C._2 = 3.70$	$V_{(2.r)} = 1.0$	$V_{(2.m)} = 1.07$
C_3- Need for Skilled Workers During the Project	$I.C._3 = 2.10$	$V_{(3.r)} = 1.08$	$V_{(3.m)} = 1.44$
C_4- Equipment and Vehicle Need During the Project	$I.C._4 = 2.10$	$V_{(4.r)} = 1.02$	$V_{(4.m)} = 1.76$
C_5- Ease of Production of the Material in Turkey	$I.C._5 = 2.40$	$V_{(5.r)} = 2.35$	$V_{(5.m)} = 1.0$
C_6- Ease of Transportation	$I.C._6 = 2$	$V_{(6.r)} = 1.18$	$V_{(6.m)} = 1.32$
C_7- Ease of Instalment	$I.C._7 = 1.40$	$V_{(7.r)} = 1.74$	$V_{(7.m)} = 1.0$
C_8- Sustainability of the Construction System	$I.C._8 = 3.3$	$V_{(8.r)} = 1.01$	$V_{(8.m)} = 1.99$
Benefits of the Construction Systems		$\mathbf{B_r = 1.23}$	$\mathbf{B_m = 1.36}$

Table 11. Benefits of the Construction Systems

CONCLUSION

Within the scope of the architectural project developed the prepared scenario, two construction systems were compared within the framework of 8 criteria. According to the analysis results obtained in Table 11, it is seen that the masonry system is more effective and suitable than the reinforced concrete system for 6 criteria, including cost, construction time and sustainability criteria, which have high importance coefficients, and the opposite is true for only 2 criteria with low importance coefficient. When the total success points of both systems are compared, the score of the reinforced concrete structure is 1.23, the score of the masonry construction was calculated as 1.36. Within the framework of this scenario, it is concluded that it would be more appropriate to build a masonry structure. However, the fact that a maximum of two floors can be built with the masonry system in Turkey is the most important factor in not preferring masonry structures.

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20- Reuse of Excavator Waste as Compressed Earth BlockConstruction Material

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ABSTRACT

The first step in sustainable construction works is the recycling of excavation waste. The reuse of excavation wastes on an ecological scale contributes to the environment and circular economy. Among the earthen building materials, there are compressed earth bricks as products with high durability and low energy consumption in production. With the use of secondary raw materials, compressed earth bricks can be produced, and it is sustainable as the production of the material is economical and there is no environmental damage. The aim of the study is to evaluate the amount and reuse of excavation wastes in the developed countries of the world and to research the process of transforming the excavation earth into a building material in a sustainable way. For this study, which was prepared on the recycling and use of excavation wastes, national and international studies were examined as a literature research. Since the re-use of excavation wastes with compressed earth brick/block transformation is a new field of study for Turkey, its applications have been investigated due to the lack of national basis. The sustainable reuse process ofexcavation wastes in architecture was modeled and the production stages were determined. By converting the clay material found in the excavation wastes into bricks, it is both energy and cost efficient, and it can be reused in existing construction sites with the compressed earth brick material produced.

Keywords: Excavation waste; reuse; earth material; compressed earth brick; compressed earth block

1. INTRODUCTION

As a result of the increasing population and construction demands with the 20th century, there is an irreversible consumption of resources in the natural environment. With the decrease in natural resources, its sustainability in the life cycle seems to be weakening. With the inclusion of the concept of sustainability in the Stockholm Declaration in 1972, awareness of the consumption of environmental resources began to emerge. This declaration, which consists of 26 principles, formed the basis of international sustainable development in order to prevent the unconscious use of resources that cause the destruction of the ecological balance [1]. In the process of sustainable development, the United Nations (UN) Rio Conference, the UN Millennium Declaration, the World Sustainable Development Summit were held, and in addition to the Millennium Development Goals, "Agenda 2030: UN Sustainable Development Goals" was prepared in 2015 [2]. There are policies to reduce the harmful effects of waste on the environment through recycling, which are related to sustainable development goals.

According to studies in EU countries, the most waste generation in terms of solid wastes is construction, mining, industrial and domestic waste types. The construction industry accounts for approximately 34% of solid waste. With the recycling of these wastes, 10% can be reused and raw materials are saved. It is known that construction and demolition wastes in Turkey have an amount of approximately 4-5 million tons per year [3].

The 2 cm high part of the fertile vegetative earth layer is formed in an average of 500 years. Vegetative earth can reach a depth of about 30 cm from the surface [4]. Excavations, which are revealed as a result of excavation works in construction areas, are dumped in officially designated areas outside the relevant site or illegally. This situation causes both loss of vegetative earth layer and environmental pollution. There are various recycling policies in order to minimize the environmental impact of excavation waste, which has a solid waste class. In the regulation on the recycling of excavation wastes in Turkey, it is stated that vegetative earth should be reserved for use in green areas. For the excavated earth in the lower layer of the vegetative earth, there are regulations regarding its use for filling purposes and its use as a clay raw material for cement production according to its chemical and firing properties [5].

Earth building materials [6] include building elements produced from earth without firing. Ecological structures can be produced from earth building materials, which are developed according to adobe material in terms of quality, save energy compared to other products, do not need cooking, provide thermal performance and bioclimatic comfort throughout their use, reduce the cooling and heating energies of the interior [7].

The first structures with high thermal properties that meet the comfort conditions were built centuries ago with earth material in different typologies. Natural materials such as earth have been replaced by modern materials such as concrete and its derivatives, regardless of the differences in their thermal behavior over time. While earth bricks (adobe bricks) were dried in the sun using hand tools, as faster production techniques became a necessity, manual or mechanical pressing methods were developed by pouring into molds and compressed earth brick / block building material was started to be used. The production phase begins to form the idea of integrating it into modern architecture as a sustainable material, with the advantages of earth, which has low energy needs for heating and cooling and has high energy efficiency. In the context of environment and architecture, studies aimed at converting excavation waste into building materials as a result of reuse are gaining importance when combining the concepts of recycling and ecology. It is estimated that 700 million tons of excavation waste will be generated as a result of existing projects and construction works that are in the feasibility stage [8].

For this study, which was prepared on the recycling and use of excavation wastes, national and international studies were examined as a literature research. In this study, a literature search was conducted on the examples of the World and Turkey regarding the conversion of the clay found in the excavation wastes, which is an ecological material, into compressed earth block [9] and brick [10]. Since the conversion of excavation wastes into bricks and their re-use is a new field of study for Turkey, the applications made due to the lack of national basis were examined.

Although the conversion of excavation wastes into earth brick material has become an increasingly important field of study, this awareness at the national level has not yet developed in practice. For this reason, application examples have been examined from international studies. Information on legal regulations has been examined from national-scale studies. For the first time in Turkey, information on the application process related to the production of earth bricks/blocks compressed under high pressure by hydraulic press was searched.

2. APPROACHES TO THE REUSE OF EXCAVATION WASTE

The scenarios were first included in 1953 due to the negative effects of excavation materials on the reuse of excavation wastes on the environment. The European Soil Data Center (ESDAC) was established by the European Commission and the European Environment Agency [16] to conduct research on the recycling / reuse of excavation wastes as a matter of combating earth pollution [8].

With the demand for natural aggregate use of aggregate obtained from tunnel excavations in the 1990s, the effects of re-use for raw material needs began to increase. Since the 2000s, it has been accepted as a potential source for excavation materials obtained from infrastructure constructions in Europe [11].

It is known that construction practices are not an environmentally friendly action. However, it is known that environmental damage can be reduced by making ecological or sustainable productions. The largest amount of waste generated by construction production is excavation / excavation waste. Components of the excavation earth; vegetative earth consists of earth, sand, gravel, stone and clay layers. Landscaping of vegetative earth etc. reuse is possible. Other earth layers are; It can be used as a top cover or for filling purposes in solid waste landfills.

In many studies in the literature, excavation wastes are included within the construction and demolition wastes. There is a classification of the sources of waste types generated during the construction process [12].

- Wastes resulting from the complete or partial destruction of superstructures or infrastructures,
- Wastes from the construction of superstructures or infrastructures,
- Earth, rock and topsoil resulting from clearing, earthworks, construction works or foundation excavations,
- Wastes from road construction / maintenance works.

In the rural architecture parts of the constructions made with traditional methods, the excavation earth can be transformed into mudbrick and its derivatives and used on site. The part of the clay, which is included in the recycling of the remaining earth layers in the constructions where ecological production is not carried out, is used in cement production. As a result of cement production, CO_2 emissions in nature increase. There is a cost of energy spent during the transportation of excavation wastes from the construction site to the storage areas, and it also creates a carbon footprint. Since the amount of excavation that occurs during the construction of infrastructure and superstructure such as tunnels, canals, dams, high-rise buildings is higher than the excavation of other building types, excavation wastes that need to be recycled / converted are important for environmental impact. Compressed earth and brick, which is an example of ecological material in terms of sustainability and contains clay in its composition, can be produced from excavation wastes. By transforming the clay material found in excavation wastes into bricks, both energy and cost savings can be achieved. With the compressed earth brick material produced, it can be reused in existing construction sites. Brick building material and masonry etc. While it is possible to use it on surfaces, it is possible to use different types of bricks in industrial production areas.

2.1. WORLD AND TURKEY EXAMPLES OF EXCAVATION WASTE QUANTITIES

In countries with a high level of development such as the USA, the United Kingdom, and Japan, forward-recycling techniques are applied. The steps of reusing solid wastes generated in the construction sector consist of storage - sorting, collection - transportation and recycling processes. Reducing environmental damage by recycling related wastes, reducing exploitation for natural resource consumption, reducing transportation costs, etc. it has many beneficial effects [13].

With the Waste Environment Directive (WFD), the EU has set a target of recycling approximately 70% of excavation, construction and demolition waste. In Turkey, studies on the reuse of approximately 125 million tons of excavated earth per year are evaluated within this scope. Construction - demolition waste is 5 million tons, it is estimated that this amount will reach 10 million tons with urban transformations [14].

Country	*Total waste amount (million tons)*	*Construction & demolition waste (million tons)*	*Construction and demolition waste rate*	*Source*
EU - 28	2,514	821	%33	EU (2015)
Germany	368	197	%54	EU (2015)
Spain	118	26	%22	EU (2015)
France	344	246	%72	EU (2015)
Italy	162	52	%33	EU (2015)
United Kingdom	241	100	%42	EU (2015)
Australia	48	18	%38	Australian Government (2013)
Japan	380	75	%20	-
South Korea	382	186	%49	Korea Statistics (2014)

Table 1. Amounts of construction and demolition wastes with solid waste type in European Union (EU) and other world countries [15].

In Table 1, information on the total solid waste amounts of 28 countries within the EU and some countries with a level of development, and the amount and rates of waste from the construction sector for this waste are given. The most Construction - demolition waste is in France. The European Union has determined a hierarchy to reduce the amount of waste, and it consists of five stages as prevention, reuse, recycling, energy recovery and disposal. According to these stages, the primary aim is to prevent the formation of waste amounts, and in the last step, there is the stage where the processes for the disposal of wastes that do not provide any use despite their reuse and recycling are implemented [22].

The use of primary raw materials can be reduced by imposing sanctions in the context of economy regarding the promotion of the reuse of excavation wastes. The reuse of rock and earth from excavations for underground tunnels in Europe has been made mandatory in infrastructure construction projects with legal factors. While Austria, Switzerland and France provide national-based solutions for the reuse of excavation waste, there are limited national regulations in Italy [8]. In the United Kingdom, Sweden and Denmark there are some taxes on the use of primary raw material sources in the construction industry. In Sweden, natural pebbles are taxed for the use of crushed rock and recycling materials. In Denmark, there is a demand for recycled materials as a result of the tax applied to primary raw materials such as stone, gravel, sand, limestone and clay. In the United Kingdom, the use of recycled aggregates has increased as a result of taxation on aggregate material [15].

According to the data of the European Environment Agency, there is an opinion that excavation wastes used for filling purposes without recycling in 2016 are not environmentally beneficial waste treatment. By calculating the material compositions, a prediction was made in terms of potential efficiency for the collection of each material composition separately. Collection rates were determined for each material and it was calculated that recycling could be efficient for 96% of approximately 250 million tons of waste [16].

The acceptance of rock and earth uncovered during excavations as waste weakens the incentive for the use of potentially productive resources and raw materials. There are tunnel boring machines that allow analysis, separation and reuse / recycling of excavated materials in order to determine the chemical and physical characterization of the materials considered as excavation waste. Since the reuse of excavation wastes creates a low cost compared to new materials, in addition to environmental effects, it creates a reduction of up to 85% in the cost of material management. Depending on the geological composition of the excavated materials, up to 100% reuse is possible [8].

3. STUDIES ON THE CONVERSION OF EXCAVATOR WASTE TO EARTH CONSTRUCTION MATERIALS

Earth is one of the first building materials. The first communities that started to live as settled built their shelters with natural materials in their surroundings. It is seen that especially earth material is used in hot climatic regions. In the history of architecture, it is known that economic productions are widely carried out due to the fact that earth is an easily accessible and abundant material. Approximately 30% of the UNESCO heritage list consists of earthen structures [17]. Building types built as earthen structures can be produced with different techniques. There are different production techniques such as bulk earth, light earth, compacted earth brick, adobe, cast-in-situ earth, vertebrate adobe, compressed earth techniques [3].

At the beginning of the 19th century, the first studies on compacted earth were made in France. It was produced by the architect François Cointeraux by pressing with hand hammers in wooden molds in the form of small earthen blocks. In the middle of the 20th century, blocks that were denser than adobe and more resistant to water and pressure began to be produced with steel manual presses. With the advancement of technology, compressed earth bricks have been produced as a result of fabrication production techniques [18]. Compressed earth can be produced with different techniques in the molds of earth that has certain chemical and physical properties. Production method; ramming with human power - pumping into molds with pressure - spraying or compression technique [6]. It is possible to produce in different geometric shapes and sizes in the industrial environment through digital design as well as in-situ casting [7].

Compressed earth is a type of material with high eco-productivity. Although the production cost is low, it can be easily recycled to nature. It can be used as both carrier and non-carrier material in buildings with different structural systems. Compressed earth blocks, on the other hand, are produced as bricks by pouring the mixture of compressed earth into molds of different sizes and applying pressure with a manual or press machine. Compared to other earthen building materials, a small amount of water is used in the production of compressed bricks. It does not create greenhouse gas effect and environmentally harmful waste like firebricks in the production process. In addition, the high energies spent in the firing process of fire bricks and the use of fossil fuels are not needed in the production of compressed earth bricks. Recyclable compressed earth building materials have strong insulation properties when produced with high thermal mass in hot climates. With industrialization, the production of cement-containing building materials has been seen as advantageous and its use has accelerated, and the interest in earth building materials has decreased. However, the use of earth building materials has started to come to the fore again due to the positive effects in terms of health and climate in the use of natural building materials. It can contribute to the production of contemporary space with the creation of industrial production possibilities of earth building materials [7].

3.1. CONVERSION OF EXCAVATION WASTE INTO COMPRESSED EARTH BLOCKS

As long as the earth building material is used with the right techniques in the building, its life span is the longest. At the same time, all of the earth materials used can be recycled and reused as building materials. It also shows that earth, which is excavation waste, can also be reused. With this method, environmental pollution can also be reduced. The thermal conductivity of the earth is 0.64 - 0.93 W/mK, and with its high insulation feature compared to concrete, it creates an opportunity to reduce energy loss when used in buildings. In terms of the amount of energy required for the production of concrete, stone, timber and compacted earth blocks [19], the material with the lowest requirement is earth with approximately 15 Gj cement etc. There is no harmful emission to the environment when compared to materials such as while adobe bricks produced under normal conditions have an average strength of 2 - 2.4 MPa compressed earth bricks have a strength of 3 - 4 MPa without stabilizer, and bricks with stabilizers show a compressive strength of 5 - 8 MPa and above. Hydraulic lime as stabilizer, cement, lime, gypsum etc. materials can be used at a rate of approximately 3-5%. The use of stabilizers increases the water and pressure resistance of the material. Compressed earth bricks also have properties in terms of sound insulation [20]. In addition, earth bricks are fire resistant materials. It reduces the need for structurally costly material support and reduces the cost in building production.

Clay minerals found in earth as a binder can have different properties. Clay minerals vary according to the structure of the earth and the region where it is located. Clay minerals, which are lamellar silicates, range in size from 0.1 to 4 micrometers. These minerals with different types are found in nature as two-three-layered and four-octagonal structures. Earth building materials can be produced with clay raw material obtained from excavation wastes. As a result of geotechnical investigations, while producing with suitable clay minerals, raw material mixtures can be created by adding aggregates to clay minerals with close compatibility values [9].

Ceramic brick and compacted earth brick materials have less impact on climate change than concrete bricks and cast-in-situ reinforced concrete. At the same time, water use impacts are less in terms of resource consumption [10]. When the bricks produced by compression, drying and combustion techniques are compared, coal etc. used in industrial production and combustion technique. cause harmful emissions. The energy efficiency of sun-dried bricks and compacted earth blocks is higher. When the water evaporates, the building material reaches thermodynamic equilibrium. There are interlocking compressed earth brick types that are interlocked in order to reduce the cost of using traditional bricks and speed up the building production process. It can also provide additional savings in terms of energy efficiency and resource use both in the production and construction process. Since it is produced from moist earth, the drying time will be fast, and it also saves time [9].

(a)

(b)

Figure 1. (a) Examples of excavation wastes used in the production of compacted earth blocks; (b) Compressed earth bricks produced from excavation waste in Turkey

In fabrication supported productions, earth and water measurements are made to increase the earth quality of the material (Fig 1). Hydraulic pressure system is used for compressed earth bricks.

In the compacted earth brick / block production process, the particles larger than 20 mm in the remaining moist layers are also sieved and the optimum water content is added to the obtained material after the separation of an average of 30-50 cm of vegetative earth on the surface of the excavated earth. It is compressed in layers in wooden or metal molds by hand or by pneumatic hammers or mechanical pressing techniques. The wall construction element is completed without the cooking process. Each brick has a minimum thickness of 5-10 cm [21].

CONCLUSION

It is seen that in the majority of the studies, excavation wastes are not classified separately, but are included within the construction and demolition wastes. Excavation wastes and construction - demolition residues are mixed. This situation makes it difficult to determine recycling rates by making raw material formation or vegetable earth separation. Ensuring the control of excavation wastes is the responsibility of local administrations, municipalities and the producers that generate the wastes. Data records regarding the amount and earth quality of the excavations should be created. Management plans for the use of excavation wastes should be established. Recycling, both in terms of cost and use of natural resources, should be done at the site where the excavation is removed or in an area close to it.

In Turkey, there is no regulation on the basis of any technique, except for adobe, which is one of the earth construction techniques. This situation weakens the control mechanism regarding the production and quality of compressed earth brick / block. The energy loss of the compressed earth brick / block production is low and includes low cost. Being an ecological material, the possibility of using excavation wastes as raw materials reduces pollution and ensures the reuse of wastes by providing recycling on an environmental scale. Although the usage area in the world is new in terms of excavation wastes, it creates a new usage / production area in Turkey. The research area needs to be expanded in order to expand the production of compressed earth bricks / blocks, which can be a type of recycling of excavation wastes, and to encourage their use.

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21- Feasibility study of using renewable solar energy in buildingswithout energy consumption, (Case Study: city Bafgh)

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ABSTRACT

Due to the energy crisis in recent years and the increasing use of fossil fuels as limited sources of energy and its impact on environment, countries were prompted to differently react to the energy related issues, efficient use of renewable energy is therefore deemed necessary. The usage of solar energy is gradually increasing. It is obvious that desert areas in Iran are so vast and due to being located in the solar radiation belt, have a high radiation potential. The present study investigates the possibility of using renewable solar energy in buildings without energy consumption in Bafgh. In order to initially estimate the solar energy in this station, the necessary calculations have been performed on the statistical information measured by the Renewable Energy Organization of Iran. Initially, using the cloudiness statistics, the number of days with a cloudiness equal to zero to two-eighths were counted as highly radiated days and their monthly and annual average was calculated. The intensity of the sun's rays is then examined. The results show that Bafgh has a clear sky for more than half of the year, which indicates that the city has a high potential and ability to use solar renewable energy.

Keywords: renewable energy, solar energy, zero energy buildings, Bafgh

1. INTRODUCTION

Iran is a sunny country and is one of the best countries in terms of the amount of solar energy received. Due to the limitation of fossil resources and the pollution caused by them, as well as the increasing demand for energy, it seems necessary to take measures for the optimal use of the rich source of solar energy in our country. Solar radiation received by earth is one of the important parameters in energy balance models, plant growth and models of actual evapotranspiration and plant potential. Despite the importance of this parameter, its measurement is done on a limited basis and this shortcoming is seen not only in developing countries but also in developed countries (1).

Renewable energy refers to a type of energy that is obtained from natural and permanent sources in nature, and its usage does not pollute the nature. These energy sources are unlimited and can be used according to environmental conditions. Different types of renewable energy include wind energy, solar energy, biomass energy, hydropower energy, geothermal energy and hybrid fuels. Accessible statistics show that 18% of the total electricity produced in the world is supplied through renewable energy, including hydropower.

This amount, excluding hydroelectric power, is reduced to 2.5% of the total electricity produced in the world. Studies show that among the types of clean energy, wind energy has the highest growth rate in the period of 2000-2008, which is due to major reasons such as low production costs and the corresponding high amount of electricity generated.

Concerning solar energy, Germany ranks first in the world in terms of installation and production, and the United States ranks first in the field of wind, geothermal, tidal and biomass energy (2).

Estimation of the composition of the country's specific electricity production by types of power plants in 2020 shows that most of the electricity produced in the country is supplied through fossil power plants, excluding hydroelectric plants, other sources of electricity, including renewable energy plants, accounts for a very small share of about 2/9% of the total electricity produced in the country (3). Figure 1.

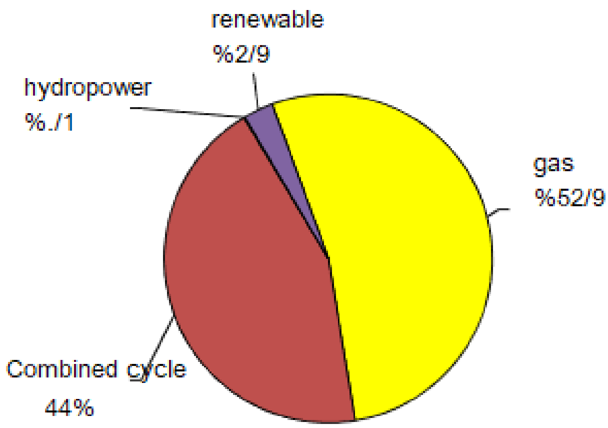

Figure 1. Diagram of the composition of the country's specific electricity production by types of power plants in 2020.

Usage of clean energy in the design and construction of buildings has received much attention in the last decade (4). Over the past decade, the environment and pollution from fossil fuels have become a major concern for human societies. The source of these pollutants is fossil fuels related to the post-combustion process and the emission of greenhouse gases. In Iran, too, absolute dependence on fossil energy sources has economic, strategic and environmental consequences, and currently Iran is ranked 10th in the world in terms of polluting the environment.

In the meantime, strategic and geopolitical issues of this subject, considering the geographical and political location of Iran, can be studied separately. For instance, among the member countries of the Organization for Economic Cooperation and Development (OECD), according to the amount of production and consumption of natural gas in the world, it is predicted that by 2030, natural gas consumption will be less than the growth rate of production (5). Table 1 shows the use of different energy sources by OECD countries and developed countries (6).

	Fossil Fuels	renewable energy	nuclear energy	All resources ،Progress rate (1971-2000)
OECD	%82/7	%6/2	%11	%1/6
Developed countries	%71/7	%27/6	%./7	%3/9

Table 1. The amount of different types of energy carrier usage in countries [6]

Iran's energy supply and consumption in 2007(1386) shows that 320.59 million barrels of crude oil or 22.6% of the total primary energy has been used to generate electricity. Of this amount of electricity consumption that has been used effectively, 91.23 million barrels is equivalent to crude oil or 6.43 percent. In other words, in order to have the electrical energy that is easily consumed in life, we discharge 233.3 million barrels of crude oil equivalent or 16.43% of the total primary energy in the form of heat loss and power loss in the environment. This is an example of primary energy waste in the country. This is while in Iran, the share of fossil fuels and renewable energy (solar and wind) and hydropower in the specific production of electricity this year is 90.4%, 0.075% and 9.5%, respectively. This ratio in North American OCED countries for fossil fuels, renewable energy and nuclear energy are 66.8%, 15.3% and 17.8%, respectively, the share of fossil fuels in European OCED countries is 53.4% and in OCED countries in Asia and Oceania is 69.7% (7). Figure 2.

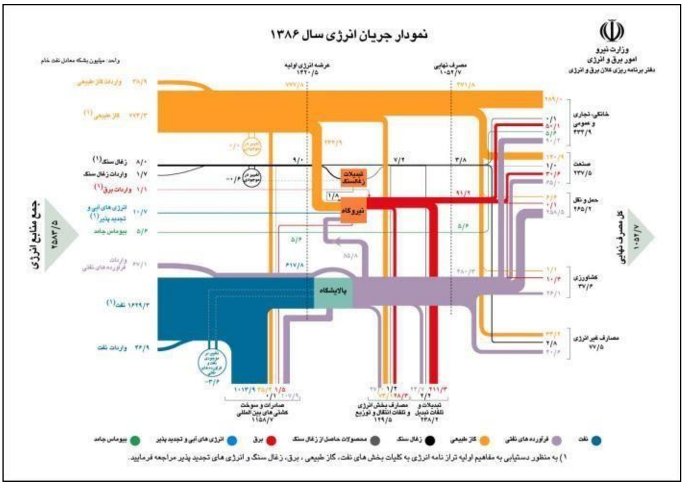

Figure 2. Energy Flow in 2009(1388) – Iran.

Zero energy buildings is a term used for the new generation of buildings where fuel consumption and fossil fuels are low or very limited. Because these buildings do not use fossil fuels, they are free of carbon dioxide and have comprehensive systems to increase energy efficiency, reduce water consumption and minimize waste. Due to changes in modern urbanization patterns, this particular category of technologies has become more practical in the design and construction of taller structures such as towers. Based on this knowledge, which is a new approach to the problemof construction, the use of energies in nature and the application of engineering methods to control them has become a new challenge and a new field of theoretical and industrial research (8). In this paper, the potential of using renewable solar energy for using in zero energy buildings in Bafgh has been done.

LITERATURE REVIEW

Domestic and foreign research in this regard is as follows: Bahadorinejad in 2005(1384) (9) presented the average monthly air purity coefficient based on relative humidity, temperature, rainfall and amount of sunshine hours for different cities in Iran and showed that air purity coefficient is an important parameter in calculating the amount of solar radiation. Inside Iran, the following studies were conducted in order to estimate the total solar radiation: Moradi in 2002(1381) (10), Khalili in 1997(1376) and 2002(1381) (11), Samimi in 1985(1364) (12) and

Kamali in 2005(1384) (13). Lewis in 2003 (14), Rivington in 2005 (15), Efim in 2008 (16) and Bristo in 2003 (17) have done similar researches to formulate a radiation atlas.

2. STUDY AREA

Yazd Province; being located in the central part of the Iranian plateau, which also includes the most unsuitable natural factors that dominate the central plateau of Iran. The great deserts of Lut and Dasht-e Kavir up to the salt lake of Qom and the salt desert of Herat and Marvast up to the salt desert of Abarkooh and Gavkhooni swamp have covered Yazd province and have made it the driest province in Iran. In addition, there is a sharp fluctuation of temperature in this area, which is geographically located between 29 degrees and 48 minutes to 33 degrees and 30 minutes north latitude and 52 degrees and 45 minutes to 56 degrees and 30 minutes east longitude of Prime Meridian (Figure 3).

This province is limited to Khorasan province from northeast, to Isfahan from north and west, from southwest to Fars province and is limited to Kerman province from the southeast. Yazd province according to the census has a population of about 1074428 people and its cities are: Abarkooh, Ardakan, Bafgh, Bahabad, Taft, Khatam, Ashkzar, Mehriz, Meybod and Yazd.

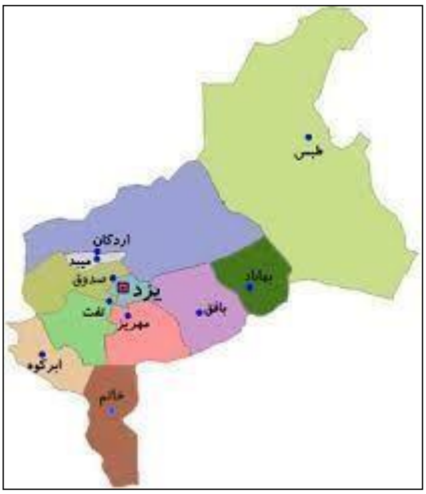

Figure 4. Map of Bafgh city divisions; Figure 3. Location of Yazd province in the country

3. STUDY STATION

Bafgh city is one of the 7 cities of Yazd province located in Iran. The population of Bafgh city in 1385 was equal to 52,888 people. The extent of this city is 15298 square kilometers and from this point of view it is the third city of the province. This city is located at a distance of 54 degrees and 43 minutes to 56 degrees and 38 minutes east longitude and also 31 degrees and 7 minutes to 32 degrees and 28 minutes north latitude in the southeastern part of the province. The distance from Bafgh city (city center) to Yazd city (center of the province) is 118 km, which are connected to each other by an asphalt road. Bafgh neighbors; from the north is, Ardakan city in the northwest of Yazd city, in the east and south Kerman province, and in the west Mehriz city. Due to its rich iron ore mines, Bafgh region has received an extra attention from the government, officials and private investors in recent years (18). Figure 4.

The required data in this article, is for Bafgh station in Yazd province, which was prepared from the statistics and information section of the Meteorological Organization (19). In the statistics and information section of the Meteorological Organization, quality control of the data and all tests of homogeneity, independence and adequacy have been performed. Therefore, with the assurance of performing the above-mentioned statistical tests on the data, after the initial processing and review of the station, we analyzed the radiant data. Table 2 shows the geographical coordinates of Bafgh station and the average time period of radiant information (19).

Studied time period	Altitude (meters)	Latitude (degrees)	Longitude (degrees)	Station name	Row
1993-2010	995	31/36	55/25	Bafgh	1

Table 2. Coordinates of the studied station

4. STATISTICAL ANALYSIS OF RADIATION DATA

Several factors play a role in estimating the potential of solar energy in a place, such as the amount of solar radiation received, the average number of hours of sunshine, temperature, etc. which in these cases, Yazd province has special capabilities. The city of Yazd is located on a yellow radiant belt and has a high potential in terms of receiving solar energy. According to estimates, the input radiant energy to Yazd is 7787 Mj / m2 per year. According to experts at the World Conference on Renewable Energies, 6 points in the world have the ability to generate electricity for the whole world, 2 points of which are in Yazd province. The average daily amount of solar radiation in Yazd province is between 4.5 to 5.5 kWh per square meter and the amount of sunshine hours in Yazd is 3200 hours per year (20) Figure 5.

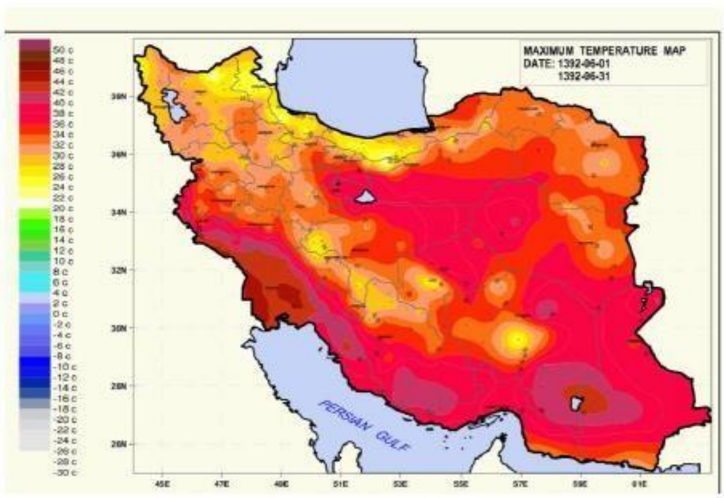

Figure 5. The maximum temperature in the solar radiation zoning Country

Figure 5. The maximum temperature in the solar radiation zoning Country

In order to determine the areas with the least amount of cloudiness, considering that the amount of cloudiness in the sky is reported by the scout based on a fraction of eight, and also consideringthat even on perfectly clear and sunny days, scattered clouds are always seen in the sky, days witha cloudiness of zero to two-eighths were reported as highly radiated days for the study station during the statistical period. Then, the monthly and annual average number of days with clear skies was calculated and used for conclusion and discussion. It should be noted that due to the huge amount of information extracted from the calculations and the limitations of the pages of the article, on a monthly and annual scale, it was sufficient to present the average number of days with the lowest cloudiness of this statistical period.

5. RESULTS OF DATA

The results of the graph in Figure 6 show that the sunniest days are in August. The results show that Bafgh station has a clear and sunny sky about 65% of the year, which indicates that it has a high capacity and ability to use solar renewable energy.

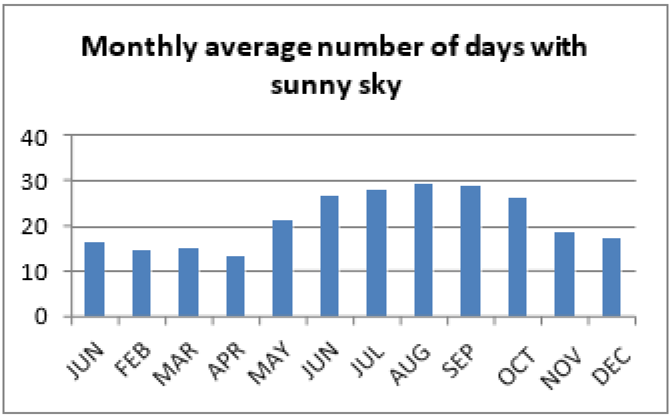

Figure 6. Monthly average number of days with sunny sky Source: Author, taken from raw meteorological information

The results for the number of days with cloudy sky, which are the number of days whose cloudiness is reported to be seven-eighths to eight-eighths, are shown in Figure 7. These days areconsidered as undesirable days in calculations related to the potential of using solar energy. The results show that the most cloudy day is in March and only 8.5% of the year is cloudy.

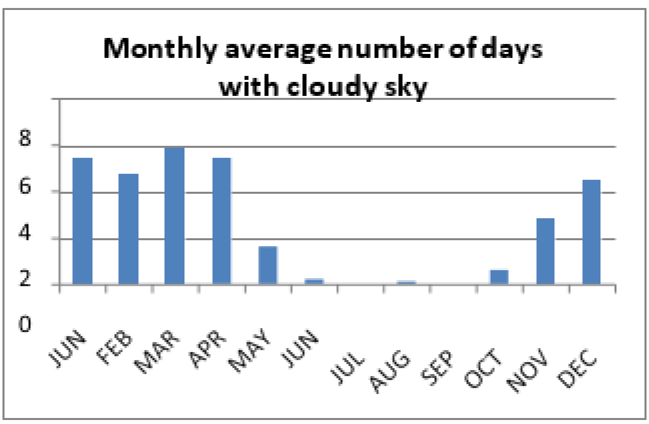

Figure 7. Monthly average number of days with cloudy sky Source: Author, taken from raw meteorological information

Furthermore, it can be seen from the total monthly sunshine hours (Figure 8) that we had the most hours of sunshine in August and July and the least hours of sunshine in February and December.

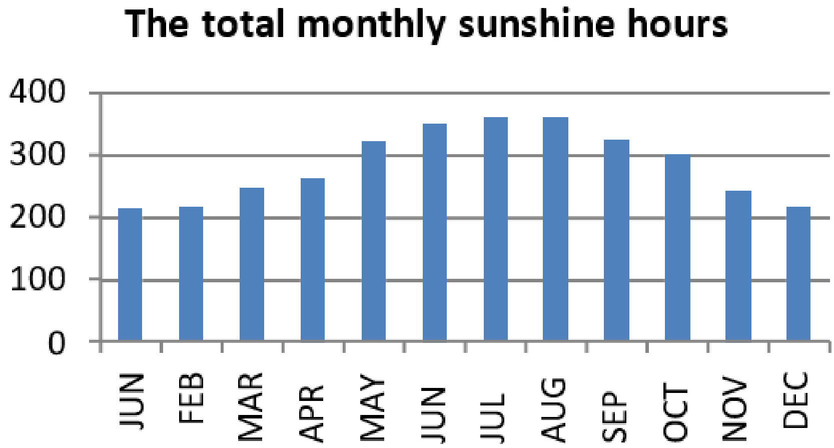

Figure 8. Total monthly sunshine hours Source: Author, taken from raw meteorological information

According to the radiation data obtained from NASA in Yazd province during the statistical period of 22 years from 1983 to 2005, which was obtained using remote sensing technology, is clear that Yazd province has a high radiation potential, so that compared to other regions of the country, the radiation potential is multiplied. According to the obtained data, the average annual normal radiation in Yazd province is about 5.4 m 2.7, which indicates the excellent conditions of the province for the use of solar energy (21). Moreover, according to the classification done in the province in terms of the amount of solar radiation energy in the region (Table 3) (Figure 9), Bafgh city has a position - good -, in which the average daily amount of solar radiation is between kwh / m2 / day5.40 - 5.30 kWh per square meter per day (21).

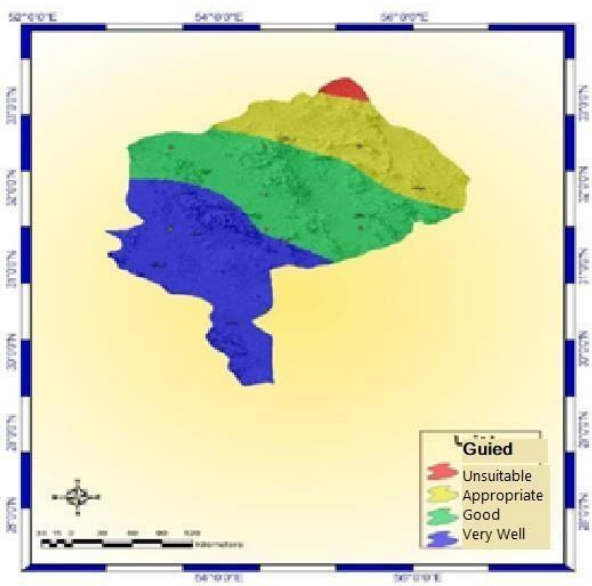

Figure 9. Image of classified map of radiation reaching the horizon in Yazd province - Green Area is Bafgh

Kw/h/m2 /day	Degree of membership	Language Scale
5.40 <	4	very good
5.30 -5.40	3	Good
5.20 -5.30	2	Average
5 -5.20	1	Weak

Table 3. Classification of solar radiation energy in the study area

Month	Monthly Total Of Sunshine Hours	No. Of Clear Days	No. Of Cloudy Days	Average Of Daily Temperature in c.
JUN	214.9	16.3	5.4	8.5
FEB	218.1	14.7	4.7	12.0
MAR	248.8	15.1	5.9	16.5
APR	264.6	13.3	5.4	22.1
MAY	322.1	21.4	1.6	27.2
JUN	352.1	26.3	0.2	31.5
JUL	362.1	27.8	0.0	33.4
AUG	362.2	29.3	0.1	31.1
SEP	325.6	28.9	0.0	27.5
OCT	302.3	26.2	0.6	22.0
NOV	243.5	18.4	2.8	15.2
DEC	218.1	17.2	4.5	10.1
Yearly	3434.4	254.9	31.2	21.4

Table 4. Monthly and annual wind and solar data

6. CONCLUSION

Due to its location on the Earth's solar belt and considering that it covers a quarter of its area, Iran has a very good position in terms of using solar energy.

The purpose of this study is to evaluate the potential of using solar energy for use in zero energy buildings in Bafgh province. In order to initially estimate the solar energy in this station, the necessary calculations have been performed on the statistical information measured by the Renewable Energy Organization of Iran. The results show that in more than 65% of the year, Bafgh is sunny and suitable for the use of solar energy and only 8.5% of the year is cloudy and not suitable for the use of solar energy, which indicates that the city of Bafgh has a high capacity and ability to use the renewable solar energy.

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conference on the application of advanced spatial analysis models (remote sensing and GIS) in Land Management, Islamic Azad University, Yazd Branch.

22- Sabat is a stable and effective thermal element in the native architecture of hot and dry regions of Iran (a case study of Yazd)

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ABSTRACT

Iran is a large country with climatic diversity. Despite construction constraints, spaces have provided environmental conditions by relying on the indigenous architecture of each region. The hot and dry climate is the widest climate in Iran in terms of occupation that has climatic characteristics of dehydration, extreme heat in summer with sandstorms at certain times of the year, and winds in different directions as well as severe cold in winter. Several solutions have been used in designing open spaces and sidewalks in desert cities and have provided the possibility of a safe, comfortable and stable life for thousands of years despite the harsh environmentalconditions of these areas. Sabat is among the solutions.

Sabat is one of the symbols of the desert city and is known as a structure of the elements of Iranian native architecture. This element has always been introduced in Iranian architectural sources as a practical element of architecture in the central and southern regions of Iran, especialin ly desert cities such as Kerman, Yazd, Isfahan, Khuzestan, and Kashan. This element has many advantages. It reduces energy consumption, uses regional materials, and provides a cheap solution to employ particular spaces and be flexible to the climatic conditions. It provides thermal comfort and optimal use of natural energy in sustainable urban development. Sabat is a versatile element in Iranian-Islamic architecture. The main application of which is expressed as a shade and protects people from heat and cold. Different aspects of architecture, climate, structure, urban planning, sustainable social life, and urban security of Sabat are addressed in this article.

The main purpose of this article is to introduce the functions and features of Sabat in the cities of Kashan, Yazd, Kerman, Isfahan, and Khuzestan, presented in the literature. In the present study, more precise parameters are applied to the old and contemporary Sabat in Yazd alongside energy simulation of an example of Yazd Sabat in the Builder Design simulation program. The research work in this study is performed by employing library resources, local research, quantitative data, and a design-builder simulation program.

Keywords: Sabat, thermal comfort, stable urban space, energy simulation, hot and dry climate

1. INTRODUCTION

Ancient Iran is the base of art, architecture, and urban planning. Architecture has always and everywhere been art related to people's lives. Iranian architecture has been populist and has always considered human needs and desires. As a result, the design spaces and architectural elements were designed to make human life better. One of the aspects of the architectural design of past spaces has been designed based on environmental and climatic conditions (1).

Sabats are also indoor and bridge-like paths inside cities that are designed based on human biological needs and play a role in improving human living conditions and comfort. Passers-by in hot and dry climates and deserts, after passing through winding alleys and the oppressive heat of summer, reach a semi-open space with a roof, breathe new life. This multi-component designed element has now been forgotten in the design of our urban spaces due to its lack of recognition, and the sabats that are relics of the past have been destroyed or left alone. By recognizing sabats in hot and dry climates, a wider knowledge of them can be achieved and they can be used in designing urban spaces today (2).

The elements covering these passages are of two types, the first type is constructed in the form of single arcs or connections between two passages. These arches have no use and do not provide continuous and tunnel-like cover for the passage; Rather, there are simple braces to control the thrust of the forces on both sides of the passage wall. The role of these arches is purely structural and due to their structure, they can be called Tavize (Figure 1).

The second type that is the subject of this article is Sabat; Which acts as a bridge-covering over the passages (Figure 2).

Sabat has had many functional values in the fields of climate, structural, social, and even defense. In this study, we study the Sabats in the historical context of different climates of Iran and specifically the Sabats in the city of Yazd and their impact on the climatic conditions of their surroundings by simulating the Sabat of Tabriz from the historical context of Yazd.

Figure 1; Figure 2

2. IRAN CLIMATE

Iran has a hot and dry climate that is characterized by long, hot, and dry summers and short and cold winters. January is the coldest month, with temperatures ranging from 5 to 10 ° C, and August is the coldest month, with temperatures ranging from 20 to 30 ° C or higher. In most areas, summers are hot to hot with almost constant sunshine, but high humidity is in the southern coastal areas of the Persian Gulf. The daily temperature can be very hot. On some days the temperature easily reaches 40 degrees Celsius or more, especially on the shores of the Persian Gulf and the Sea of Oman, which carries the risk of overheating. About 70% of the average rainfall in the country occurs in November.

2.1. THE HOT AND DRY CLIMATE OF IRAN

In this investigation, it was intended to perform a case study in Yazd. Yazd is located at 31.8948 ° N 54.3570 ° E, 1200 m above sea level. The location of this region is demonstrated in figure 3. This city is located in the hot and dry climate of Iran. Prolonged dry heat and intense temperature difference between winter and summer and the intense difference between the day and night temperatures are the climatic features of this region (3).

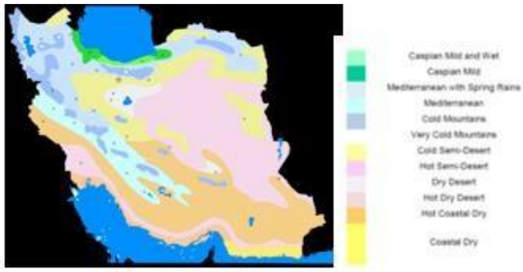


Figure 3. Location of Yazd Province on the map of Iran; Figure 4. Climate Map of Iran

3. SABAT

3.1. THE CONCEPT OF SABAT AND CONSTRUCTION FACTORS

Sabat in the Persian language has ancient roots. The first part (Sa) means comfort and the second part (bat) means settlement and mansion. Sabat to all buildings that were erected for comfort, both in the city and outside the city (4). What is brought in this research from Sabat is the coverings and elements of the bridge, which is on narrow passages and urban passages that are mostly used to improve human living conditions in hot and dry climates. The main purpose of designing this element was to pay attention to human needs and to organize the human living conditions of that time. One of the most important spatial functions of Sabat is to create shade by a roofed and semi-open space that creates maximum shade on the ground, which can be observed in urban areas of these areas, creating air blinds and temperature differences (5) adjusting environmental conditions, He mentioned the creation of an air circulation tunnel, sitting and resting inside it. Due to its semi-covered structure, this structure leads to the formation of air blinds in summer, which cools the air inside Sabat from the outside. And this half-covering in winter made the air inside Sabat warmer than outside. Sabat is also a means of counteracting the monsoon winds. According to theabove definitions, it can be concluded that the main function of sabats as a climatic element is to prevent direct sunlight and protect against monsoon winds, and also as a structural element to strengthen the building and prevent The drift of the walls has been considered (6).

3.2. THE MAIN REASON FOR MAKING SABATS IN HOT AND DRY CLIMATES

In this definition, the main reason for making sabats is the angle of vertical and direct sunlight, especially in hot seasons in these areas, and also the problem of monsoon winds with dust and fine desert sands that are neutralized by sabats. To be. Sabbaths are a type of fixed canopy that is fixed in all seasons. Therefore, their efficiency in terms of creating shade and comfort points depends on daily and annual changes in the position of the sun (Figure 5). It has become collective in urban neighborhoods and social stability in urban neighborhoods and therefore is compatible with the criteria of a sustainable city (7).

In Figure 6, a small part of the old neighborhoods of Yazd (Golchinan) where Sabat Tabrizian is also in this area, the number of Sabat and Tavize that are located are shown in red, which are very organically formed, and a large number of these elements strength and stability. Shows the city.


Figure 5; Figure 6. Aerial photo of a part of the historical region of Yazd and the impact of Sabat on the stability of the city

3.3. FEATURES OF SABAT

1. Adjusting environmental conditions and providing comfort conditions: Sabats on urban spaces and passages, by creating shadows and tolerance, elevate human beings against the environmental conditions and hot and dry climate of the region, and create air blinds (8) in The traditional architecture of desert areas Alleys are often narrow and have several turns that reduce the speed of cold winds, and in the meantime, the presence of the element Sabat has also come to the aid of this climatic architecture. Until the cold winds that enter the passageways collide with the obstacle that is the wall of Sabat in its upper layers and the wind speed decreases (6).
2. Structural role: Due to the issue of privacy and introversion of Iranian houses, high perimeter walls are built, but due to material savings, the walls of historic buildings are generally designed to be narrow and narrow, resulting in double side forces. Sabat helps to compensate for the small thickness of the brick walls to a considerable extent and prevents them from falling, and increases the building's resistance to any horizontal force caused by earthquakes, wind, etc. (9).
3. Creating a sense of neighborhood: The part of urban spaces that were created from the construction of Sabat due to confinement, roofing, and difference in height with the general space of the passage became a center for gathering residents or the entrance space to one or more houses (10)
4. Causing space shock and pausing in space (4)
5. More privacy in some buildings: In some dead-end alleys, Sabat is also implemented, in the entrance of which a solid door was installed, which was suitable for increasing the security of the residents of the alley. This type of space is called "Darband"
6. Sabat social structure: In the past, Sabat was a place for gatherings of neighborhood residents, and these gatherings have made the people of the neighborhood aware of each other's situation and understand each other's problems, and thus solve problems with each other's help. In new urban planning, Sabat may no longer have such a place and the volume may seem useless, but Sabat is an advantage and a virtue that has been forgotten (4).
7. Sabats and Defense: The Sabbaths, due to their proportions and height, were a deterrent against the attack of the enemy riders (11).

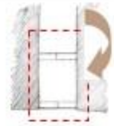
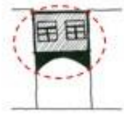
Formology	Description		Types and samples	Plans and views
Type of cover	Cover Continuous	Sabats covered with barrel vault		
		Sabats covered with Sharp vault		
		Chamber sabats The right size eyes to the alley personal use		

Table 1- Formatology of Iranian sabats

4. SABBATS OF HOT REGIONS OF IRAN) KHUZESTAN-KASHAN-ISFAHAN-KERMAN-YAZD) KHUZESTAN

Due to the high heat and humidity, how establishing buildings and special architectural elements in this city are a way to create comfort. Due to the humidity in this area, it was made of bricks or drilled by hand.
Sabat Kazem Lami: The orientation of Sabat Lami, like most of Sabat in Dezful, is northeast, southwest, perhaps due to the prevailing winds in the warm months of the year, which are to the west and southwest. (12)

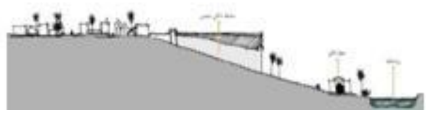


Figure 7. Sabat input; Figure 8. Sabat Kazem Lami; Figure 9. Sabat Dokan Shams location

Sabat Dokan Shams: At the beginning of entering Sabat, we encounter a large number of hand-made stone steps that lead us surprisingly down and adjacent to the river (Gargar River). This stepped path ends with an old building that belongs to the Sassanid period and had the function of a fire temple. This sabat has been drilled by hand in the heart of the rocks of the Gargar river (13).

Kashan-Isfahan-Kerman-Yazd: Due to the close climatic similarities of these 4 cities, it can be said that similar sabats and similar materials have been used, and due to the low humidity, more clay and thatch have been used.

Figure 11. Isfahan

Figure 12. Kashan

Figure 13. Kerman

5. ARCHITECTURE OF YAZD CITY

The old texture in these areas is dense and arose from the connection of buildings around narrow and irregular alleys. The urban space is also completely enclosed and the establishment of biological complexes is determined based on the direction of the sun and wind. The following reasons have been effective in shaping the contemporary texture of buildings as described:
- Protecting urban spaces, passages, yards, and buildings against atmospheric factors, especially adverse winds with the help of dense texture
- Reduce the speed of desert winds with the help of winding alleys and reduce their destructive effect.
- Providing the possibility of creating shade on all surfaces of narrow alleys with the help of high walls around the passages. - Reducing the contact surface of residential spaces with hot air outside (7).

6. SABAT TYPOLOGY IN YAZD

Arches have always existed in the history of architecture with two general shapes round and pointed arches. Other shapes are usually a combination of these two shapes.

7. SABAT CONTEMPORARY

Due to the hot climate of Yazd and the scorching sun in Yazd University, which is a relatively large site, an attempt has been made to use it for the busy roads of students and to create the thermal comfort of Sabat, which is a model of local architecture. These sabats are divided into two types:
1. Sabat is made of clay and mud: which is made using the same local materials and old construction techniques, and bypassing it, in addition to being protected from the sun's radiation and heat, it has revived the architecture of the past. (Figure 16)
2. Sabat with native trees of the region: By closing the scaffolding in the traffic route and covering its roof with native plants and trees of the region, it is a cheap and effective method (Figure 15).

Figure 15

Figure 16

8. SABAT TABRIZIAN MOSQUE (A CASE STUDY OF YAZD)

The studied Sabat is located in Yazd city, Ghiyam Street and Golchinan Alley. This alley has three Sabats, which we will study in Tabriz Sabat.

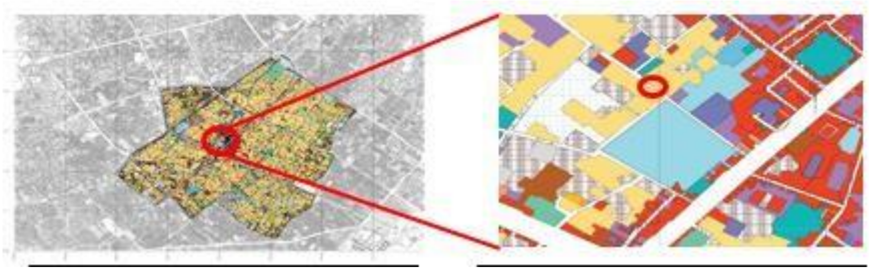


Figure 17. Old texture of Yazd; Location of Sabat Tabrizian

8.1. STRUCTURAL ANALYSIS OF SABAT TABRIZIAN MOSQUE IN YAZD

Analysis of vertical and horizontal forces on the arch and their transfer to the foundation Gravitational force (compression) in this sabbat is applied to the arch of the arch applied to the two clean sides of the force. This force is applied in two directions of the horizon and perpendicularto the relative wall, which is broken down by the vertical force and then transferred to the ground.The thrust force also enters the clean side in the direction of the horizon and tries to destroy the cleaner, which is neutralized by the reaction of the thrust force that enters the relative wall from the adjacent arch. This sample (arch) produces less force in terms of compressive and thrust load.(11)

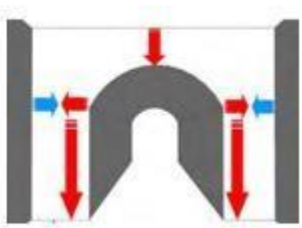


Figure 18. Sabat Tabrizian Mosque; Figure 19. How to transfer vertical forces (compression) and transfer it to Jarzo then to Sabat base

8.2. SIMULATION OF A SAMPLE TO EVALUATE ITS COMFORT CONDITIONS IN HOT AND COLD SEASONS

In this section, we examine Sabat Tabrizian Yazd and express the results of its simulation in Design Builder software. This simulation was performed on a summer day (July 15) and as the figures show, the wind speed is 6.45 m / s and its direction is northwest. This wind enters Sabat from the southwest with a flow rate of 4681.33 l / s (Figures 20 and 21) and from the northeast with A flow rate of l / s4598.04 leaves Sabat (Figures. 20 and 22). As it is known, Sabat reduces the wind speed and controls the wind, and it can be concluded that Sabat has more favorable conditions than the surrounding spaces when the wind blows at high speed.

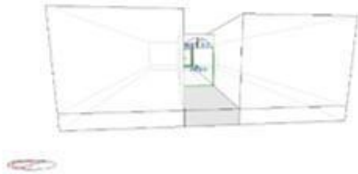




Figure 20 Figure 21 Figure 22

<u>Simulation and investigation of airflow in Sabat on a summer day</u>

As shown in Figures 23 and 24, on a summer day, the highest airflow is near the roof of Sabat and the lowest is in the middle of Sabat and near the ground, which is a place for pedestrians.

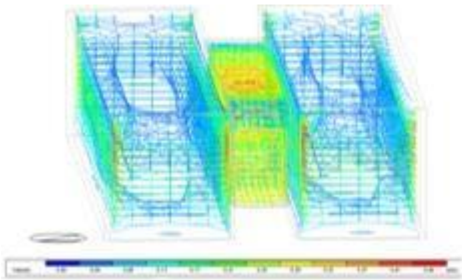
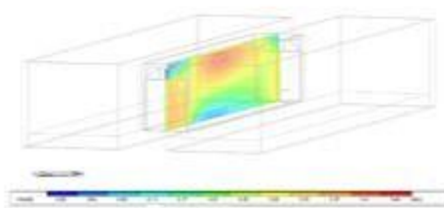



Figure 23 Figure 24

<u>Simulation and investigation of airflow in Sabat on a winter day</u>

As shown in Figures 25, and 26, on a winter day, the lowest airflow is near the roof of Sabat and the highest amount is near the ground and the place for pedestrians.

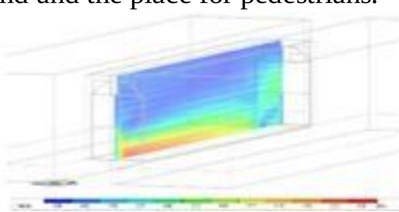



Figure 25 Figure 26

<u>Simulation and investigation of Sabat's internal temperature on a summer day</u>

As shown in Figure 27, the temperature of Sabat in the middle of it decreases by 1-2 degrees Celsius compared to its inlets and creates more favorable conditions than the open spaces around it.

<u>Simulation and investigation of Sabat's internal temperature on a winter day</u>

As you can see in Figure 28, the temperature of Sabat near the entrances on a winter day is higher than the average temperature of Sabat.

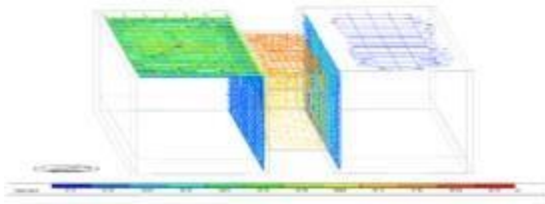


Figure 27

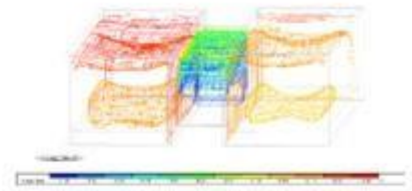


Figure 28

CONCLUSION

Sabat has been introduced as a structure with the main function of sunshade and windbreaks unique to Iran's central and southern regions and is one of the architectural features of desert areas of Iran. By simulating a Sabat sample, it was found that in Sabat, the velocity of the output current from the inlet is lower, which can be concluded that it reduces the wind speed, and the back-to-air space in Sabat has a smoother airflow than the wind-facing space and reduces The wind blows The internal temperature of Sabat is lower than the surrounding environment in summer and winter, which has caused the presence of Sabat in the streets on hot summer days and shading, providing a cool environment for pedestrians. This indicates that Sabat is a sustainable architectural space for the city, which in addition to thermal comfort has its stability and resistance to natural and unnatural factors. For this purpose, an attempt was made to gain a deeper understanding of Sabat by mentioning the example to increase its better understanding. Although these techniques are obsolete or less considered today due to modern technology in the urban planning and construction industry, so proper modeling of them can be the right way in urban planning, reconstruction, and restoration of various arches in historical buildings.

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23- Assessing the Criteria of Social Sustainability in the HistoricalContext of Yazd; Sahl-ebne-Ali Neighborhood

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ABSTRACT

Historical neighborhoods are one of the urban spaces that contain a set of social, cultural, and economic values and are a suitable context for social sites. They are not only a desirable context for living but should also be combined with the contemporary life of societies and their needs over time to form an effective interaction between communities with historical sites.

The development of cities, industrialization and the phenomenon of tourism on the one hand and the inability of historic neighborhoods to meet contemporary needs on the other hand is a threat to the two-way interaction of communities with historic sites that has reduced residential housing in the historical context and thus reduced sustainability. Thus, sustainable conservation as a comprehensive action by emphasizing the concepts of "social interaction and sustainability" can improve the quality of life in historical sites in accordance with contemporary needs and lead to the continuation of a dynamic presence and life in the historical context. In order to increase the sociability and social interactions of spaces, three physical factors should be considered the physical body of the historical sites (as a suitable platform for voluntary activities), environmental activities (by holding purposeful gatherings and seasonal gatherings and the realization of civic participation), and human factors (to meet psychological needs).

The potential of neighborhoods, in addition to being the bedrock of internal development and physical cohesion and social solidarity of cities, on the other hand have been the source of creating a space of remembrance and connection between the past and present. Among the social spaces in the neighborhood, we can mention Ab Anbar, Mosque, Hosseinieh (Ritual gathering place), Saqakhaneh (a place for drinking water) and Hammam, which in the past caused willing or unwanted encounters between neighbors and over time, it has been effective in forming a communication network and becoming a place for social interactions. But today, with the spread of modernism, neighborhoods have undergone extensive changes and the function of some of the social spaces mentioned that had the role of creating social interactions has been greatly diminished. Therefore, this study intends to measure social interactions and sustainability in this neighborhood by measuring the criteria of the physical body, environmental activities and human factors in the social spaces of Sahl-ebne-Ali neighborhood located in the historical city of Yazd, while preserving its cultural and historical values, causing vitality and promoting social interactions in the neighborhood.

Keywords: Historical neighborhoods, Yazd, social interactions, social sustainability, social spaces

1. INTRODUCTION

The purpose of architectural knowledge is to create a suitable environment for improving the quality of life. Achieving this goal requires a correct understanding of man as a social being. Human talents flourish in humanity with others and their values are promoted. In general, the promotion of human interactions and relationships has been considered as a factor in the development of individual and social life. In the traditional cities of Iran, the layers of life from personal privacy to large social spaces had a clear hierarchy, and the sequences of space began from the room and crossed the courtyard to the vestibule, Darband, Barzan, alley, Bazaar and continued to the main square of the city. This constant movement helped to separate spatial territories, regulate social relations, and even give a sense of security to the inhabitants of a city. The velocity of movement at the overlap of the layers was consciously reduced at three scales, micro, medium and macro, and sometimes rested to provide a suitable behavioral environment for social interactions. Places such as courtyard-scale in houses (for family interaction), neighborhood centers (for neighbors' interaction), and city-scale squares (for city dwellers interaction) provided the socio-spatial connections of urban life. The architecture of the present age, following all its successes and failures, has optimally included the individual dimensions of human beings, and what remains is most of the social dimensions of this being. Certainly, meeting the individual needs of human beings along with social interactions in the dimensions of family, neighborhood, and even wider dimensions, will lead human beings to perfection.

With the rapid developments of the contemporary era, entering the transition phase and changing the subsistence infrastructure and social relations, this quality was disrupted. With the placement of the checkered network of streets, most of the alleys and public spaces of the neighborhoods, which were the center of social interactions of the residents, were reduced to passageways and social life disappeared.

Sahl-ebne-Ali neighborhood of Yazd, as one of the important neighborhoods that has met part of the cultural, social and religious needs of the community, consisted of those who had a common culture and extensive interactions with each other. Due to the factors mentioned above, as well as the weakening of relations between families, it has caused people to move away from constructive interactions. Therefore, this study intends to measure social interactions and sustainability in this neighborhood by measuring the criteria of body, environmental activities and human factors in the collective spaces of Sahl-ebne-Ali neighborhood located in the historical city of Yazd, while preserving cultural and historical values.

2. NEIGHBORHOOD, A PLACE FOR HUMAN CONNECTION

A neighborhood is a place that forms the basis of the interaction between humans and structures. The neighborhood is a socially suitable place for the formation of social organizations as well as cultural and social aspects of urban affairs and is considered as an essential tool for understanding the relationship between people, community and nature. In other words, the neighborhood in the concept of activity and place is the most important structural element in people's daily lives [1]. Historical neighborhoods have been a spatial hierarchy from a completely private space to a completely public space, whose collective spaces have been a multifaceted and multi-functional space. It can be said that each person's first experience of an impersonal and public space was the public space of the neighborhood, where prepares the person to attend public spaces [2].

Charles Horton Cooley, who made the first scientific attempt to identify urban neighborhoods, examined the neighborhood as a social organization and the process of socialization and face-to-face community, emphasizing the importance of the first group as the family, the children playgroup, neighborhood units and its impact on children's socialization and the creation of normative patterns of behavior, the role of "community familiar with each other and face-to-face dialogue based on family, common place and common public interests" is important in the durability and consistency of social ties [3]. In 1999, a document was drawn up on the future shape of British cities. The report recommends "a hierarchy of public spaces related to buildings and their entrances in order to strengthen the sense of security and a sense of belonging to a cohesive local community" [3].

The sense of belonging to the main center has led to social integration and social relations and have been very delicate in the formation of the neighborhood and the communication network and other physical elements such as water storage, mosque, Hosseinieh, Saqakhaneh and Hammam [4].

Neighborhood socialization
• Connecting users with neighborhood residents
• Flexibility and usability at different hours
• Supporter of various social groups
• Multipurpose space and meeting different needs
• Enclosure to instill a sense of security and a sense of place
• Use of green space
• Simplicity of shapes in part and whole in order to understand the space and create rhythm
• Proportions of the dimensions of the buildings in relation to each other
• Human scale
• Diversity and contrast with regularity and avoid monotony
• Structure and identity to create a memory
• Conceivability and readability to understand the environment
• Physical and visual permeability
• Spatial hierarchy
• Paying attention to local and traditional architecture in order to create attachment and belonging

Table 1. Neighborhood socialization factors; Source: Author

2.1. SUSTAINABLE CONSERVATION OF NEIGHBORHOODS

Historic sites can continue to live in the heart of contemporary life when they have the ability to meet the needs of their residents and be recognized as a desirable content by them. Now, considering the changing nature of societies and their needs over time, the need for change in historical environments is needed. Therefore, with the beginning of the third millennium, the interaction of the two concepts of conservation and development was emphasized so that conservation along with development and change management can meet the needs of residents that arose from the conditions of each era, while preserving all-round heritage values. As a result, conservation has become a comprehensive and integrated concept that, in addition to all the different aspects of heritage, also includes the component of change. After considering the concept of "sustainability" as a requirement for the continuity of environmental life, this concept has been used in the urban area since the mid-nineties; Which sought to continue the life of an urban environment as a livable content for residents and with respect to the economic, social and environmental balance paid attention to all aspects of that environment. As a result, due to the alignment of the concept of sustainability with the ultimate goal of conservation, sustainability became the main component in conservation and the sustainable conservation approach was adopted as the main approach in the twenty-first century. Sustainable protection is a comprehensive approach that, with a comprehensive view, includes two components of change and continuity [5]. According to various documents and statements in this field, a common definition for the concept of sustainability can be reached, which includes three dimensions: environmental, economic and social; Sustainability is the common denominator of these three areas [6]. This issue has been focused on neighborhood-wide movements over the past 150 years, with the main goal of improving living conditions and protecting natural resources, and many of the proposed solutions have been used to date [7].

In the 21st century, the human and social dimensions in historical environments and issues such as the interaction of different human groups with each other and also their interaction with the environment and its tangible and intangible values were emphasized. Communities and collective life in the public spaces of neighborhoods play an effective role in establishing social interactions between individuals and are therefore the most appropriate platform for achieving sustainable urban development. These spaces have the nature of stability hidden in them and only need to realize their potential [8].

Public spaces play an effective role in establishing social interactions between individuals and thus preserving and stabilizing historical environments. Collective living in public spaces depends on promoting social interactions [9], attracting different individuals and groups [10], social security and thus encouraging different groups to increase tolerance in a more social environment [11], and the creation of an active and lively atmosphere. Socialization in public spaces is based on people's need for a sense of social belonging and interaction with each other, and this will be possible in a supportive social space along with providing physiological comfort [12], claim to territory, sense of ownership and justice in space [13]. Social interaction and communication can be a physical issue, a look, a conversation and communication between people, which itself requires the definition of appropriate events and activities and thus the role of people in space and their membership in groups and social networks.

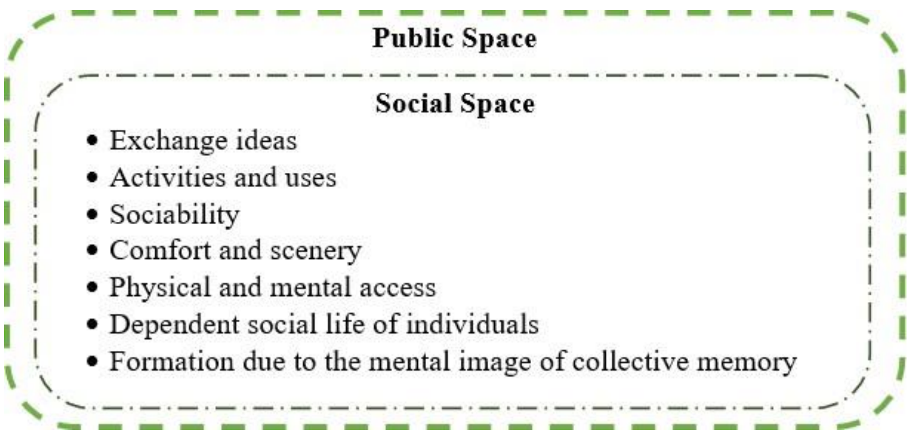

Figure 1. The relationship between public space and collective life; Source: Author

Thus, the social environment results from a stable combination of activity and place, the three basic elements of which are humans, body or environment, and activity that human beings in that do in the environment. The relationship between these three factors affects the socialization of space. This means that the more the environment is in harmony with the behavior and the environment can meet human needs, the more the environment will be able to attract the audience. Therefore, effective factors in people's desire for social interaction and sociability of urban public spaces can be divided into the following three categories [14]:

-Physical factors that shape the environment
-Environmental functions and activities
-Human factors (psychosocial factors of space users)

In fact, the establishment of social interactions between individuals and the sociability of spaces can be achieved by properly combining spatial-physical, functional and behavioral characteristics of space users.

3. INTERACTIONS AND SOCIAL STABILITY IN SAHL-EBNE-ALI NEIGHBORHOOD

Sahl-ebne-Ali neighborhood, which is located in the southern part of the historical area of Yazd, has elements such as Sahl-ebne-Ali mosque and tomb, water reservoir and valuable houses such as Rasoulian house. The formation of this area as a neighborhood is related to the late Zandieh and early Qajar period and parts of it have expanded in the Pahlavi period. Sahl-ebne-Ali neighborhood is located near the southern part of the historical bazaar and this issue has raised this neighborhood as one of the important neighborhoods for merchants in the past. Considering the quality of the buildings in the neighborhood, it can be seen that this neighborhood has been inhabited by wealthy people in the past. A study of the past situation of Sahl-ebne-Ali neighborhood shows the existence of a traditional neighborhood center active in the past due to its elements (water storage, Hammam, Bazaar, Mosque and tomb of Sahl-ebne-Ali) which were located in the main path of the neighborhood.

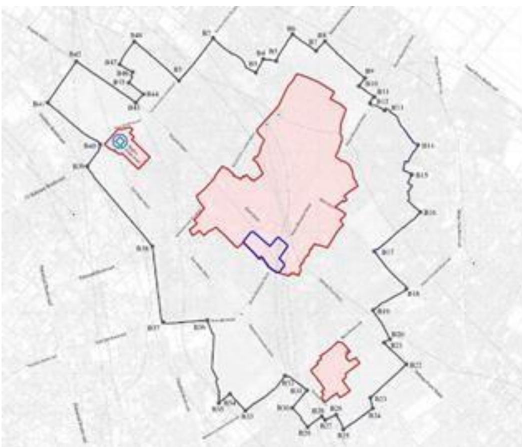


Figure 2. (Left) The area of Sahl-ebne-Ali neighborhood in the field of world registration, which is marked in blue; Redrawing: Author; Figure 3. (Right) Sahl-ebne-Ali neighborhood area; Redrawing: Author.

Changes and transformations in social, economic and physical affairs over time on the one hand and the street paving of the Pahlavi period on the other are the two main factors of sudden changes and physical disintegration of this neighborhood and consequently the evacuation of the neighborhood indigenous inhabitants and the replacement of rural and non-indigenous immigrants, have provided the ground for its physical deterioration. By constructing Pahlavi Street and passing it through the main backbone of Sahl-ebne-Ali neighborhood into two separate sections, it provided the ground for the loss of working life of this main part of the neighborhood.

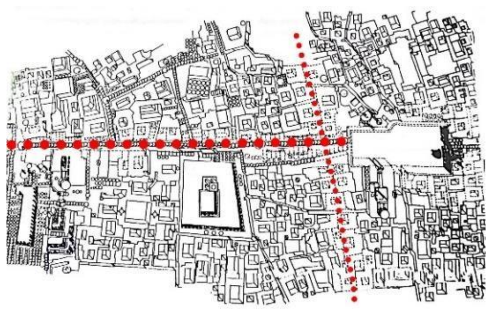

Figure 4. Pahlavi-era street paving; Redrawing: Author.

This factor, along with other factors such as changes in people's patterns and lifestyles and the loss of function of the main elements of the neighborhood such as water storage, bazaar, mosque and caravanserai caused the neighborhood to lose its definition as a homogeneous social unit and only the main structure and skeleton of the neighborhood and some of its elements remain. Based on multiple sources, the criteria of "social security", "social participation", and "social interaction", "universality (disabled)", "pedestrian / bicycle-based", and "spatial diversity and "vitality" is known as the most important components affecting the realization of social sustainability [15]. Based on the above criteria in the form of physical components, environmental activities and human factors, a questionnaire has been developed and the general results are presented in the table below.

	Aspects	Components	Response	Percentage
Socialization, interactions and social sustainability	Physical	Forming and organizing collective spaces by inviting local people to participate in various activities	Yes	20%
			No	80%
		Comfort and physical comfort of passages and spaces due to proper arrangement of furniture	Yes	0%
			No	100%
		Form, geometry, order, harmony, variety of dimensions and proportions and other aesthetic dimensions of passages and spaces	Yes	90%
			No	10%
		Provide a calm atmosphere and visual security through the visibility of passages, proper lighting, free lines of vision, elimination of insecure areas and the presence of signs and symbols for easier understanding and prevention of misguidance	Yes	0%
			No	100%
		Optimal use of natural materials and natural elements such as water, plants, light and shade in the neighborhood	Yes	40%
			No	60%
		Desirability of circulation, spatial communication and access to passages, especially for the elderly	Yes	20%
			No	80%
		Existence of sufficient parking lots and favorable connection with the urban transportation system	Yes	90%
			No	10%
	Activity	Efforts to form purposeful communities and spontaneous cultural activities based on the environment and gatherings	Yes	15%
			No	85%
		Considering the characteristics of the type of activity, activity density, activity concentration, activity scale, activity time in defining the uses in order for the audience to benefit from appropriate services in the neighborhood	Yes	65%
			No	35%
		Provide active entertainment such as direct experience of space, people and social and passive activities such as the ability to observe and watch others and events and happenings	Yes	25%
			No	75%
	Human	Creating a platform for creating organized social interactions such as free exchange of information in the form of demonstration and training of skills, gaining environmental experiences and the possibility of creative expression of individuals and groups	Yes	15%
			No	85%
		Provide the necessary conditions for random social interactions such as dialogue	Yes	15%
			No	85%
		Providing the necessary facilities for the presence of various social groups in the neighborhood, especially the elderly, as well as young people and adolescents in order to create culture	Yes	65%
			No	35%
		Establishing security and mental comfort	Yes	10%
			No	90%

Table 2. The most important components in the realization of socialization, interactions and social sustainability; Source: Author.

The designed questions were presented to two groups of experts and non-experts. Specialists include 20 students of architecture, urban planning and professors, and non-specialists include 30 residents, permanent and temporary passers-by. Some examples of questions were raised as follows:

- In the activities of the collective spaces of the neighborhood (such as the cultural ceremonies of Sadoughi House, various ceremonies in Sahl-ebne-Ali shrine, various ceremonies of the Faculty of Art and Architecture, etc.) is the presence of local people used to participate in various activities?
- Do the passages and spaces inside the neighborhood have suitable furniture?
- Do the passages and collective spaces of the neighborhood have form, geometry, order, harmony, harmony, variety of dimensions and proportions and other aesthetic dimensions?
- Do the passages and spaces inside the neighborhood have security, proper lighting, and the signs and symbols needed for easier understanding?

In general, both groups of respondents are dissatisfied with the current situation of the neighborhood, which was socially assessed in the realization of sustainable protection, which is 62.9% in the physical dimension, 65% in the activity dimension and 73.8% in the human dimension. The results of the evaluation indicate that in terms of physical dissatisfaction due to lack of necessary furniture and equipment, adequate lighting and adequate security, use of green space and good circulation for the elderly and residents. In terms of activity, dissatisfaction is due to the lack of spaces and collective activities, required uses, as well as appropriate urban services and infrastructure, especially recreational and leisure services for residents, and from a human point of view, dissatisfaction is due to the lack of attention to lay the groundwork and provide the necessary facilities for the presence of various social groups in the neighborhood. Based on the analysis and analysis of data, the identified weaknesses and gaps should be used as an opportunity to address it and the factor of continued community presence with emphasis on social dimensions in achieving sustainability.

CONCLUSION

Given what has been said, sustainability means the continuation of a platform's ability to respond to the needs of communities while interacting with the environment around them in the long run; Therefore, in order to achieve it, it is necessary to pay attention to the preservation and promotion of human well-being, just like environmental welfare; In other words, sustainability should not only focus on environmental standards, but should also include social interactions, including human-human and human-environmental interactions, which point to the importance and effective role of social dimensions in achieving sustainability.

Sustainability provides an integrated and dynamic vision of conservation, in the shadow of which conservation seeks to meet contemporary needs; Therefore, when effective protection is formed, it causes continuity in the historical environment and that environment becomes stable. Now, considering that the continuity of life of an environment depends on the continuity of the presence of society and its interaction with the environment around it, and also due to the challenges of today's modern and industrial world, social dimensions are of considerable importance. Hence, "social sustainability" is the driving force that plays an important role in finding this cycle (the cycle of protection and sustainability) and is considered as a turning point in sustainable protection. Also, the concept of social sustainability itself consists of components that by promoting each of them, social sustainability is also promoted and affects the process of sustainable protection.

However, in sustainable neighborhood planning, it is necessary to consider social and economic issues along with environmental stimuli, if unstable social conditions can ultimately lead to environmental instability. Meanwhile, Sahl-ebne-Ali neighborhood, located in the southern part of the historical context of Yazd, is known as one of the historical and important neighborhoods of Yazd, which has been able to maintain the physical features of traditional Iranian neighborhoods to a large extent; This is while the unfavorable social situation has led to dissatisfaction and inconsistency of social status and environmental qualities. The present study is a field research with a descriptive-analytical approach in which a theoretical framework was developed using the documentary method and data collection was collected in the neighborhood using a survey method and a questionnaire. The results show that the level of residents' satisfaction with environmental qualities is low and as a result, social stability is low, which indicates the decline of social capital among the residents of this neighborhood and the cause of neighborhood migration in recent decades and the gradual rupture of kinship relations between residents.

The unbalanced structure of the distribution of functions, the separation of the ossification of the neighborhood and the lack of neighborhood green space, recreational and leisure services in the neighborhood have created social instability. Based on this, organizing functions and social structures, implementing neighborhood accesses, developing local social networks, and finally creating spaces for communication between residents can be considered as the most important suggestions in the strengthening of the interaction between environmental qualities and social sustainability.

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24- Adobe windtowers in Iran

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ABSTRACT

Adobe is one of the oldest building material dating back to the beginning of civilization. It is said that the first use of adobe was around 8-10 thousand BC. The origin of adobe was discovered by early humanbeings. When they saw the soil that was cooked and hardened from the clay next to their hearths, they understood that they could use this tool in building materials. Today, mudbrick is used in all historical buildings, including fire temples and mosques, on the facades of buildings and in the flooring of structures. Another application of adobe in historical buildings, which we see as an architectural heritage today, is windtowers.

Windtowers are traditional structures used in Iranian architecture in hot, humid, hot and dry climates, and they are tools that refresh and cool indoor air using renewable wind energy. These structures consist of 2 parts, external and internal. The exterior consists of a closed roof made of adobe and brick on the roof of the building, with most of it a vertical duct at right angles. Wind-towers are usually designed according to the needs of the house/building, so the larger the inlet, the greater the incoming air volume.

Windtowers have holes at the top that allows directly the wind inward. The interior of the building consists of a single opening and is divided into 2 or 8 parts with inclined separator wings according to the openings made of mud brick and brick in other types

Keywords: Adobe windtowers, wind catchers, Iranian architecture, badger

1. INTRODUCTION

Windtower has been used in Iran since ancient times and is one of the special masterpieces of Iranian architecture and one of the signs of science and intelligence for its predecessors to live in arid and desert regions. In the cities of Yazd, Kashan, Jahrom Tabas and even along the Persian Gulf coast, especially in Qeshm and along the Arvand River, he used ventilation systems similar to windbreakers, the principles that govern his work.

In this paper, the historical course of the windbreak from past to present, its features and advantages, and finally, the use of windbreaks in buildings today will be presented in both symbolic and functional forms(Figure 1).

Figure 1.

The research method in this article is descriptive-analytical and the studies will be based on library and research.

Windtowers, one of the components of Iranian local buildings in hot climates, provide air conditioning by using renewable wind energy as a cooling system. The windtower is one of Iran's architectural masterpieces, estimated to have been used in Iran several thousand years ago. The windtower is one of the architectural elements built with a climatic approach in the domestic architecture of hot, dry, hot and humid areas.

It is connected to the mechanical energy of the engine, etc. As a device that circulates the air without the need, it cools buildings in the desert in summer months, and accordingly, it controls the wind flowing from outside and directs it into the house.

Windtowers are usually designed according to the needs of the house and of course how much the entrance the larger the volume, the larger the incoming air volume. Direction of most wind curtains towards the prevailing winds. It is not ineffective in high altitude work and the wind speed dispersion from zero to high velocities and curved to a constant value at altitude changes dispersion and on the other hand, due to the presence of more dust around decreases as it increases. In this way, as the air altitude increases, it has more speed and less dust (Figure 2):The function of windtowers in areas where moisture is needed in addition to wind flow has been in the form of modern water coolers. It enters through its pores and is directed to the water pool. In new windtowers, in the conventional wind deflector column, the more efficient and cooler air-formingwet curtains are used.(Figure 3).

Figure 2 & Figure 3

Using wind towers in Iran dates back to pre-Islamic times. Wind towers have been built at various points since ancient times, but archaeological excavations no scientific conclusion has yet been reached. There is no information about the upper parts of any structure other than the foundations or little information is obtained. Some date the use of wind towers in other countries to the centuries BC. It is very difficult to find the first plan of wind towers in architectural remains. The first signs of destruction appear especially in the wind towers. There are examples of old wind towers surviving from the 19th century and other samples were destroyed.

2. HISTORY OF WINDTOWERS IN TURKEY

Examples of wind towers in Anatolia, which are common in the Middle East, It is located in Şanlıurfa. The wind towers in Şanlıurfa are called badgel in the local language. Badge The name is quite famous, with the word ''badgir'' used for windtowers in Iran. Apart from ''Badgelin'', in Şanlıurfa, to describe this building component, in the local language. The name ''badia'' is also used. In traditional Şanlıurfa houses, the visible part of the wind receivers is on a flat roof. This part, whose arched body is covered with a half dome, is actually the windtower. Forms the upper part. This protrusion seen from the outside is called the windtower. The inwardly concave arc-shaped face of the tower indicates the direction in which the wind was The received wind is the air duct, which is one of the parts of the windtower that is not visible from the outside. It flows from the north, northwest or west through The outlet is under this air duct, which is located just above the ledge on the rear wall of the porch. When viewed from above, these air outlets, the updraft duct and the head of the windtower is visible.It is produced for ventilation and cooling of the cavity. In traditional houses of windtowers, the wind direction is the north.It flows into the iwan through the opening just above the middle niche. Haci Hafizlar Mansion is one of the traditional windbreak houses of Şanlıurfa(Figures 4 and 5).

Figure 4. & Figure 5.

3. HISTORY OF WINDTOWERS IN IRAN

Most windtowers in Iran, especially four-way windtowers. It is divided into four vertical channels by its separator and one of the channels always takes the breeze and the other three axes act as wind chimneys, helping the outflow of moist air.(Figures 6,7) According to the effect of the chimney, as the temperature increases, the density of the air increases and as a result the air rises.

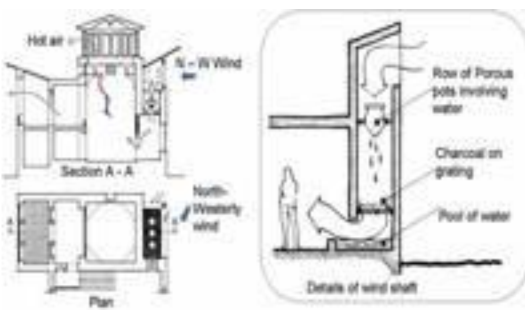

Figure 6. & Figure 7.

Windtowers are based on three types, Ardakani, Kermani and Yazdi (Figure 8). Ardakani windtower is mostly seen in Ardakan region and the direction of windtowers. They do not have openings from the west, east and south. The construction of this type of wind tower is relatively simple compared to other types of windtowers. It is economical. Therefore, it is possible to build a windtower for each room, but Kermani windtowers are simple and small and are dedicated to the house of lower middle class families. Any building can make these windtowers and main materials of these elements mostly clay and mud. Because such wind towers are bidirectional, twin windtowers. They are built as twins in the direction of known winds. The operation of the Ardakani windtowers is a little more accurate and ideal because wind pressure in one direction allows rapid evacuation of hot and polluted air on the other side.

Figure 8.

4. TYPES AND PLANS OF WINDTOWERS

4.1. FIRST TYPE

Wind towers fall into several categories in terms of their external shape. Strong winds and storms The most small piece made on a partition, such as the heater hole in the roof, to prevent simple type of windbreaker, in this method the wind tower only creates cool winds and pleasant breezes and they are closing the other fronts. In some cases, one-way wind towers are built behind strong and destructive winds and actually these wind towers perform the function of ventilation and air evacuation. Dimensions. It is smaller and simpler in shape than other types. This diagonal path (the upper part of the roof) (see below) is connected to a vertical duct in the wall and has an outlet like a heater inside the building (Figure 9). The window is placed on one side and the room is ventilated. This model is more occurs in Sistan and parts of Bam cities.

Figure 9.

4.2. SECOND TYPE

The second type has three wings and two types, three interconnected wings, and three separate wings. In this example, one, two or three facades can be used separately, but such wind towers use is rare. Another example:Badgir mansion, the jewel of the Golestan Palace complex: It was built on the south side of the Gulistan Garden, during the reign of Naseroddin Shah. It is a building belonging to the period of Fath Ali Shah, which became modern with the conquests. air conditioning and the presence of windtowers to transfer it to the pool house and main hall. Under the hall and the mansion, you can breathe the air of the pool house, the hall and the rooms.

4.3. THIRD TYPE

A four-way windtower made more complete and detailed than other types and generally It is divided into several parts by brick or wood or plaster wings inside the channels. And in some instances, the cold humidity of dry and dusty air and relatively large and beautiful, where it is separated from the water by absorbing the dust and a pool was built. For instance: The windtower of Dolatabad mansion in Yazd is the highest wind tower with a height of 18 meters is the tower.

4.4. FOURTH TYPE

This example can be seen in Yazd, Kerman and Bushehr. In the city of Yazd and some parts of central Iran polyhedral wind towers (often octagonal and sometimes even circular) varieties can be seen. The main wings in the square plan are the cross wings, the H wings and the Cross wings. It is designed in three types. For instance: As the name suggests, there are 6 water tank wind towers in Yazd.

4.5. FIFTH TYPE

Chopoghi windtowers, the outer volume of the manufacturer's windtowers, instead of a cubic outer space the sixth type of wind, which he used to form several bent (knee-shaped) pipes. It is a deflector, but the channels and internal parts are in Sircan as in multi-sided examples. . The facade of windtowers has its own characteristics, and finally thin, adobe brick or done with plaster.

4.6. SIXTH TYPE

This windtower is a very rare example found in Kashan with protection in the lower part of the courtyard (Figure 9) Windtower of the Abbasian estate (Abbasids) in Kashan: this windtower is lower than courtyard level(Figure 10).

Figure 10.

5. WINDTOWER STRUCTURE

Local architects designed brickwork from the roof to the floor facing a small room dedicated to the windtower. For example, it gives a special effect to the facade of the windtower and enhances the building of the windtowers. Strengthens, because sometimes the windtowers in Ardakan and Meybod and their surroundings. It is built facing the street.

Windtowers (arc):

The width between the two wings is called the "arc". The width between leaves five, seven and 11 arcs respectively. The number of springs in this region is not even. Every windtower's depth is one to two and a half meters. Sometimes the power of the windtower can be up to half a meter. To increase the wind, wood is placed between the walls of the towers. The roof of the two columns "capillary" form is closed. In this way, two bricks are tangible upwards. The roof of the windtower allows fresh air to be drawn in or hot and polluted air to the outside. Then, with half a straw they cover the roof of the windtower with a diameter of three centimeters. Sometimes the space between two columns leveled with bricks and straw, then two or three rows of bricks to the sides of the roof is placed. So laying the bricks this way, in addition to the strength of the windtower.. Sometimes the roofing material is thatched. Later A row of bricks is placed on it. And the distance between the bricks is closed with plaster and soil. Material in houses with more facilities, plaster work is done on the arc walls of the windtower. The arc number of the windtower is directly related to the size of the windtower. On the other hand, the number of springs on both sides of the windtower, the strength of the wind on the same side, and the total relates to the weather of each region(Figure 11).

In some houses, sometimes for the winter, when the windtower is not needed, the spring of the windtower is in some parts, razors are made of brick or clay. Or a valve is installed at the bottom of the windtower and they turn it off when needed. This job is done every year in late autumn and on the eve of winter. Since the households are resting in the room under the windtower during the summer months. The birds especially pigeons nesting in wind towers and dropping their droppings down possible. Therefore, to prevent this, the spring part of the windtowers is made of wire mesh or wood.

Figure 11.

6. WORKING PERFORMANCE OF WIND TOWERS

Wind towers are effective at generating natural cooling in two ways.

1. Air movement
2. Evaporative cooling (Evaporation)

In a general category, windtowers create air movement and perform performance in two ways. can be displayed.

1. Directing the wind towards the building (when the wind blows).
2. Diverting the indoor air to the outside (when the wind blows)

At the top level of the windtowers, it is usually perpendicular to the direction of the prevailing wind. Thus, when the windtowers are placed in the wind direction, the air vents exposed to positive pressure and vice versa, negative pressure at the rear air vents occurs and ventilation only occurs when the wind speed is greater than 2.5 meters per second(Figure 12).

Figure 12.

At night, the formation of air flow inside the windtowers and the wind temperature of the mass of windtowers, due to the thermal radiation of their surface drops to the temperature of the sky and the so-called windtower is cooled; Windtower interior surfaces by exchanging heat with the air, the air is slightly cooled and then the windtower or enters the building below. The only way for the wind tower body to lose heat is the continuous evaporation of the ambient air with the walls, floor and ceiling. In this case, the wind is warmer than the ambient air because the warmer wind vaporizes the water droplets in its hull, and blows the windshield body at the same rate. Natural ventilation of windtowers where wind speed is not critical.

This causes cooler air to come out. Bottom to the tower withdrawn and alternately replaced by courtyard air. This can happen at any time of the day, but mostly at night and maybe in calm weather. The differences between the inside and outside of the building determine the air movement because as the temperature increases, the air density decreases, as a result of which the temperature difference between the inside and outside of the building and different areas causes pressure differences and this is followed by air movement. Same effect, thermal thrust, hot the average temperature between the air column and the outside temperature, and the temperature of the warm air column (wind channel) depends on its height(Figure 13). In addition to the heat problem in hot and dry areas, dry air and low humidity is among the factors that endanger thermal comfort; Therefore, in most cases, these windtowers are the best for creating a cooling system with evaporative cooling(Figure 14).

Figure 13. & Figure 14.

7. HOW WIND TOWERS ARE BUILT

Water was found in the space under the windtowers in four ways:

1. Placing water jugs under the wind tower

2. Establishing a pool in the middle of the wind tower room
3. Connecting the windtower to the living area by a moist horizontal channel.

There is a windtower a little far from the residential area that reaches from the canal. This channel The flowers and plants in the gardens are kept constantly wet by watering and infiltration. located under the gardens and under the courtyard; And out of the wind tower The air was cooled by evaporation from this wet underground duct and then enters the field.

• Construction method

The construction of wind towers refers to these two methods and how to build them. There are two construction methods available:

Channel construction: These spaces, in a section of one meter wide and two meters long,
It was built in square and rectangular dimensions depending on the multi-door room and the cellar. This section usually has two channels:

1. Subchannels
2. Upper channels

The hole for the lower duct to reach the basement or pool house, and the upper ducts in the room. The hole is one-third to one-fourth above the crypt, and in some cases toward the ground. Today, a net is installed at the top (entrance) of the wind tower channel. The middle channel from the ceiling level to the windtower can be implemented in various ways.

3. Connect the wind tower with groundwater flow through a vertical channel(Figure 15).

Figure 15.

The hole for the lower duct to reach the basement or pool house, and the upper ducts in the room. The hole is one-third to one-fourth above the crypt, and in some cases toward the ground. Today, a net is installed at the top (entrance) of the wind tower channel. The middle channel from the ceiling level to the windtower can be implemented in various ways.

8. MATERIALS USED IN WIND TOWERS

•The importance of the body components of wind towers as an element with a climatic function is obvious.Reed clay or adobe brick was used in the construction of the wind towers.

It is very convenient; since the earth element has an uncompressed and soft volume and water Figures 16,17 and 18).
Holes form, which prevents heat and cold from reaching the molecules. Dirt, layer and turns into clay. The building materials of wind towers are generally raw clay, brick, mud, plaster and salty wood.

•Salty wood, a tree with a high coefficient of strength and resistant to termite attack type. The color of the facade of the windtowers, with the color of the straw. In addition, the presence of straw in the mud, contributes to the texture of the facade, which prevents the absorption of rays. Clay in hot and humid areas and the brick is clearly visible; This is probably due to the use of environmentally friendly materials was due.

Figure 16; Figure 17; Figure 18

9. ADVANTAGES OF CONVENTIONAL WIND DEFLECTORS AND DISADVANTAGES:

The most important advantage of traditional windtowers is that they are passive systems, that is, they work. They do not need any energy other than wind energy.

The main disadvantages of traditional windtowers can be summarized as follows:

1.It is possible for dust and insects to enter the building from the windtowers.
2. Some of the air entering from the windtowers exit through the other openings of the building. When the wind towers have a single opening to the wind, the air is the same enters a large volume building at once.
3. The amount of cold air that can be stored in wind towers is generally limited .Wind towers due to the low heat capacity of energy-saving materials) and in the building may not provide the necessary cooling for hot summer days (Figure 19).
A. The cooling feature is not fully utilized by absorbing latent heat and evaporating air.
B. Wind deflectors are not used in areas where the wind speed is very low Application of Wind towers in modern architecture

Figure 19

10. ADVANTAGES OF CONVENTIONAL WIND DEFLECTORS AND DISADVANTAGES:

Wind towers may not be used as a ventilation system. However, in the current situation, required cool buildings, using the general principles governing how they work.Important measures can be taken to reduce energy consumption. With the emergence of modern architecture and especially the use of mechanical installations, The role of climate elements in buildings has gradually decreased, but climate and environmental protection are constantly since the second half of the last century.

Conversion and use of clean energies such as sun, wind and water has become very important. Since this period in the field of architecture, the importance given to the environment and the climate compatible with the climate buildings and architectural design studies started

A. Reliable and effective tool for the use of wind energy in the world of building industrialization. As a result, products called windtower were launched. In the design of these products. In addition to benefiting from the experience and structure of traditional windtowers, the disadvantages of using the traditional form are eliminated and the main idea is modern. and used in developing architecture.
B. Based on the natural effects of wind and the movement of hot and cold air, modern wind-towers that are not part and use vertical vents, brings fresh air into the room and removes used air. The operation of this system is warm and light(Figure 20). By moving the air upwards, the traditional windtowers follow simple rules which causes a pressure drop in the chamber and hence suction and heats.

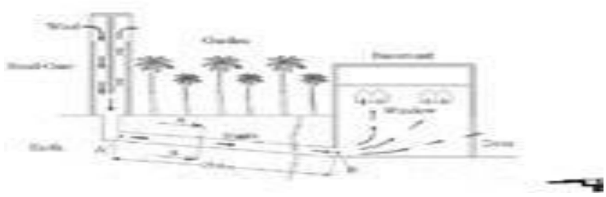

Figure 20

CONCLUSION

In general, the current use of wind towers according to their history can be divided into two categories:
A. Symbolic use
In this approach, the formal and visual features of the wind towers are included in the concept and design idea. For example, the famous and prominent Iranian in the design of the Museum of Contemporary Art architect Kamran Diba, in the general volume of the museum, visual and stylistic of the wind towers. This feature is also reflected in the buildings of the Persian Gulf countries. For example, one of the buildings built in the Jumeirah neighborhood next to the Burj Al Arab in Dubai.
B. Functional application
Today, in adition to the ventilation and cooling system of the building, windtowers are available. Natural ventilation at certain times of the year with the help of windtowers comfort conditions can be provided and only the wind can no longer meet the needs of the residents.

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25- Half-Timbered – Adobe Material, Sustainability

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ABSTRACT

All creatures have searched shelter for themselves to maintain lives and they have created own shelters inspired by nature, both imitation and materials that found in environment. People who instinctively build shelters using natural materials such as stone, soil, sand, clay, wood; they have also discovered many different construction and construction techniques depending on mobility of the world, change of human life, life expectancy, development of technology and new teachings. In this context, one of the traditional construction techniques and teachings of people from the past and half-timbered (hımış yapı) which is produced with adobe material are also considered as an example. Adobe material that is produced from the soil, which is exist in origin of half-timbered tradition with its features originating from its natural structure; the fact that, it has a nature-friendly, sustainable, and suitable for climate condition behaviour has led to the preference of adobe material in production of half-timbered structures. Half-timbered heritage from the past is decreasing because changing livings, environmental conditions, and supply demand relations; parallel with this situation because of the slowing down of transmission of tradition from generation to generation, heritage of half-timbered construction tends to be lost. However, for the future of the world, in 21st century efforts to bring concept of sustainability to forefront and increase awareness on sustainability have contributed to bringing the half-timbered construction tradition back to the agenda and to the emergence of contemporary examples. The material, material properties and construction techniques should be supported by technological developments and transferred it to future generations to maintain the tradition of half-timbered construction produced by adobe. Allowing material for serialization of production, increasing the resistance of the material to environmental conditions will contribute to continuity of buildings and the building tradition. The study mainly dealt with half-timbered and its origin of the adobe material in half-timbered construction production, afterwards it mentioned construction technique of structures, sustainability and relationship with environment and protection methods, then it aimed to reveal positive effects of adobe material on human health and life. Paper recognizes to existence of brick, stone, twig and adobe, adobe fillings in the half-timbered construction tradition, and focuses on adobe filling and half-timbered materials. The existence and characteristics of the half-timbered tradition in different regions of the world are also within the scope of the paper. Interpretation of analysis, it is provided that characteristic of the traditional half-timbered concept is more understandable and acceptable.

Keywords: Half-timbered, adobe, sustainability, environment, traditional and contemporary

1. INTRODUCTION

In many settlements of Anatolia, people live in buildings that they have built with traditional methods. These living spaces, which are built using natural materials, are generally designed with a wooden framework system and framework system skeleton is completed with stones, soil, straw, etc. fillings. The first examples of this type of buildings are found in the 13th century in Anatolia and the 14th century in European countries and these buildings are called the half-timbered (hımış) structure. According to Kuban [1], half-timbered is defined in two different ways; "1. A type of adobe filling which is used to fill in between wooden frames, 2. A wooden beam wall which is walled with adobe". Adobe takes place in the literature as a visible material all over the world. There are both traditional and contemporary examples in many parts of the world. It is predicted that, first examples were made in Mesopotamia. Some parameters make the material preferable for contemporary examples such as its raw material is soil-based, it is included in a nature-friendly material class on the basis of sustainability, and its recyclability potential is at maximum levels etc. This soil material can be used both as a "carrier" and as a "plaster" Özgünler (2012) pointedout in his study that, adobe is a traditional material, it has a minimum energy requirement from itsuse to consumption, and it is an environmentally friendly material [2]. When an assessment is made within the framework of the sustainability of building materials and the damage they cause to the environment, it is known that adobe material any causes or minimal damage to the environment.

2. HALF-TIMBERED TECHNIQUE AND FEATURES

Half-timbered is a building type that wooden materials are used on the basis of the structure system and complementary element of the wall is provided with stone, brick, mud brick, materials in the inter-frame areas which are called masonry materials. The Word of half-timbered means, "A wall or building made by filling adobe between wooden frames" [3]. In this building system, the concept of filling is completed with adobe, stone and brick etc. as mentioned above. Other definitions of half-timbered; It can be classified as timber-work (bağdadi) or wood coated. The buildings are raised on wooden foundations in some of the half-timbered. In areas which has too much stone material, different stone buildings are built according to the stone characteristics of the region. According to the regions in situations that change and transform, the stone material canbe built not only as a foundation material but also raised it along the ground floor wall. This situation is usually valid, where the ground floor is a barn and animals are took shelter. It is a known feature that the half-timbered was built on a stone foundation, it is raised with a wooden structure and it is filled between the skeleton with adobe and bricks. In this point of view, "Plastering the laths or straw nailed on wooden pillar…" (wall or ceiling) [4] is called timber-work(bağdadi). Structure that are formed by covering the structure with wood from the outside and it is formed by plastering the interior of the timber-work and it is leaved an empty space between theinterior and exterior coatings are also defined as "wood-coated" [5].

2.1. ORIGIN OF THE HALF-TIMBERED AND ADOBE MATERIAL

In the eras of the prehistoric "homo erectus (the first man to discover fire)", the houses in which leather and reed rods were used as carrier materials and mud was used as binding material show the effect of local materials on the construction system and building style. In the early times, with the end of the hunting period and the transition to the settled period, people used the materials that they found in the environment to meet their shelter needs. The most remarkable of these materials was mud brick made from clay soil. In Anatolia, Egypt and Mesopotamia, regular shaped mudbricks were recorded even earlier (from the 6th millennium BC). however, it continued to emerge in later periods [6][7][8][9]. It is a clever introducing that the penultimate part of Wright's 1985 book which is titled" 'Ancient Building in South Syria and Palestine, Leiden' is about the epics of Sinuhe, Gilgamesh and Homer, is a all inclusive which is covering the years 2000 BC and 3000 BC and it is dealt with together in Mesopotamian literary texts and transmissions" [10]. It is defined that this information, which forms the basis of the four sections connected to this section, it can be discussed and it requires.

The fact that bricks, adobe and similar binding materials have been used in the origin of the half-timbered system since the earliest times and it defines half-tibered structure system is rooted. Example 'Fig. 1' which is given below present that the visible facade of the straw building system.

Figure 1. An example of a house façade based on half-timbered system [11]

Figure 1 shows a typical half-timbered system. It is thought that adobe was used between the pillars. Because it is clearly seen that the pillars are often mounted side by side in vertical lines and supported by cross connectors to be directed to the right and left.

In the Sub-Saharan region of the African Continent, there are multi-storey adobe buildings have developed as religious buildings, such as the "Cathedral Basilica of the Holy Family in the center of Nairobi" or the "Hare Krishna Temple in South Africa" [12]. It is particularly noteworthy that multi-storey structures were built with mudbrick material.

2.1.1. TRADITIONAL AND CONTEMPORARY EXAMPLES OF HALF-TIMBERED AND ADOBE MATERIAL

The adobe material is obtained from clay soil, which is a type of mud, so its primitive examples can be traced back to Neolithic times. In the geography of Turkey, there are many examples representing the primitive examples of adobe, whose origins date back to ancient times, and it is possible to encounter many examples all over the world at the global level. It is known that the houses where some communities in Turkey live were built from adobe material. In the ancient times, it is stated that, Families living in Çatalhöyük 'Fig. 2' in the province of Konya, they live a house which is made by "adobe, wood and reed" and after this house used; it was covered with soil and new house is built on buried house, this situation was repeated about every "80 years" [13]. The structures are built in Çayönü in Diyarbakır 'Fig. 3', which date back to the Neolithic period, it also represents the first examples of adobe house [14]. It can be said that these primitive house examples have local stone and adobe material in the origin of their construction, it represents origins of the houses built using adobe in Anatolia and reaching the 21st century. UNESCO World Heritage houses named "Taos Pueblo" 'Fig. 4, 5', which are the residential areas of "Indians" and located in the north of Mexico, it can be considered as the first examples of adobe structures in the world [15].




Figure 2. Catalhöyük [16]; Figure 3. Cayönü [17]; Figure 4 & Figure 5. Taos Pueblo [18]

On the basis of contemporary examples of the 21st century, adobe is used as a building material in many parts of the world by adding additional materials directly or indirectly to it. Yves Saint Laurent Museum 'Fig. 6', it planned and built by the synthesis of traditional local and modern architecture in Morocco and designed by Studio KO. Presence in Hormuz 2 'Fig. 7' implemented by Zav Architect on the island of Hormuz in Iran. The example of adobe living units are some of the examples that represent the use of the material as a contemporary material.

Figure 6. Yves Saint Laurent Museum, Studio KO [19]; Figure 7. Presence in Hormuz 2 / ZAV Architects [20]; Figure 8. Residence, La Paz, Bolivia, Gernot Minke [21]; Figure 9. Residence, La Paz, Bolivia, Gernot Minke; Figure 10, Plan view of Residence, La Paz, Bolivia, Gernot Minke [22]

Gernot Minke who is working on contemporary buildings and sustainability, he builds the structures which are designed with adobe material. A housing project he did in Bolivia 'Fig. 9, 10' is an example of a contemporary adobe house.

2.2. THE USE OF ADOBE MATERIAL IN HALF-TIMBERED

Adobe was a common building material in the past centuries. Straw or reed stalks were used strengthen to clay. When adobe material was used in half-timbered style, it was necessary to create a base with branches to prevent it from falling in the direction of gravity. The gaps of the half-timbered style are filled and placed, and half-timbered receives support from its structure. "When cracks are formed over time on the mudbrick placed between the wood skeletal structure, it is filled with a dense lime mixture obtained from the wool and lime mixture" [23]. The half-timberedsurface, which has dried well, and it is placed in the wooden structure, is covered with a layer of lime, and painted.

2.2.1. PRODUCTION OF HALF-TIMBERED AND ADOBE MATERIAL

The wood construction system differs to a certain extent according to the type of materials used as filling material. This type of construction is classified as "Systems which are made using branch and clay filling", "Systems which are made using stone filling", "Half-timbered systems which are used brick filling", "Half timbered construction systems which are used adobe filling" [24]: In branches and clay filled systems, tree branches are knitted between vertical wooden carriers in the form of a vertical basket weave.The production is - both inside and outside - completed by plastering clay from both sides of these knitted basket weaves. In stone filled systems, clay is used as a mortar while the stone material is filled between the wooden frame. In brick filling systems, the gaps between the wood frame system are filled with brick material by placing them straight or obliquely 'Fig. 10'. Half-timbered system which is filled with adobe, the spaces between the wooden frame are filled with adobe, a material that has been used since the earliest period of history.


Figure 10. Cross-linked texture on wall surface suitable for adobe material with dense interspaces [25]; Figure 11. Wooden frame system with square partitions "Göz-Dolma" [26]

Adobe material can be considered as a light material compared to others. Adobe as filling material, soils which contains "30%-40%" clay are fertile. A few days after the shaped mud bricks are taken out of the mold and turned for drying its on the other surface. A very different feature of the half-timbered is a system of horizontal and vertical connections; These are viewed in square-shaped view which are divided by small cross-sectional pieces. Square partitions are supported from inner corners or corners to prevent deformation in spite of cross movements, weather conditions, earthquake etc. In the technique called "Göz Dolma" 'Fig. 11', the inside of the square spaces is completed with adobe, brick etc. materials. In the technique called "Göz Dolma", the inside of the square spaces is completed with adobe, brick materials etc. This type of half-timbered system is found in very few houses in the Eastern Black Sea Region [26].

2.3. SUSTAINABILITY OF ADOBE MATERIAL WITH EXAMPLES INDEPENDENTLY OF HALF-TIMBERED

To minimize damage to nature, environment and human health, a lot of research and studies are being done in the 21st century. In this context, the use of nature-friendly materials in the construction sector comes to the fore and it is significant. It is known that the materials which is used in the construction of the buildings cannot be reused when the lifetime of the building is exhausted, or the dust and gas released during the demolition are dangerous. Factors such as obtaining the raw stuff of the materials used in building construction by natural processes, being from nature, being recyclable and being reusable, come to the fore on the basis of the sustainability of both the material and the environment within the framework of human health and environmental health. Examples of adobe material in a half-timbered show a material behaviour within the framework of sustainability. As an example of the recyclability potential of adobe material, it is known that in case the adobe soil cannot be obtained in good quality, the existing adobe in the buildings is reused by wetting method [27]. One of the being nature-friendly building examples of half-timbered which adobe is used as filling material, are important based on sustainability and the use of hybrid materials. Construction systems are formed by filling with soil material after the creation of the half-timbered. Because both wood and adobe are materials from the nature, half-timbered minimizes the damage to nature. It provides convenience to the user with its ease of processing and its ubiquity [24]. In the villages known as "Pueblo" in New Mexico, houses of Native American people are made by "adobe and wood" materials. "Houses have flat roofs and may have one or more floors" Country folk have been living in these houses for more than 1000 years. The houses in this village were named Santa Fe style based on researchers [25]. Native American country folk, as a Native American origin, come out of the soil as clay and mud brick and are identified with their homes. Native American country folk identify soil, clay, and adobe material with their homes. There is straw in the adobe of the traditional houses of the village. Each adobe space develops in the style of stairs and rises from one to the next like steps. "The adobe material is easy to recognize by its texture and rounded forms and it is typical of many New Mexican especially Santa Fe buildings" [28].

3. ANALYSIS OF THE ADOBE SUSTAINABILITY IN A HALF-TIMBERED AND INDEPENDENTLY OF HALF-TIMBERED

Sustainability features of adobe material and half-timbered, it reveals the importance of structure and material for human life on future.

life process / adobe-half-timbered	Time process	First examples	Using	Production method	Sustainability	Assessments
Half-timbered	13th and 14th centuries. in Turkey and Europe	Anatolia and European countries	Residential, religious and some public buildings	It is built with wooden skeleton system and filling material.	The materials are obtained from nature. It is recyclable.	It is a healthy building system from the earliest times to the present.
Adobe material	From the Neolithic to the 21st Century	Catalhöyük – Cayönü	It is plain and it is used in structure systems.	Obtaining mud from clay soil mixed with water and added straw residues.	The material can be decomposed dry or wet and reused.	It is an extremely healthy material that has been around since the Neolithic Age.
Adobe material structures in a half-timbered	The history of adobe is thousands of years older than half-timbered.	The first examples are found as old as the half-timbered.	Equivalent to the use of a half-timbered.	As the filling material, adobe and half-timbered are more frequent in texture.	The material can be reused by disintegrating with the wetting method.	The use of adobe as a filling material in the half-timbered is present in the oldest examples. It is the healthiest.
Adobe material independent of half-timbered	The adobe material begins at Çatalhöyük.	It is also found in Catalhöyük – Cayönü and Taos Pueblo.	The most primitive and up-to-date version of adobe is in use.	Mud as a clay soil, clay is poured into moulds and adobe is made.	It is a material that breathes and comes from nature.	It breathes and it is healthy because the straw with mini air grooves is put inside.
Assessment	The half-timbered and adobe are both the oldest and contemporary.	First examples provide better recognition and have been preserved.	It is still used in Anatolia, Guatemala, and Peru.	Adobe is used alone and as a filling material in a straw structure.	Half-timbered and adobe are healthy buildings, so it deserves to be researched and maintained.	Half-timbered filling material and plain adobe are being researched as contemporary and they point to the future.

Table 1. Matrix analysis for sustainability of adobe and half-timbered

3.1. EVALUATION OF THE ADOBE MATERIAL SUSTAINABILITY IN A HALF-TIMBERED AND INDEPENDENTLY OF HALF-TIMBERED

Half-timbered construction style and adobe material have been a healthy structure and material since the oldest dates. Adobe is both a building material on its own, its examples can be seen in the past, and it gains equal value as a filling material in the half-timbered construction style. Because the adobe material is obtained from clay soil, it has an adhesive quality to each other. At the same time, the feature of a hollow rod of straw, which is an additive, allows the adobe to breathe. It breathes and is an extremely healthy material. The first examples of adobe material and wood structure can be found in the oldest periods of history. The oldest examples are still available in Anatolia, Guatemala, Peru, Sub-Saharan Africa. As well as the single-storey examples, the multi-storey examples could not be demolished until the century they lived in. Half-timbered construction style and adobe materials are currently being researched, and since they are healthy materials and properties, they point to the future.

CONCLUSION

The first examples of which were found in the 13th century in Anatolia and in the 14th century in European countries, it is an old building style that was built by filling with adobe, brick, small stone pieces etc. The half-timbered construction style, in which wood is used extensively, it is observed as a construction style that is mostly used in the Black Sea region, which has a large forest area in Turkey. In the earliest times, the wall or ceiling of the half-timbered building, in which mud brick was used mostly as filling material, it was plastered on bars or reeds nailed on tree poles, and it is also known as timberwork (bağdadi) building. With these points of view, the half-timbered structures with an empty space between the inner and outer cladding, which are formed by covering the half-timbered construction from the outside with wood, and plastering it from the inside, such as timberwork, they are also defined as wood-clad structures.

Adobe material is obtained from clay soil. It is turned into mud by mixing water into it. It is obtained from a certain amount of sticky mud. It has been used since the Neolithic age. According to the geographical regions of the world, in areas where stone material is scarce and forest density is low, adobe is used simply as a material, sufficient to build a house. The earliest examples are still found in Anatolia, Guatemala, Peru, Sub-Saharan Africa, and New Mexico. Timber cut from the forest is used only for the roof material. On the other hand, the entire structure system of the building is covered with wooden material for the half-timbred. The surface is created with wooden pillars under the gaps in which adobe is placed as a filling material.

The spaces built with adobe materials are also maintained on the basis of contemporary examples of the 21st century. Yves Saint Laurent Museum planned and built by the synthesis of traditional local and modern architecture in Morocco and designed by Studio KO, Presence in Hormuz 2 implemented by Zav Architect on the island of Hormuz in Iran, these adobe units are some of the examples that represent the use of the material as a contemporary. Gernot Minke who is working on adobe buildings in a contemporary and sustainable sense. A housing Project that he built in Bolivia is an example of a contemporary adobe house.

The use of adobe material as a filling in the half-timbered structure is in the knowledge and experience of centuries. However, when the adobe material that fills the gaps creates cracks over time, a dense material obtained from a mixture of wool and lime is used to close the cracks to prevent this. When adobe and bricks are used in the types of the half-timbered construction style, the skeletal gaps are considered as dense, and cross-links are used. In addition, a small number of dwellings have an unusual style of wood construction in the Eastern Black Sea Region. There is a structure system that is divided into small square sections called "Göz-Dolma" on all façades in the intermediate partitions. This square-section wooden frame is supported separately from its corners, they prevent its movement in the diagonal direction and they strength it. The square partitions are filled with adobe or brick material.

The half-timbered structure system and adobe material embody its own sustainable feature. It also draws attention in a village where Native American people live, it is called Pueblo and located in New Mexico, which is a typical example of its deep-rooted history. Country folk have been living in these houses for more than a thousand years. The adobe houses in the villages called Pueblo rise on top of each other in the form of layered stairs as if they were on a sloping land. Country folk have been living in these houses for more than a thousand years. These are called to as Santa Fe-style buildings.

As can be seen, adobe houses and half-timbered houses, which have been followed all over the world, have been sustained until the present time, and create healthy environments for living people, are both healthy, durable, sustainable, and very humane. When the sustainability analysis was made with the data of the adobe material and the half-timbered construction style on the basis of this paper, the following information emerged.

The adobe, which is obtained from clayey soil, is a building material that breathes with straw material. It is developed as an extremely healthy material for human health. It continues to be used either alone in adobe houses or as a filling material of the wood construction style. It continues to be used as a filling material either alone in adobe houses or in a half-timbered structure. In the contemporary sense, both the wood construction style and the adobe material are increasingly the subject of research. Because applied research is carried out especially in local regions, in Anatolia, in regions such as Guatemala, Peru, African Sub-Saharan Region and New Mexico. Even in Europe, the architect named Gernot Minke and many researchers who took him as an example, under his leadership, are discussing and developing the adobe building style with new experimental examples. Even in Europe, the architect named Gernot Minke and many researchers who took him as an example are considering and developing the adobe building style with new experimental examples. Half-timbered and adobe material deserve to research and new experiments for the continuation of human life, environmental health, and sustainability.

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26- Typology of Traditional Houses with the Courtyard Elementin Yazd

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ABSTRACT

The evolution and development of culture and architecture in Iran has a long and complex history. Iran has been the center of world action for centuries; it has been a capable exporter of not only architecture but also other cultural impacts. The architectural shapes and forms of many important houses in Iran have been developed by the concept of introverted culture. The essence of the internal organization of space in Iranian housing is the "courtyard", an interconnected and integrated structure which is an appropriate answer to the physical and spiritual lives of people. One of the primary forms of housing development is houses with courtyards, which can be found in various patterns in different regions, especially in the hot and arid regions. Over the centuries, this type of historical housing has developed into a logical configuration. This configuration of forms has been strongly influenced by the local characteristics of its content and culture; thus, the user has been able to enjoy maximum benefits with minimal impact on the environment. In the courtyard, cultural concepts that induce an archetype aspect have been cleverly integrated. Climate and culture have formed the type of courtyard housing in Iran, particularly in the historic city of Yazd. In fact, courtyard housing has become the prevailing historical housing pattern in the hot and arid region of Iran and has shaped the urban areas. In addition to cultural patterns, climate conditions have had a significant impact on the formation of the courtyards of Yazd's historical houses. In this study, with the help of literature and field data collection and a review of the existing houses in the historical texture of Yazd, a classification of the form pattern of the courtyards has been concluded. The three overall classifications of houses with courtyards are central courtyards, four-platform courtyards (Chahar Soffeh), and garden houses. Architects, with the assistance of the typology of courtyards in the hot and arid region of Yazd, are able to re-integrate culture and climate into their designs and, as a result, produce more sustainable buildings which can respond to local needs

Keywords: Historical housing, courtyard, Yazd, pattern, climate

1. INTRODUCTION

Many Western models of urban housing are influenced by cultural traditions, construction methods, climatic conditions, and construction sites. Not only is Western typology built without regard to social and cultural documentation, but building regulations and planning laws applied by countries such as Iran, Egypt, Libya, and Saudi Arabia are based on European models. Thus, the traditional courtyard house, which has existed as the first type of urban building for nearly two thousand years, finds itself facing modern regulations. Courtyard houses are one of the earliest forms of housing development and have existed in various forms in many areas. Over the centuries, this type of house has become a logical configuration that maximizes the area built in the urban area. While climate and culture have shaped courtyard houses in the Middle East, there are other examples in Europe, China, and Latin America whose patterns have been revived. In fact, courtyard houses have generally formed in hot and dry areas, forming urban areas in their cities; In addition, the impact of socio-cultural patterns should be considered alongside climatic conditions.

2. LIVING IN THE HISTORICAL TEXTURE OF YAZD

Most of the historical texture of Yazd, like other cities, includes residential function. The distinguishing feature of residential buildings in Yazd is its antiquity and adherence to the principles of Iranian architecture. Residential buildings, like other buildings of historical texture, have undergone changes in the system of construction and spatial divisions based on their historical period. Apart from this, factors such as the geometry of the land, the predominant religion of the period or the religion of the landlord, the economic situation of the landlord, the needs and conditions of the owner, etc. have influenced the architecture of residential buildings.

3. COMMON HOUSES IN THE HISTORICAL TEXTURE OF YAZD

Most of the central courtyard houses left in the texture belong to the Qajar period. The common features of these houses are that the courtyard houses of Yazd are a complete manifestation of introversion. The courtyard, the organizing element of the courtyard-shaped spaces, its direction and the general plan of the house, is affected by the general form of the house and is also influenced by climatic factors such as sunshine and religious factor. The difference in the level and number of floors in the houses is also due to climatic factors such as access to water. In places where water is available at a lower depth, houses, like Owlia house, form a sunken garden on one to two floors below ground level. In some cases, the yard is located above the ground floor and is almost on the roof.

3.1. ELEMENTS AND COMPONENTS OF THE COURTYARD HOUSE

The common feature of the historical houses of Yazd can be considered in their elements and components. These elements are present in most houses. The presence of these elements can be largely attributed to climatic and cultural factors. Which have undergone changes over time and in different historical periods. Changes in the components of the house are an important factor in the style and period of the houses. The courtyard, the Talar, the vestibule and the wind catcher, and the types of rooms and enclosed spaces, etc., which will be mentioned below, are among the most important of these elements. These elements affect the physical form of houses.

The Yazdi architect has built a house whose inhabitants can live comfortably in the heat of summer and the cold of winter. Therefore, the space of the house is divided into two parts: summer living room (basement, Talar, Howz-khaneh or the pool house, Payab and Tanabi) and winter living room (Tehrani, Seh-dari, Panj-dari, and the attic). The summer part of the house is built on the south front and the winter spaces are built on the opposite and west fronts. Usually on the eastern front due to the light of the west, arches and small porches are lined up. When the temperature was very high, the family went to the cellar and used the cooler air. In some houses, where the branches of the Qanat passed under it, there was a way to reach the Qanat from the basement, and sometimes the water of the Qanat entered a small pool on one side and exited it on the other side. They said. The presence of water pool and wind catcher's inlet ducts has increased the humidity and cold in this space [1].

3.1.1. TRADITIONAL COURTYARDS

The courtyard is a structural element that was created in hot and dry regions and is now accepted in different parts of the world. This area is like an enclosure surrounded by a building or wall and opens to the sky. The courtyard is one of the oldest architectural components used by humans in buildings [2].

Some evidence suggests that houses with courtyards existed in Iran about 8,000 years ago. They have been excavated in Qazvin region (northwestern Iran). The rooms were located on one side of the courtyard and included living spaces, storage room and shops. The courtyard was also an important architectural feature in Mesopotamian civilization. There are a number of surviving buildings with pre-Islamic and Islamic courtyards, such as the main building of Choghaznabil from 1250 BC, the burnt building on Hesar Tapeh, Damghan from 1000-800 BC; Assyrian Palace from the Parthian period; Firoozabad Fire Temple (3rd century AD); Palace in Sarvestan (5th century AD); Fahraj Mosque (8th century AD); Grand Mosque in Shiraz (19th century); New Mosque in Shiraz (13th century) and Khan School in Shiraz (17th century). These examples show the deep coexistence between the courtyard and the house in Middle Eastern society [3].

The courtyard is the main space element of a traditional house. In fact, it plays a decisive role in the spatial organization of the house, both during construction and during use. The courtyard is the source of life in the houses of Yazd. The courtyard determines the share of the sky in each house, and the pool is the mirror of the sky, where water, the manifestation of purity, purifies the space of the house. Gardens, trees and herds are the neighbors of the pond, without which the house has no soul. Yards have a multi-functional space. One of its functions is the role of communication. In addition, this functionally flexible space accommodates activities such as sleeping, children's playing space, family gatherings, and weddings and religious ceremonies. The number of yards varies according to the landlord's occupation and social status. In such cases, some yards gather service functions such as kitchen and storage around them. The formation of the house has in many cases been based on the religious beliefs of the owner of the house; So that the houses with two courtyards with Andarooni (internal) and Birooni (external) is a sign of this issue.

Figure 1. Courtyard of houses in Yazd

The courtyard is the site of annual celebrations, weddings and religious ceremonies, although a Panj-dari room is also used for parties and table setting [4]. The presence of pools and plants inside the courtyard compensates for the lack of humidity and in addition to creating shade, also increases the softness of the air. All the openings and entrances of the rooms open to the courtyard or the space leading to it and the courtyard is the communication space between all parts of the house [1].

-Birooni (External) Courtyard

This courtyard is actually an independent and special space for entertaining guests and non-relatives and non-Mahrams. It is a small courtyard in the shape of a square or rectangle. In the center of this courtyard is a circular, octagonal or star shaped pool. The garden is in the four corners of the pool or on its sides and is decorated with citrus trees.

-Andarooni (Internal) Courtyard

It is a large and spacious courtyard, the proportion of which depends on the rooms around the courtyard, and sometimes with dimensions close to the garden. The internal courtyard is specific to the lives of family members.

-Sunken Courtyard

A courtyard in the heart of the courtyard (usually in the heart of the internal courtyard) is to access the Qanat water [4]. Trees and shrubs that are planted in Iranian courtyards, especially in Yazd, are specific and in some cases, climatic and sometimes cultural priorities have led to their planting in the garden.

Figure 2. Sunken courtyard of Kasmaei and Lari houses in Yazd

-Narenjestan

Small courtyard for the possibility of growing and protecting the evergreen, productive and blessed ژitrus tree. The proportions of Naranjestan are so large that on the eve of the cold season, the yard can be "covered" and the trees can be protected from frost. The stems, leaves, flowers, fruits and aroma of spring citrus are all beautiful and aesthetically create an excellent quality in the Narenjestan and its surrounding spaces. Due to the limited dimensions of the Narenjestan when the windows are open, it is possible to communicate and come in close contact with the foliage of the tree, which is important in terms of dimension and quality of the landscape [5].

Figure 3. Narenjestan of Kasmaei house in Yazd

4. TYPOLOGY OF COURTYARDS

To address the issue of typology, it is necessary to define the species and its criteria. Classifying data based on common principles and characteristics is an important step in recognizing phenomena. For this reason, the classification of objects by means of geometry and order, or in other words typology, has a long history in architectural theories [6]. According to the research needs and the background of the formation of housing patterns in different countries, the typology of the house from the scale of the complex to the block, including the interior of the unit and the entire residential unit has been done with different criteria. American researchers "Tice", "Sherwood" and "Polyzoides" have categorized Los Angeles courtyards into one-sided, two-sided, L-shaped, U-shaped, and central courtyards in terms of land occupation [7]. The German researchers Pfeiffer and Brauneck, in their book on the typology of courtyard houses, have divided houses into groups of houses with a central garden, L-shaped houses, passive houses, and atrium houses [6]. In general, indoor typology is usually based on how the interior spaces are accessed or circulated. courtyards in Yazdi houses are classified centeral courtyards, Chahar-Soffeh (four porch) courtyards and garden-houses.

4.1. Chahar-Soffeh (Four Porch) Houses

Next to the houses with the central courtyard, which are mostly Muslim, most Zoroastrian houses are four-porched, so that the influence of the Zoroastrian religion and their beliefs and the sanctification of the number four as a symbol of the building blocks of nature, affect the shape of the house. The importance of religious ceremonies and special celebrations has been effective in shaping the spaces of the house, including the porches and the Tanabi room.

Figure 4. Varjavand House, a Chahar-Soffeh House

Most of these house are pre-Qajar houses, and this courtyard is the heart of the house and its center, both geometrically and functionally. The size of the yards is often small, one of the reasons for which can be attributed to its function replacing the witctacher. Due to the small size of these courtyards, there is usually no water pond in them, but small gardens are located in it. In some houses, to cope with adverse climatic conditions such as strong sunlight, the yard was roofed, in which case, a garden is located next to the roofed yard. In some cases, a central courtyard is formed next to the four-porch courtyard. The existence of the central courtyard can be attributed to better lighting and also higher privacy, which is modeled on Muslim houses.

4.2. GARDEN HOUSES

Garden houses are another type of houses in the historical texture of Yazd. In the past, due to the favorable weather conditions in the city, these types of houses were formed. A number of these houses still stand today. In this type of house, a small garden has played a pivotal role in the formation of the whole complex and in general, the important spaces of the house have established a good relationship with it. In fact, in this type of house, a small private garden has replaced the yard. In garden houses, a yard with surrounding spaces is usually built to separate the different areas of life, both public and private, at the end of the garden, which is considered as the private area of the house. This main building is generally built as a pavilion. In addition, a ancillary building with service functions is constructed in such houses. The small garden of the house has a different structure from the courtyard and due to its considerable size, it includes a lot of trees, especially fruit trees. Garden houses have a high wall, the main reason for which is to maintain garden security and privacy in the house.

Figure 5. Sedgh garden house in Yazd

CONCLUSION

As a result, contemporary architects and designers learn from past and indigenous architectural techniques. A very important issue is the lack of indigenous methods in new developments in many parts of Iran, including Yazd. In addition to the lack of indigenous methods, contemporary residential designs ignore cultural and environmental conditions that lead to unsuitable architecture. A variety of indigenous methods, including courtyards (private, semi-private and public), basements (public), can be actively added to new contemporary designs. The main purpose of the design is to create an efficient and practical connection between contemporary architecture and indigenous methods used in the past. In areas with very different climatic conditions, knowledge of the weather and other elements along with a proper understanding of the architectural heritage of these areas is essential to create appropriate designs in these areas. Ignoring traditional architecture and ignoring local climatic conditions will create inefficient and unstable designs. By examining the houses in the recorded historical texture of Yazd, classification of the location of the courtyards in the traditional houses of Yazd has been reached, which the general categories are: houses with centeral courtyards, Chahar-Soffeh (four porch) houses and garden houses.

No.	Type Name		Symbolic Form	Selected Example
1	One courtyard	Three fronts		Kolahdooz-ha House
2		Two fronts (reciprocal)		Vaziri House
3		Four fronts		Seda va Sima House
4		Edifice		Akhavan Tabrizi House
5	Two courtyard	Internal-external		Rasoulian House
6		square rectangle		Targhi House
7		Octagonal		Ahmad Mirza Malek House
8		courtyard on Sabat		Bahador House
9		Roofed yard		Babaei House
10	Multiple courtyards	Conventional		Golshan House
11		Sunken courtyard + Sunken courtyard		Imamzadei House
12		Sunken courtyard + central courtyard		Owlia House
13		Two central courtyards + one front courtyard		Tehrani House
14		Non-level courtyards		Papoli House

Table 1. Typology of centeral courtyad houses

No.	Type Name		Symbolic Form	Selected Example
1	Chahar-Soffeh			Mehrbanoo House
2	Two courtyards	Roofed Chahar-Soffeh + garden		Ardeshir House
3		Chahar-Soffeh + courtyard		Farokh Ormazdi House
4		Chahar-Soffeh + one-sided courtyard		Janfada House

Table 2. Typology of Chahar-Soffeh courtyard houses

No.	Type Name		Symbolic Form	Selected Example
1	one front			Rahmani Garden House
2	Two fronts			Abdol-Rahim Khan Garden House
3	Combinatorial	Yard + L-shaped garden		Arbabi Garden House
4		Two yards + garden		Moshir Garden House
5		Garden pit + garden		Olumi Garden House

Table 3. Typology of garden houses

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27- Principles of Hassan Fathy's architecture; Doctrines forToday

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ABSTRACT

Hassan Fathy started to his architectural practice at a time when modernism was becoming increasingly popular and widespread all over the world, and drew attention with his attitude towards this 'new' global style, which does not pay attention to concepts such as history, culture, tradition and locality. To locate Fathy in his era, he was 31 years younger than Frank Lloyd Wright, 13 years younger than Le Corbusier, and 2 years younger than Louis Kahn. Although he started his architecture practice relatively after the famous pioneers of the modern movement, he opposed the general discourses of the period and gave importance to an architectural approach that was fed by traditions, local culture and history. Use of local natural materials and sustainability have been at the forefront both in the techniques and methods used in Fathy's architecture. Although Fathy's architecture was not widely accepted in his early periods, later on, his work and philosophy made quite an impact around the world. Especially with the publication of his book "Architecture for the Poor, an Experiment in Rural Egypt", was published in Cairo in 1969 and USA in 1973, the whole world got to know Fathy and his doctrines. In his designs and discourses, he sought answers to how the experience and knowledge from the past would illuminate present day's expectations and the requirements.

When Fathy's discourse and doctrines are examined in his pursuit, it is seen that three basic principles are at the forefront; the affordability of the buildings, the involvement of the local folk in the production process and energy efficiency. Fathy's architecture stands out with its traditionalist, ecological and sustainable features that benefit from vernacular culture and experience. Although ecology and sustainability have been the fields that have been studied intensively in recent years, the fact that Fathy became aware of these concepts at a time when the whole world focused on modernism and did not care about these concepts shows that he developed an innovative and original approach besides his traditional character.
Within the scope of the study, Fathy's architecture was tried to be analyzed, especially through the buildings he designed in Egypt, within the concepts of ecology, sustainability and energy efficiency. Along with physical analysis and evaluations through his buildings, his teachings and phylosophy were also examined with a critical view, especially through the texts he produced, and tried to be interpreted in the context of the dynamics of today's architectural environment. Afterwards, projections for the future were expressed, considering that Fathy's farsighted teachings were not actually a periodic attitude and approach.

Keywords: Hassan Fathy, ecological architecture, vernacular architecture

1. INTRODUCTION

Hassan Fathy, who lived between 1900 and 1989, is one of the most important figures of Egyptian architecture (Figure 1). He graduated from the Polytechnic School of Architecture in Cairo's

University in 1926 and has done his architecture practice for over 60 years (1). He was born in a family of high socio-cultural level in Egypt and grew up in Alexandria and Cairo. He has traveled to Europe, and even worked as a guest lecturer in some schools after he became famous. He has never been to the rural areas of Egypt before designing in those areas. Although he was given an architectural education in the Beaux Arts school, it is seen that Fathy's designs were excluded from the influence of this dominant and classical tradition in the 19th century.

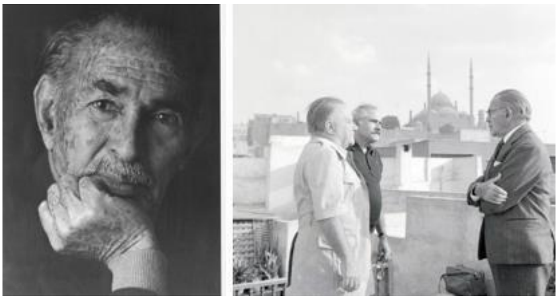

Figure 1a. Fathy's portrait (left) b. Lawrence Durrell (left), Dimitri Papadimos and Hassan Fathy (right), in Cairo (Url-1)

During the periods when European-origin movements were widely accepted in non-European countries, Fathy sought an architectural practice that was nourished by his own origins instead of adopting these movements that did not care about local culture and traditions. Fathy's architectural thought has a critical and distinctive character that cannot be directly reduced to a particular architectural movement. Fathy became famous all over the world, especially with the publication of his book, which was published in Egypt in 1969, in America in 1973, and his ideas and doctrines began to be discussed. In his book "Architecture for the Poor", he sought answers to how the experience and knowledge from the past would respond to today's expectations and the requirements of the age, through the architectural practices in the village of Gourna. When Fathy's philosophy is examined, three basic principles draw attention in the design and construction to be made in the countryside; low energy consumption, low cost of structures and public involvement in the production process. Particularly, the participation of the public in the construction process of the buildings is very important for Fathy. According to Süha Özkan, these sensitivities of Fathy were noticed too late in Europe. Years later, Fathy's book was published in French as "Construire avec peuple", which means building with the people, instead of "Architecture for the Poor" (2). The same book was published by the Chamber of Architects in Turkey in 2010 as "Participatory Architecture" (Katılımcı Mimarlık).

Fathy's philosophy of architecture and social approaches attracted attention especially with the publication of his book in America after 1973. The modern movement, which was subjected to intense criticism after the second half of the 20th century in Europe, was criticized and rejected much earlier in Fathy's thought. From this point of view, it is obvious that Fathy was a pioneering architect with a philosophy far ahead of his time. The approach of Fathy architecture, inspired by the traditional, valuing local culture and accumulation and rejecting global approaches, has come to the fore again with concepts such as vernacular architecture, ecology and sustainability, which have been spoken frequently in the architectural community recently. Fathy has become an important architectural figure, first in the Islamic geography and then all over the world, both with his stance against global discourses and his farsightedness.

In the last few decades, the concepts of ecology and sustainability have become the topics of intense debate in the field of architecture as a result of the depletion of energy resources, global and climatic crises, and people's inclination towards the natural and sustainable as a result of living

spaces that are far from natural. The term "ecology"was coined in 1866 by the German scientist Ernst Haeckel, and it became a rigorous science in the late 19th century. The concept of sustainability was first expressed as a forestry term in 1713 by Carl von Carlowitz in his book Silvicultura Ecológica. Although the concepts of sustainability and ecology are concepts that entered the literature in the 18th and 19th centuries, respectively, it can be considered relatively new that this subject has become controversial in the architectural environment. The concept of sustainable design emerged after the World Building Congress in Gävle, Sweden in 1988. In the report called Agenda 21 (Agenda 21 on Sustainable Construction) prepared by CIB (Fr: Conseil International du Bâtiment: İng: International Council for Building), a classification was made regarding the standards of this subject (12). The concepts of ecology and sustainability, which have been on the agenda of the architectural environment for nearly 30 years, are actually conceptsthat stand at the center of Fathy's architectural approach. Fathy preferred nature-friendly, recyclable and sustainable materials in all of his designs. With such an approach, he used the mostaccessible, low-cost building materials of that region in his designs in Egypt and other Central Asian countries, with local construction techniques, to which he added his own interpretation (Figure 2).
Figure 2. Mud brick production in New Gourna (13) Making of sun-dried bricks, New Gourna (14)

In this context, instead of imprisoning Fathy's foresight and thoughts within his own period, evaluating it with a actual perspective and trying to understand his from today's architectural environment can be a consultation area for future projections.

2. FATHY'S ARCHITECTURE AND THE CRITICISM OF MODERNISM

It is not easy to position Fathy's architecture in its own period and to evaluate it in terms of a certain architectural trend and style, and it will not be the right approach. While it is relatively possible for the architectures of his period to be evaluated through classifications such astraditional and modern, Fathy's architectural approach cannot be interpreted through a defined architectural style. The most important reason for this situation is that he could not accept a certain architectural approach like his contemporaries, and he both cared about the accumulation and traditions of the past and exhibited a "modern" stance depending on the requirements of the age. This is why Tanyeli evaluates Fathy together with Schmitthenner, Pikionis, Eldem, and Correa inhis book "Mütereddit Modernler", in which he examines the architects who have a conflicting relationship with modernism (3).

2.1. FATHY AND MODERNISM

The modernism movement, which is one of the important breaking points in the history of architecture, was based on the ground created by the technology that developed after the industrial revolution. With modernism, sociocultural and social inputs, which are of great importance for architecture, lost their importance and this situation had important reflections on the architectural environment. The new world order, which emerged as a result of industrialization, had a significant impact on the social structure. The buildings, whose relations with the changing technological criteria have weakened, have lost their importance with the modern movement and a global definition of architecture has been made with new materials and techniques. Changes in the ideological and social structure and consumption habits, changes in production processes due to technology and rapid mechanization have formed the basis of modern architecture. Modern architecture, which is based on newly emerging developments, has severed its ties with the past and rejected the past. As a result, people whose social and cultural memory has been interrupted have weakened their ties to the past. As a result of this situation, especially since the second half of the 20th century, the modernism movement has been subjected to serious criticism.

Modernism has influenced the entire architectural environment, especially since the beginning of the 20th century. In this process, most architects have determined a position in the context of their proximity to modernism. There have also been those who have taken a contrary attitude against modernism, which is highly accepted and accepted around the world. Fathy is one of these names. His distance from modernism, which was the dominant architectural thought during his lifetime, sets him apart from his contemporaries. He was never under the influence of modernity unconditionally, despite his experiences with Art Deco Modernism and Bauhaus architecture in Cairo and Alexandria, where he spent his life, and the modernism experiences he gained from his trips to Europe (6).

According to Fathy, the modern architectural movement was created by foreign authorities who were not sensitive to culture, civilization and tradition. Fathy claims that such an approach is unacceptable in the Arab world. According to Fathy, the thought of modern architecture emerged depending on the developing technique, industry and economy in Europe and showed an attitude that does not care about social values. Because of this feature, he thinks that this style erodes the architectural diversity and richness. In Fathy's criticism, modernity is a meaningless approach that ignores local values, riches and possibilities, reduces architecture to a single type, and has only some formal rules (7).

According to Uğur Tanyeli, Fathy's architectural approach cannot be expressed in any architectural style and cannot be directly included in any architectural ideology prevailing in Europe. In addition, Tanyeli, in his latest book, describes 5 architects together with Fathy as "hesitant modern" and states that although these architects are actually modern, they hesitate to stay in modernity and feel a kind of uneasiness. Tanyeli does not think that these architects are not actually modern, but expresses that they have a kind of conflicting relationship with modernity. According to Tanyeli, these architects think that architecture, society and life are much better in the world of the past and they miss such a past. He states that they do not see the contributions of modernity as the contributions of the modern world, and that they existed in the past. These architects, including Fathy, once thought that the world was much more tolerant, rational and humanitarian. Western-based discourses aren't enough to define Fathy's architecture and ideology. The main reason for this is Fathy's opposing attitude to the dominant approaches of his time (3). In this context, it can be said that Fathy has a strong nostalgia for the past and rejects modernity and the Beaux Arts movement in which he grew up.

Although Fathy's architecture is positioned against modernism, it actually contains parallels with modernism in terms of its own dynamics and features. Fathy's thought argues that architecture should update itself, and does not stand against using the opportunities and technology of the age.

Fathy's biggest criticism against the modern movement is that modernity ignores the ties with the past and shows a brand new approach. However, Fathy attaches great importance to cultural accumulation, traditions and local riches.

2.2. DESIGN PRINCIPLES OF FATHY ARCHITECTURE

Fathy's architecture is not only composed of professional orientations and sensitivities, but also has a structure that needs to be examined with its social and societal dimensions. According to Özkan, instead of the global social structure and architectural style that spread with modernization, Fathy adopted an architectural philosophy related to the original social structure (2). According to Fathy, modernism imposes European values and standards on non-European societies in the bureaucratic, political, social and cultural sense. The "modern" architectural understanding, which radically changes the traditions and identities of societies and proposes a new social order based on technological developments, has brought along social identity problems. Again with this new social structure, problems have emerged in the continuity of belonging and social memory. This order, which emerged with modernism, has been subjected to intense criticism by different disciplines over time. In parallel with these criticisms, Fathy also produced new ideas and criticisms that cared about his own cultural roots in Egypt. This ideology, which Fathy put forward in the periods when modernism was not yet criticized in Europe, was understood and accepted in later dates.

While modern architecture gives more importance to urban space and thinks about it with the ideal city form; Fathy cares about the needs of the rural poor and focuses on developing an ideal architecture for them. In his designs in rural areas, he not only develops a structure-based approach, but also produces public spaces, open and semi-open spaces and components in the urban sense (Figure 3). In this context, Fathy has developed a design strategy that attaches importance to publicity with a more holistic approach, rather than just a structure-based design approach, as can be clearly seen in the example of New Gourna village. The following lines in Hassan Fathy's book reflect his ideas for those living in rural areas;

"If you were given a million pounds, what would you do with them? A question they were always asking us when we were young, one that would start our imagination roaming and set us daydreaming. I had two possible answers: one, to buy a yacht, hire an orchestra, and sail round the world with my friends listening to Bach, Schumann, and Brahms; the other, to build a village where the fellaheen would follow the way of life that I would like them to (4)."

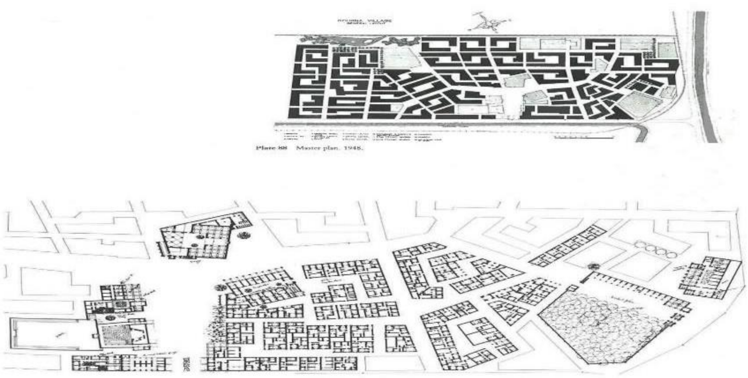

Figure 3. Fathy's New Gourna Masterplan (up) and Ground floor plan (Url-4)

Fathy argues that architectural design, like other branches of life, should not break away from tradition and maintain it. In this context, the lessons learned from the traditions of the region, both in terms of form, technology and production, have shaped his architectural practice (6).

Three important features stand out in Fathy's architecture. Perhaps the biggest difference of Fathy from the leading architects of his time is that he thinks that users should also participate in the process, especially in buildings with low socio-cultural levels in his architectural philosophy. In this way, it will be possible for the people to produce their own living spaces and to increase the sense of belonging. Another intend of this approach is to enable the people to learn the traditional building production methods, to be educated in this process and to make the modifications themselves when necessary. This approach of Fathy can be clearly seen in the title of his book in 1969, in which he describes his experiences in Gourna and increased his worldwide recognition; Construire avec le Peuple (English name: Architecture for the Poor). Another prominent feature of Fathy architecture is the economical production of buildings. The principle of low-cost building production, which Fathy prefers in his designs, does not mean that his buildings are unqualified or poor quality, on the contrary, Fathy argues that the right architecture can be produced with an approach that uses local natural materials, nourished by local tradition and culture. According to Fathy, modernism, which does not care about locality and cultural heritage, is a sick approach that cuts ties with the past. In Fathy's architectural teaching, it is important to reinterpret the knowledge and experience brought by the past from a contemporary perspective, rather than just an approach that imitates the past.

Because Fathy's historicism is beyond the "visible". Tanyeli considers historicism as an approach that goes beyond appearance in architecture. In this sense, Fathy also built his designs with historical tools, methods and approaches, beyond revealing products that seem historicist with daily self-interested realities. In this sense, Fathy architecture stands on a ground beyond the "image" (8).

Underlining that the architecture of a region is a response to the geography and climate of that region and that architecture is specific to regions and societies, Fathy criticized the Modern Movement's ignoring this feature of architecture. He sought the communication that architecture establishes with climate and geography in the traditional analyzes of the region and the reasons that make up these analyses. Beyond how successfully he reflects his architectural discourse on his works, his insistence, effort and desire to reveal ways of connecting with the lost past are impressive (2).

However, regionalism and traditionalism are not enough to define Fathy's philosophy of architecture. Simplicity, functionality and usefulness are more important concepts to understand its architecture. The traditionalist attitude in his approach to architecture and his strong relationship with the past make his architecture relatively related to vernacular architecture. The simple and plain language, which can be observed both on the planimetric plane and on its façades, is one of the characteristic features of Fathy architecture. In this sense, Fathy stands close to the "honesty" discourse of modern architecture. Likewise, "repetition" as a design component can be read both in its spatial arrangements and in the language of the façade. The effect that Fathy captured on the facades comes from the "volume and window system" rather than the "color and surface" manifestation (11). Fathy considers symmetry as a concept that makes designs mechanical and soulless. Fathy's approach to architecture and his understanding of beauty can be clearly understood in his own sentences below:

"Although I believe that the appearance of a building has the most profound effect upon its inhabitants, yet one cannot house men in the Parthenon. One's beautiful designs must serve the humble everyday needs of men; indeed, if these designs are true to their materials, their environment, and their daily job, they must necessarily be beautiful. (4)"

Fathy's book (Architecture for the Poor; An Experiment in Rural Egypt) in which he describes his planning and architectural studies in the village of New Gourna reveals the social responsibility that Fathy assumed through architecture (Figure 4). There is a search for continuity in Fathy's architecture, and this search is fed by traditions. The approach that rejects the traditions and the past of modernism is one of the most criticized features of this movement in Fathy philosophy. Fathy sees the continuity of traditions as a reflection of the cultures of societies and thinks that these traditions differ in every society. As a reflection of his traditionalist attitude, Fathy is generally positioned against global currents and is seen as a defender of local and vernacular architecture. Traditionalist approach and cultural memory, which are the main features of vernacular architecture, have an important place in Fathy's philosophy. In addition to its vernacular character, Fathy architecture is also an important field of study for today's popular concepts such as ecology and sustainability.


Figure 4. Old Gourna village (left, url-2) and Fathy's New Gourna (right, url-3)

While examining the local architectural features, he investigates the possibilities of adobe as a building material. He conducts material experiments in the laboratory with his friends at the university and makes use of these experiences while producing adobe. He collaborates with local craftsmen who can cover the roof with a dome and vault without using wooden formwork. He does not see local architectural features only from a formal point of view. Analyzes plan typologies, spatial elements and their usage and meanings. He collects information directly or indirectly from the local folk. In the light of this information, he develops designs that are not alien to them but will improve the poor quality of life they live in.

As a direct reflection of his architectural understanding, Fathy cares about the climatic and unique characteristics of the region in his spatial arrangements. In this context, generally a typology with a courtyard has been adopted in the design and settlement decisions of the buildings, depending on the hot climate of the region. He also chose the material usage according to the climatic characteristics of the region and generally used the most easily available adobe as basic building material in the region. In addition, he thought about how the right relations should be in the urban scale depending on the functions of the buildings and he gave importance to these relations in the site plan.

CONCLUSION

Fathy, who was born at the very beginning of the 20th century (1900), completed his architectural education at the Polytechnic School of Architecture in Cairo in 1926, which provides education in the Beaux Arts ecole, and started to practice architecture at a time when the architectural environment all over the world was under the spell of modernism. Despite this, Fathy was not unconditionally influenced neither by his education at the university nor by the dominant trend of the period, modernism. In his architectural understanding, instead of adopting a certain architectural style and being subject to that style, it is a priority to shape his own truths with the historicity and tradition in which he grew up. Fathy's discourses have been one of the leading criticisms of modernism among the postmodern discourses of the period, especially since the middle of the 20th century, and his book has become one of the prominent books of the period. Fathy claimed that the architectural style, which spread all over the world during his time, ignored the traditions, cultural characteristics and human factor and detached architecture from its context, and he spent his life in an effort to create an answer to this break with his architecture and philosophy. He explored how empirical knowledge and traditional analyzes from the past can contribute today's rapidly changing conditions.

It is very meaningful that an architect like Fathy, who has an Aga Khan award, won the most prestigious architecture award in 2022 with Fathy's architectural philosophy and teachings. Although the architect Diébédo Francis Kéré, who grew up in Burkina Faso, started to practice architecture almost a century after Fathy, he adopted the most characteristic features of Fathy's architecture as the building blocks of his own architecture. Kéré has this to say about the production process of a school he built in Africa: “When I started, the resources were limited — I didn't have enough money to build the school. Also, I had to involve the community in order for them to have labor. So, instead of going to the city to recruit people with better construction skills, I was interested in making people from Gando become part of the process, hoping to transfer some knowledge to them (15).” The process described here is exactly the same as Fathy's approach to participatory architecture or building with the local people. Again, similar to Fathy's stance against modernism, Kéré thinks that it is necessary to embrace tradition for social development. It is not possible to modernize with 'Eurocentric' methods, leaving tradition and locality behind. The traditional method and the use of local materials with a contemporary perspective, which are one of the most important characteristics of Fathy architecture, are also very important for Kéré. He expresses his priority in designs as exploring how to combine the materials and techniques currently used in local architecture with a more advanced technology (Url-5).

Fathy's philosophy, which does not fit the architectural practice into certain patterns and periods, is human-centered and feeds on traditional heritage, and attaches importance to local materials and methods, although it was exposed to many criticisms, it could be understood later and brought Fathy to the forefront in the world of architecture with his teachings and wise approaches. Issues such as ecological design, sustainability and sustainable development,which are at the center of the architectural agenda today, are the most important concepts thatshape Fathy's architecture. While these issues are not yet discussed in the architectural environment, Fathy's awareness of this issue transforms him into a farsighted and forward- thinking architectural figure. Today, an architect from a similar geography with Fathy has become the most talked-about name all over the world, with an approach that exactly coincideswith Fathy's discourses. In fact, this quote from Kéré sums up the whole story: "If we learn tobuild with local materials, we have a future."

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28- Preservation of a Valuable Historical Adobe Building byDesigning a Lightweight Structure in Yazd University

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ABSTRACT

This article is a report of the design and construction process of a lightweight roof structure over the remains of a historical building called the "Naji house" in the Historical City of Yazd. the Naji courtyard includes the remains of a historical house belonging to the Faculty of Art and Architecture of Yazd University and is part of the Historical City of Yazd. Archaeological sondage shows that the house is more than 600 years old. Therefore, it was necessary to design a structure that could preserve and protect the remains of this house against the wind, rain and sunlight. It was also necessary that the structure be very lightweight and have a minimum number of foundations to make the least intervention in this historical site. This project was defined as the final exercise of the building technical design course for senior B.Arch students. The result of this exercise was the construction of an early prototype of a structure designed by students. During this exercise, students understood their previous teachings about materials and structures as well as the climate in more depth and used them to design a highly efficient and environmentally sustainable structure.

Keywords: Naji house, adobe architecture, student project, design, construction

1. INTRODUCTION

Naji's house dates back to the Ale-Muzaffar historical period and is more than 600 years old [1]. This house is located in the block complex of the Faculty of Art and Architecture of Yazd, next to Movadat house and Lari Darband, which is now recovering its historical layers through restoration. This house has two parts, basement and ground floor. As shown in Figure 1, all the roofs are destroyed over time and the rest of the walls are exposed to sunlight, wind and rain. The dimensions of this building are approximately 17 x 16 meters.

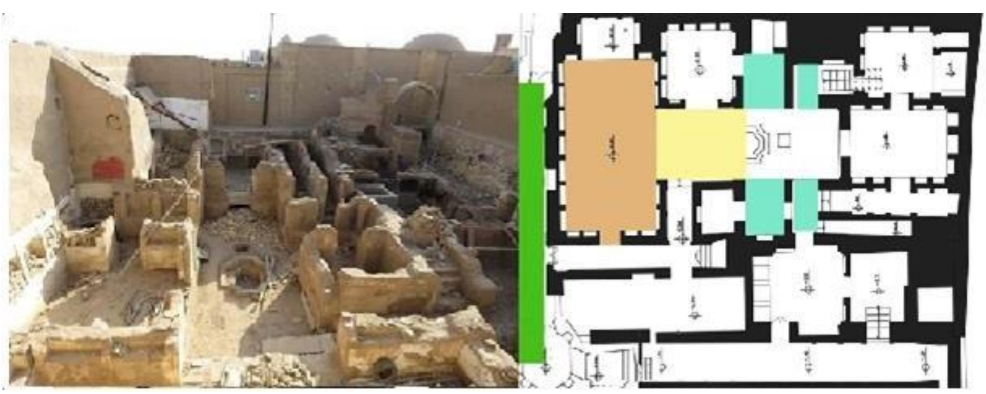

Figure 1. Naji house. ground floor plan (right), current situation(left)

Therefore, it was necessary to design a protective roof for this building, which lies in the category of sustainable and earthen architecture. Of course, the designed structure should be environmentally sustainable and implementable in the historical context. Therefore, designing and constructing part of this structure was chosen as an exercise for the building technical design course. This exercise was performed in 2018-2019 in the art and architecture faculty of Yazd university. The aim was that students use their acquired knowledge of structures to design an efficient and lightweight roof structure and construct an early prototype. This exercise became an excuse for students to think about designing optimum and efficient structures and learn their previous teachings in structure, environmental control and materials in a more conceptual way.

2. TECHNICAL DESIGN OF BUILDING COURSE

Course of technical design of buildings is one of the courses that has been planned with the aim of integrating the taught technical material and the architectural design practice. This course provides educational conditions for the theoretical courses to be memorized, understood and applied. Therefore, due to the existence of suitable contexts for the integration and application of structural knowledge in architectural design, this course was selected.

B.Arch. Students in the 7th semester take the technical design of buildings course, which is a 3-credit course consisting of 1 theory unit and 2 workshop units. according to the curriculum, these students have already taken theoretical courses related to structure and technical subjects in the previous semesters. technical design of buildings course is held seven hours a week as a workshop class.

Before the outbreak of covid-19 in 2018, This course was held in person and allowed the students to experience field study, team work and finally design and construct an architectural structure according to the needs of a real project. This course was held with the full-time presence of two professors of architecture and a part-time professor from the field of structural engineering who in the past taught statics and structural courses in the faculty.

2.1. STRUCTURAL DESIGN FOR ENVIRONMENTALLY SUSTAINABLE ARCHITECTURE

Macdonald has defined the role of structure in environmentally sustainable architecture. It depends on the relationship between the form and performance of structure. An efficient structure is one in which a high load-carrying capacity results from the use of a small amount of material. The principal reason why the shape of a structure affects its efficiency is that it determines the types of the internal forces which occur when a given load is applied. The important distinction is between bending-type internal force and axial internal force. the type of internal force which occurs is dependent on the form of the structure. for any load pattern, there will be a form, the form-active shape, which will allow the load to be resisted by purely axial internal force. [2]

For designing an efficient structure, it was necessary to convert the prior knowledge on basics of structure to conceptual knowledge. [3]. Conceptual knowledge is very important in applying the teachings in the design process and achieving innovation. Professionals are the people with more conceptual knowledge [5], [6].

All of designing a protective structure, an attempt was made to make students better understand the basics of structure in some exercises with theoretical explanations in between.

2.2. STRUCTURAL DESIGN PROCESS

Theoretical and prerequisite knowledge of structures have already been presented in related courses in previous semesters. Therefore, what is important in technical design of buildings course is understanding the taught materials and implementing them in the design process.[4]

In the first sessions of the semester, first theoretical explanations were given about the forces, axial, moment and shear stresses, as well as the effect of the form and geometry of the structure on the distribution of internal forces in structural members. The purpose of providing these explanations was to create a conceptual understanding of the axial force in the efficiency of the structure as well as the role of the structural form in determining the internal forces of the structure and understanding form-active structures. These short seminars were completed with practical exercises and design with the help of physical models of structures, model making, hand drawings and case analysis. One of the exercises related to this section was designing a compressive structure similar to Gaudi suspended models and then designing a tensile structure using a maquette.

Students were asked to study and design compressive and then tensile structures in groups of three to four. They were asked to design a compression structure similar to Gaudi's work, and then a tensile structure, both in a plan in the form of a cross, and present them with maquette and drawings. Then, these designed models were analyzed in the classroom with the help of professors of architecture and structure, and their structural defects were corrected to create a proper understanding of the behavior of these structures with high efficiency.

Figure 2. Exercise 1, design and construction of a maquette of a compression structure by students who used paper and origami techniques to show how compressive forces are transferred. More than a thousand paper pieces are used in this maquette as compressive elements.

Figure 3. Exercise 2, design and construction of a maquette of a tention structure

3. FINAL PROJECT: DESIGNING A LIGHTWEIGHT STRUCTURE FOR NAJI HOUSE

The final exercise was to Design a Structure to protect the remains of the Naji House. A structure like a roof which con covered the house and be resistant against the wind, rain and sunlight radiation and also be lightweight. In addition, according to the basement, the foundation should have been a minimum number and be placed on top of the rafters.

The final exercise began based on students' previous knowledge using sketches and structural drawings. during the initial design, students studied cases similar to their structures in groups. next, the concept diagrams created by students were analyzed and evaluated in terms of sustainability, optimization and response to various problem factors in the presence of teachers of architecture and structure, and new options were created again.

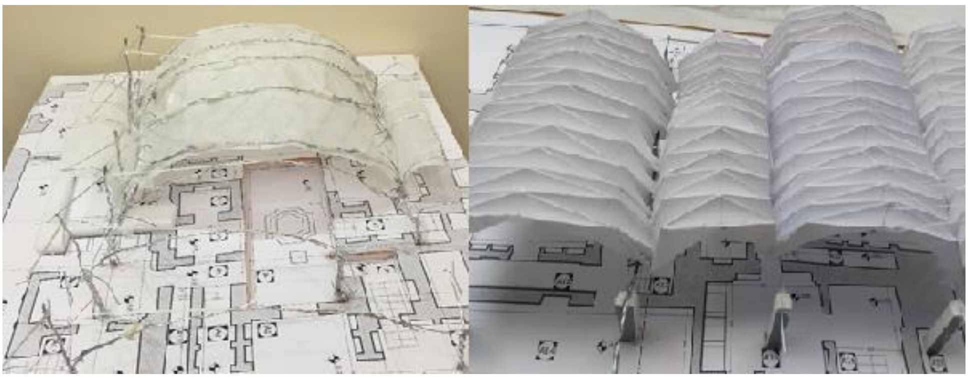

Figure 4. Final Exercise, Examples of Lifeguard Roof Design.

3.1. DESIGN AND CONSTRUCTION OF FINAL PROJECT

One proposed design was selected from among the 11 finalized designs by students to be constructed in a real scale, pictures of which are presented here. The selected design included a modular and single-base structure based on spatial lattice structures and satisfied the design criteria including the lightness and efficiency of the structure, the small number of foundations and the minimum intervention in the historical site, the applicability of the structure without damaging the historical building.

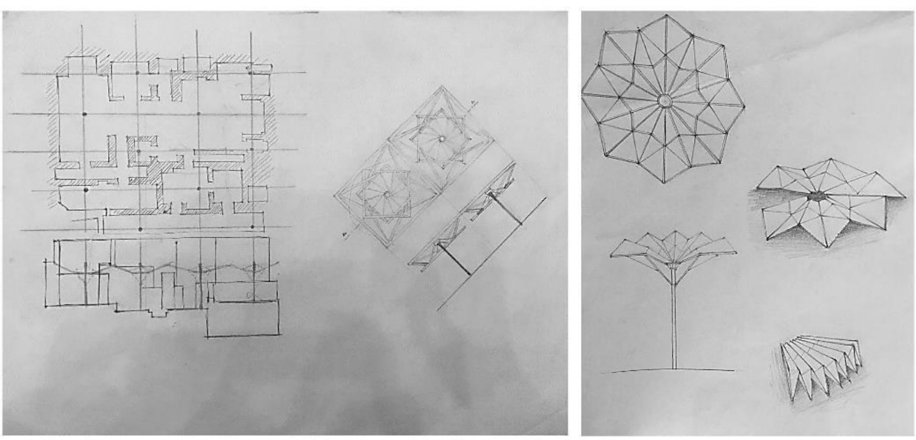

Figure 5. Some of the initial sketches that led to the construction of the final structure

Figure 6. Selected and proposed structure

Then, students in new groupings, began designing and drawing the executive details of the structure, Numerical calculation and Structural form analysis, financial and executive estimates of the construction. The selected structure was analyzed with the cooperation of the structural instructor, and numerical calculations were performed based on wind, snow, cover and live loads.

The selected structure was then constructed in 1:5 scale in the construction workshop of the art& architecture faculty in a one-month period from late December to January 2019. It's 1:1 construction required funds provision, which was delayed because of covid-19 outbreak; it will be finished in the new semester when in-person attendance is allowed again. The design process of one of the groups which led to the final structure is presented below.

Figure 7. Constructed structure with 1:5 scale

Figure 8. Construction process of the selected structure, in the workshop of Rasoolian's house (art & architecture faculty of yazd).

CONCLUSION

The construction of a structure to preserve the valuable historical building of Naji House on the site of Art and Architecture faculty of Yazd university was considered as the final project of the technical design of buildings course for B.Arch students. During this project, students became familiar with this valuable house and collected information, took measurements and also designed and constructed a roof structure to protect it. The project design criteria Included the lightness and efficiency of the structure, minimum number of foundations to have the least intervention in the historical site and being able to construct the structure without damaging the historical building. During this process, in addition to constructing a structure by students, the teachings on the basics of structures were understood and implemented in a design-based method.

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29- Bio-based reinforcements for rammed earth construction

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ABSTRACT

The growing concern about environmental issues connected to architecture, engineering, and construction (AEC) sector has given a boost to building practices driven by the use of earth-based materials. As it is well known, earth-based materials show great environmental advantages compared to other contemporary materials (wide availability, low embodied energy), promising material properties and outstanding aesthetic performances.

One of the main limitations of earth materials is their brittle behavior when subjected to tensile stresses. This issue becomes important when earth buildings are located in seismic areas where they inevitably experience bending and shear in the walls.

In order to make earth construction seismic resistant, timber and natural based reinforcements (as reeds and natural ropes) have been used both in traditional and contemporary practices to promote box-like behaviour and enhancing the flexural strength of earth buildings.

This contribution reports a review of the main natural and timber-based reinforcement systems used for contemporary raw earth construction, with a focus on rammed earth structures. Moreover, it presents the results of the design of an innovative reinforced and modular rammed earth constructive system made with natural or recycled materials, developing a technology with low energy consumption and low environmental impact, specifically designed for areas with high seismic risk. The main thermal and mechanical performances of the system are briefly depicted.

Keywords: Earth-based construction, rammed earth, bio-based reinforcements

1. INTRODUCTION

In line with international and European directives [1, 2], the construction sector today must respond to a series of new demands, being the most pressing those concerning the reduction of available resources, the containment of energy consumption and the abatement of CO_2 emissions. Construction based on the use of natural building materials have attracted international attention in response to the current energy crisis and the deterioration of natural resources due to their availability, lack of toxicity, recyclability, low energy incorporated in the manufacturing/production phase and good hygrothermal and acoustic performances.

In the context of new construction, solid rammed earth building systems (also in combination with reinforcing framed structures) have undoubted environmental benefits and high thermal performances in temperate climates characterized by a large thermal oscillation between day and night. The high thermal mass, and therefore the inertia of these building envelopes, stabilizes and balances the internal temperatures and humidity of the buildings, ensuring internal comfort conditions [3, 4]. In addition, rammed earth envelopes have high fire resistance and excellent acoustic characteristics.

Massive rammed earth walls represent nonetheless a problem when it comes to their seismic behavior. Indeed, the greater is the mass of walls, the higher are the induced seismic forces; this issue is moreover worsened by the weak rammed earth response under compression forces, and the very low tensile strength, with a mechanical performance which is significantly influenced by hygrothermal conditions [5]. This issue can be partially solved by the addition of fibers in the rammed earth mixes, which creates a three-dimensional mesh which can enhance the tensile properties of the mixes while creating a ductile behavior of the walls [6].

Still, rammed earth buildings are very vulnerable to earthquake excitations. Widely observed failure modes in previous earthquakes include brittle failures such as falling over due to out of plane actions, cracks at edges and also at loading points where the load of the roof is transferred to the wall, losing connectivity due to weak connections and propagation of cracks due to close distance between openings and corners [7]. Several seismic resistant devices are proposed in the literature to mitigate vulnerability conditions of earthen structures; specifically, the repair of cracks with injection of compatible grouts [8], strengthening of walls with wooden, canes or other bio-bases reinforcing elements [9], addition of top and intermediate ring beams [10], and strengthening with surface mesh rope reinforcement [11] and textile reinforced mortars [12].

The following contribute aims at reviewing the main strategies adopted to enhance the seismic resistance of raw earth, and in particular, rammed earth constructions, by describing the main reinforcement adopted, with a focus on bio-based reinforcements. Moreover, this paper presents the result of a prototyping procedure for a novel type of reinforced and modular rammed earth construction made with natural, low-cost or recycled materials with low energy consumption and low environmental impact, specifically designed for areas with a high seismic risk, whose main thermal and mechanical performances are depicted.

2. BIO-BASED REINFORCED RAMMED EARTH CONSTRUCTION

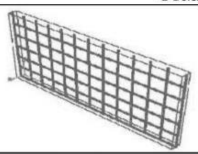
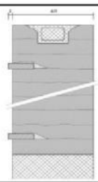
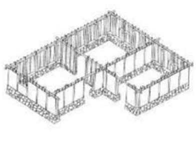
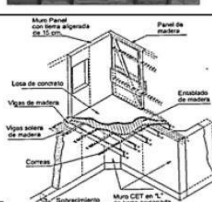
The bibliographic research on historical and contemporary raw earth constructive technologies was based on scientific publications, traditional construction manuals, commercial technologies, standardized and patented construction systems. The objective of this analysis was to identify the best performing reinforcement systems for rammed earth walls.

Raw earth and rammed earth walls are usually combined with high-tensile strength functional elements that improve their seismic-resistant behavior (timber frames, reeds, natural and non-natural fibers nets and ropes, etc.). The analysis, which is resumed in the following table 1, shows a series of information concerning the studied technologies:

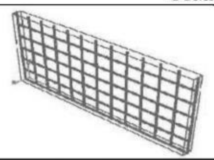
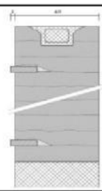
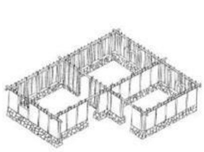
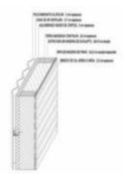
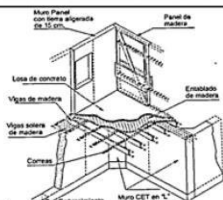
- the name, the geographic location and the indication of when the system was adopted;
- the constructive process used (in situ, prefabricated or partially prefabricated);
- the loadbearing structure (type of walling structure, type and position of reinforcing elements);
- type of floors;
- anti-seismic devices adopted, if any;
- thermal improvements adopted, if any;
- connection details, if detailed.

As far as contemporary construction is concerned, most technologically advanced countries (Europe, North America and Oceania) offer rather homogeneous technological solutions for raw and rammed earth construction, with the use of vertical steel reinforcement for the walls, connected to a top and a bottom concrete beam. Some exceptions are given by the use of timber reinforcement [18]. These reinforcements guarantee a seismic-resistant behavior.

Reinforced earthen construction techniques are present throughout developing areas as South America, as evidenced by the research and dissemination activities carried out by the PROTerra network: from the *tabique/bahareque*, to the Peruvian *quincha*, to the reinforcement systems for adobe and rammed earth masonries [13]. Concerning adobe and rammed earth walls, reinforcement can be internal or external to the wall thickness, with numerous variations that have been refined over time.

			CONSTRUCTIVE SYSTEM FEATURES				
NAME & REF.	PROCESS	SCHEME	LOADBEARING STRUCTURE	FLOOR	ANTI-SEISMIC DEVICES	THERMAL IMPROVEMENT	CONNECTION DETAILS
			COMMERCIAL AND STUDIED SYSTEMS				
RE reinforced with bamboo columns or wood members [20]	On site		Rammed earth made in situ with internal diffuse bamboo reinforcement arranged according to a vertical/horizontal mesh	-	The vertical bamboo reinforcements connect the concrete base and foundation to the upper ring beam (also in concrete)	-	-
Prefabricated RE [21]	Prefabricated RE panel, assembled on site		Prefab unstabilized RE panel are installed by use of earth mortar. Usually a concrete or steel structure is coupled to RE wall.	Concrete slab, steel framing.	In seismic areas, longitudinal and vertical reinforcement steel bars are used, which are in special grooves made at the upper edge of the panels.	Gravel cellular glass insulation has been used	By means of steel bars that connect the RE panels to the loadbearing skeleton
RE panel reinforced with bamboo [22]	On site		RE with improved stability (T-shaped compacted elements, 14-30 cm thick) and reinforced with 4 vertical bamboo rods inserted in the wall (2-3 cm diameters).	Timber flooring	Vertical connections through bamboo elements anchored to the lower and upper bamboo ring beam (embedded in the masonry base).	-	A joint between RE panels allow them to move independently during an earthquake. The roof does not rest on the wall.
Prefabricated Wooden-framed panel [23]	Prefabricated wooden panels, earth infill on site		Timber skeleton, 10 x 10 cm columns each 60 cm, fixed to a base board of 18 x 6 cm. Secondary structure with 4 x 6 cm stiffening diagonals screwed to the main elements.	Timber, earth infill.	-	Local soil mixed with wood chips (plastic mixture). Additional Cork insulation panel.	-
RE reinforced with timber posts [24]	In situ		RE walls with outer timber post reinforcement and wooden ring beam.	Timber or canes flooring.	Timber post reinforcement must be connected to the wooden ring beam.	Straw is used in the mixtures.	This research showed poor connection details (use of iron wire).
CET wall: Rammed earth (GF), wood framing (FF) [25]	RE on site (GF), Prefabricated wooden panels, earth plastering on site (FF)		Loadbearing 30 cm-thick RE wall (GF). Sometimes there is an interior wood reinforcement in the walls. Lightweight loam and wattle and daub, 15 cm thick (FF).	Timber, hemidiaphragm mezzanine	Walls are L, Y, T shaped to provide better stability. Timber top ring beam.	-	-

Legend: GF=Ground Floor, FF=First Floor, RE=Rammed Earth

NAME & REF.	PROCESS	SCHEME	CONSTRUCTIVE SYSTEM FEATURES: LOADBEARING STRUCTURE	FLOOR	ANTI-SEISMIC DEVICES	THERMAL IMPROVEMENT	CONNECTION DETAILS
COMMERCIAL AND STUDIED SYSTEMS							
RE reinforced with bamboo columns or wood members [20]	On site		Rammed earth made in situ with internal diffuse bamboo reinforcement arranged according to a vertical/horizontal mesh	-	The vertical bamboo reinforcements connect the concrete base and foundation to the upper ring beam (also in concrete)	-	-
Prefabricated RE [21]	Prefabricated RE panel, assembled on site		Prefab unstabilized RE panel are installed by use of earth mortar. Usually a concrete or steel structure is coupled to RE wall.	Concrete slab, steel framing.	In seismic areas, longitudinal and vertical reinforcement steel bars are used, which are in special grooves made at the upper edge of the panels.	Gravel cellular glass insulation has been used	By means of steel bars that connect the RE panels to the loadbearing skeleton
RE panel reinforced with bamboo [22]	On site		RE with improved stability (T-shaped compacted elements, 14-30 cm thick) and reinforced with 4 vertical bamboo rods inserted in the wall (2-3 cm diameters).	Timber flooring	Vertical connections through bamboo elements anchored to the lower and upper bamboo ring beam (embedded in the masonry base).	-	A joint between RE panels allow them to move independently during an earthquake. The roof does not rest on the wall.
Prefabricated Wooden-framed panel [23]	Prefabricated wooden panels, earth infill on site		Timber skeleton, 10 x 10 cm columns each 60 cm, fixed to a base board of 18 x 6 cm. Secondary structure with 4 x 6 cm stiffening diagonals screwed to the main elements.	Timber, earth infill.	-	Local soil mixed with wood chips (plastic mixture). Additional Cork insulation panel.	-
RE reinforced with timber posts [24]	In situ		RE walls with outer timber post reinforcement and wooden ring beam.	Timber or canes flooring.	Timber post reinforcement must be connected to the wooden ring beam.	Straw is used in the mixtures.	This research showed poor connection details (use of iron wire).
CET wall: Rammed earth (GF), wood framing (FF) [25]	RE on site (GF), Prefabricated wooden panels, earth plastering on site (FF)		Loadbearing 30 cm-thick RE wall (GF). Sometimes there is an interior wood reinforcement in the walls. Lightweight loam and wattle and daub, 15 cm thick (FF).	Timber, hemidiaphragm mezzanine	Walls are L, Y, T shaped to provide better stability. Timber top ring beam.	-	-

Legend: GF=Ground Floor, FF=First Floor, RE=Rammed Earth

Table 1. Different rammed earth reinforced constructive system

3. DESIGN AND PRELIMINARY PERFORMANCES ASSESSMENT OF AN INNOVATIVE RAMMED EARTH CONSTRUCTIVE SYSTEM

3.1. DESIGN

Prototyping and validation procedures were used for designing the reinforced and modularrammed earth constructive technique and building process. Particularly, the first design of the constructive system was carried out at the Centro Tierra of the Pontificia Universidad Católica dePeru, the main formulator of the Standard E 080 - *Diseño y construcción con tierra reforzada* [11].

According to this standard, the construction system must use at least a solid 40 cm thick rammed earth wall and the building characteristics (wall's height, spacings between loadbearing elements, voids width) must respect specific geometric features [11]; finally, the rammed earth walls must present a reinforcement system composed by an exterior rope mesh reinforcement with vertical and horizontal tensioned ropes, blocked by rope cross connectors, and a top timber ring beam composed of two longitudinal members and several cross connectors, which must be firmly connected to the reinforcing system of the walls. Use of other types of reinforcements, as entire canes, timber posts, woven vegetable fiber branches and natural ropes braided into external orthogonal meshes is also encouraged.

The solution investigated, developed together with the local industrial partner Guglielmino Soc. Coop. and currently filed for a patent application [26], consists of a construction system composed of rammed earth walls to be built, on-site, with new mixtures of clayey soil and recycled materials from other production chains (natural fibers and filler material), reinforced with seismic-resistant devices consisting of a timber reinforcement framing and nylon/polyester rope ties. According to this system, the earthen masonry responds mainly to vertical loads, while the vertical timber elements absorb the bending and shear stresses caused by any earthquakes, increasing the inertia of the cross-section. Moreover, an auxiliary horizontal surface reinforcement made by ropes was adopted to prevent from out of plane mechanisms. Finally, the top and bottom timber ring beam guarantee the box-behavior of the buildings. Figure 1 shows a three-dimensional view of the adopted reinforcing system (on the left) and the prototype wall for the validation of the constructive process (on the right).

This invention envisages the development of a formwork system integrated with the timber stiffening frame, capable of guaranteeing rapid, low-cost and partially prefabricated installation. The timber frame has a dual function: it is a support element for the formwork during the construction phase, and it acts as a reinforcement structure for the walls in the event of an earthquake. The system is partly manufactured in the factory (with a controlled supply chain in relation to the shape and size of the timber components, constituent mixtures, jointing systems, etc.), and then it is assembled on-site to guarantee the control of the quality of the product, of the process and, therefore, the expected performance response.

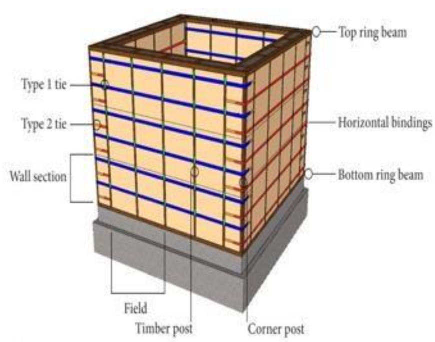


Figure 1. Three-dimensional reconstruction of the reinforcement system (on the left) and prototype wall for the validation of the constructive process (on the right).

3.2. EXPECTED MECHANICAL AND THERMAL PERFORMANCES

The good mechanical performance of the designed rammed earth reinforced constructive system was deduced from several full-scale tests made on rammed earth building models at the Pontificia Universidad Católica de Peru. In particular, the effectiveness of the timber reinforcement system has been proved by the tests realized in [27]: with this kind of reinforcement, the walls can withstand bending moments at least three times higher than the unreinforced walls [28]. As highlighted by the authors, one of the advantages of placing the reinforcement in the walls by connecting it to the wall joints and the foundation is that it allows a greater rigidity to the roof beams, therefore ensuring that the roof behaves as a semi-rigid element and the floor beams as edges horizontal braces. Another advantage of including a reinforcement to the walls, timber or otherwise, is that if the walls fail during a severe or rare earthquake, failure is not due to slippage in the joints but rather to diagonal traction. The effectiveness of rope reinforcement in earthen buildings has been extensively confirmed with further investigations [29] and by real observations during Lampa's earthquake of 2016 [30], proving that it maintained structural integrity and stability and prevented the partial collapse of wall portions during the motion.

The research group have assessed the expected mechanical performance of the designed rammed earth technology by means of finite element modelling on MIDAS FEA NX software. In particular, the calibration of the model has been done on the base of previously realized experimental tests on rammed earth walls [30]. Non-linear analyses were carried out on rammed earth panels using constitutive laws that allow to reproduce the cracking phenomenon implemented within Smeared Crack and Damage Crack Plasticity model [31], opportunely tuned to model the brittle behavior of unreinforced rammed earth material.

A detailed description of the non-linear analysis will be given in a future contribution. Here we will just mention the results of the modelling of a building element consisting of a rammed earth panel of dimensions 2.70 x 1.60 x 0.40 m reinforced with six timber posts of dimensions 2.70 x 0.10 x 0.05 m, subjected to a vertical pressure, kept constant during the analysis, equal to 0,05 N/mm^2 to simulate the presence of a hypothetical roof, to a displacement equal to 30 mm and to its own weight. The analysis showed that the horizontal force reaches the limit value and then undergoes an abrupt decrease in strength, therefore, the presence of the timber posts gives a certain ductility to the element. The mapping of the damage is distributed at the base of the panel and concentrated in the contact areas between the timber posts and the rammed earth walls, due to the presence of sliding and detachments between the elements. Further analysis will focus on the appropriate modelling of horizontal connections between the timber reinforcements and rammed earth, such as the assumed rope ties reinforcement system.

The good thermal performance of the designed rammed earth technology was estimated on the base of dynamic thermal simulations on Design Builder software under free-running conditions, calibrated on the base of rammed earth material properties, with and without the use of bioclimatic strategies (mainly night cross ventilation and overhangs) and application of thermal insulations, in Mediterranean climates. Results concerning this analysis were reported elsewhere [9, 32]; here we will simply recall the main results of our analysis:

- The use of a massive material as rammed earth for the envelope keeps the curve of inner surface temperature almost constant with respect to the curve of outer surface temperature, with low values of decrement factor (DF < 0.005) and satisfactory values of time lag (TL > 17 h);

- Indoor mean air temperature profile for the best bioclimatic design option lies between 28.3 and 31.27 °C in the analyzed period, with a significative reduction compared to the base model (not using bioclimatic strategies).
- Combined bioclimatic strategies succeed in satisfying normal comfort expectations (using adaptive comfort model) for uninsulated rammed earth walls without use of HVAC systems in summer conditions, for more than 75% of the analyzed time; an additional reduction in discomfort hours of around 20% can be found by using exterior thin layers of bio-based thermal insulations (cork or flax shive boards) or lime-hemp thermal plaster.
- Concerning energy needs for space cooling, the use of combined bioclimatic strategies energy demand for cooling by 35.5% with respect to the base case; a further decrease in energy needs for cooling by 25% can be found in the case of insulated options.

CONCLUSION

This contribution presented the results of a research aimed at designing an innovative constructive system in reinforced rammed earth characterized by low energy consumptions and specifically designed for high seismic risk territories.

The specificity of the constructive system is substantiated in the strong ecological connotation, in the high performance in terms of resistance to seismic phenomena and in the low energy consumption resulting from the characteristics of the designed envelope.

The building system proposed here inherits technical knowledge developed in highly seismic areas of our planet and integrates it with a logic which is strongly linked to the industrial production of natural-based building materials and to the optimization of the building process.

The mechanical, thermal and energy performances of the investigated system were evaluated by means of numerical simulations and calibrated on the basis of experimental analyses carried out on existing rammed earth walls and buildings. Concerning the mechanical performance, the system seems to provide a good response also thanks to the increase in ductility provided by the timber reinforcement system. However, the actual seismic response of the system remains to be verified also by carrying out tests on walls loaded in the plane and out of plane. Concerning thermal and energy aspects, the system seems to provide appropriate levels of comfort and low energy consumptions, especially in climates such as the Mediterranean one. Further developments will concern the quantification of the contribution of the moisture contained inside the rammed earth walls in the mitigation of thermal flows and consequently, in the reduction of energy consumptions.

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30- Data Mining for Adobe in Perspective of Sustainability andManagement

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ABSTRACT

Adobe is a natural material which has been used for many years. Although it was used in primitive architecture in early years of the world, it continues to be used as an effective and sustainable material for today's architecture. Adobe is one of the key factors for architecture to save the sources and provide sustainability of investment. Hence, it becomes important to manage the adobe structures to ensure efficient material because of sustainability. Many researchers tend to analyze and evaluate the adobe in different perspectives. As a result of this, in this paper it is aimedto conduct an extensive literature study which focuses on the relationship between adobe,sustainability and management. For the comprehensive literature study, articles belonging last tenyears are examined by using Scopus to determine the gap between adobe, sustainability, and management. It is thought that this study could be used for further studies as a compact data as well as identifying current gap areas of adobe research.

Keywords: Adobe, sustainability, management, adobe architecture

1. INTRODUCTION

The adobe material is one of earliest natural material and has a widespread worldwide usage. Adobe, combined with earth, straw, and water, is a traditional and sustainable material that is used for structures. According to Jimenez-Delgado and Cannas-Gerrero [1], adobe structures are generally constructed with two different methods which one of them is non-fired sun-dried mud bricks mixed with organic materials and the other one is masonry units made with earth and straw where strength is carried out by mechanical processes without chemical processes. Because of being so natural and preparing with natural techniques, adobe has an important role in sustainability. Adobe is an eco-friendly material which does not need additional energy for its application and preparation. It can be completely recycled, and it produces minimal wastes when it is demolished [2].

Sustainability, minimizing or eliminating negative impacts to the environment, is an essential and popular term for our world because of limited sources. Sustainability aims to use renewable materials and methods while creating a healthy environment. Similarly, sustainable construction aims to operate a healthy structure based on resource efficiency and ecological design and construction [3]. Adobe is one of vital material which suitable for nature of sustainability construction in terms of reducing and reusing resources and overseeing nature. Owing to, analyzing the sustainable materials, and managing the implementation processes and whole production processes of materials, from cradle to grave, in terms of sustainability has an importance factor to constitute a better environment as a responsibility of the construction industry.

This paper aims to conduct an extensive literature study that focuses on the relationship between adobe, sustainability, and management to determine to research areas and gaps in the literature using the bibliometric analysis.

2. DATA COLLECTION AND METHODOLOGY

Searching different studies, evaluating existing knowledge and determining current studies are necessary to improve new one and making suggestions for further studies [4]. There are different analyzing methods for managing a systematic review of studies such as literature review, content analysis, meta-analysis, and bibliometric analysis [5].

The bibliometric analysis, data mining, was used to evaluate a statistical analysis of articles studies in the field of adobe, sustainability, and management in this study. A bibliometric study measures the information sources as a technique to be utilized by the scientific method [6]. Eck and Waltman [7] described bibliometric analysis as a statistical analysis of published articles and citations to reveal their impact within a specific field of study.

In this study, *Scopus* search engine, which has a large source, was used to classify the last ten years research (2013-2022) on adobe and analyze the relation between adobe, sustainability, and management amongst abstract, keywords and title citations. Then, *VOSiewer* software tool was used to determine the research fields which related with "Adobe". In addition, in this bibliometric analysis, it was focused on articles written in the English language. This study was composed by four main steps as below:

STEP 1

- Keyword search in the *Scopus* database using the keyword "Adobe"
- Selection of only articles in English language, published/article in press. between 2013-2022
- Exporting the data with *CSV format* to analyze in the *VOSiewer* software tool
- Developing a map of links and analysis of clusters in the *VOSiewer* software tool
- Analyzing the findings

STEP 2

- Both "Adobe" and "Sustainability" keywords were searched together in the *Scopus* database
- Selection of only articles in English language, published/article in press. between 2013-2022
- Analyzing the findings

STEP 3

- "Adobe", "Sustainability" and "Management" keywords were searched together in the *Scopus* database
- Selection of only articles in English language, published/article in press. between 2013-2022
- Analyzing the findings

STEP 4

- Analyzing the articles focused on Adobe, Sustainability and Management fields

3. FINDINGS

Keywords were searched in *Scopus* considering abstract & keyword and citation information by 2013 to 2022. Then related articles were filtered in English language and they were explored with *CSV format.* Findings were analyzed with *VOSiewer,* which is one of the basic science mapping & visualization tools [6].

Step 1

In the first step, only "Adobe" keyword was searched in *Scopus* considering abstract&keyword and citation information by 2013 to 2022. The total 1524 articles, in English language, were selected and explored with *CSV format.* Findings were analyzed with *VOSiewer* as seen Figure 1.

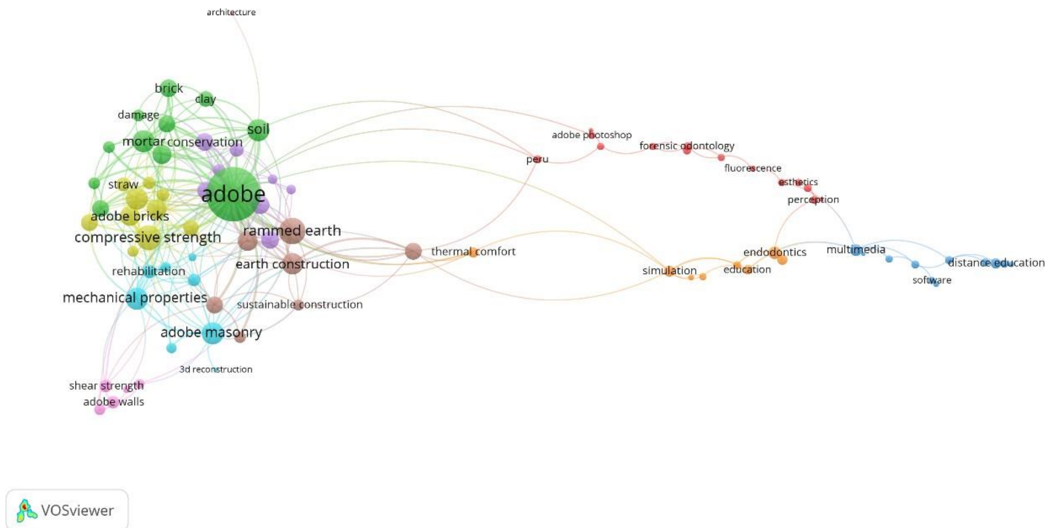

Figure 1. Bibliometric analysis results.

In Figure 1, different concepts are represented by nodes and connected by curved lines, which indicates mutual citations of articles with adobe. It is shown that rammed earth, compressive strength, mechanical properties, and earth construction have larger node size and front size compared to other terms due to is high mutual citations with adobe. According to the Figure 1, materials such as brick, clay, straw, and soil seem main research topics as well as mechanical and statical properties. However, sustainable construction has a weak link whether management has no link, unfortunately. As a result of this, it can be understood there is no strong relation between adobe, sustainability, and management at first analysis

Step 2

The second research was done for "Adobe" and "Sustainability" keywords in *Scopus* database. The concept of both keywords' relation through last ten years in shown in Figure 2.

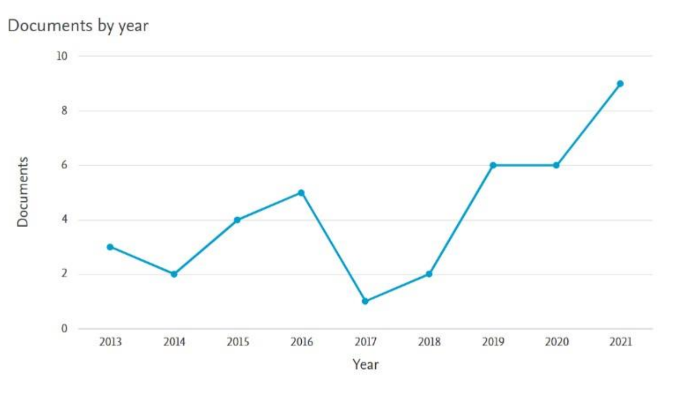

Figure 2. Documents related to "Adobe" and "Sustainability" sorted by year.

38 articles have been determined with this research, containing both keywords. It is seen that two concepts have been working since 2013 and number of the documents have reached the highest number in last year. Last three years have the highest research in both keywords' field. On the other hand, as per Figure 3, %32.4 of the regarding documents belong to engineering.

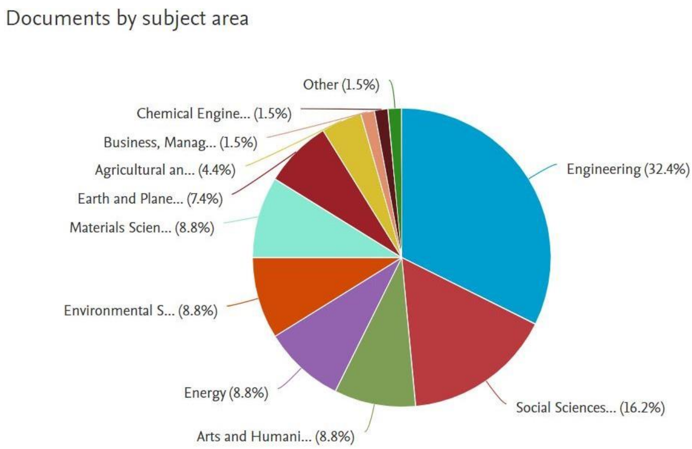

Figure 3. Documents related to "Adobe" and "Sustainability" sorted by subject area.

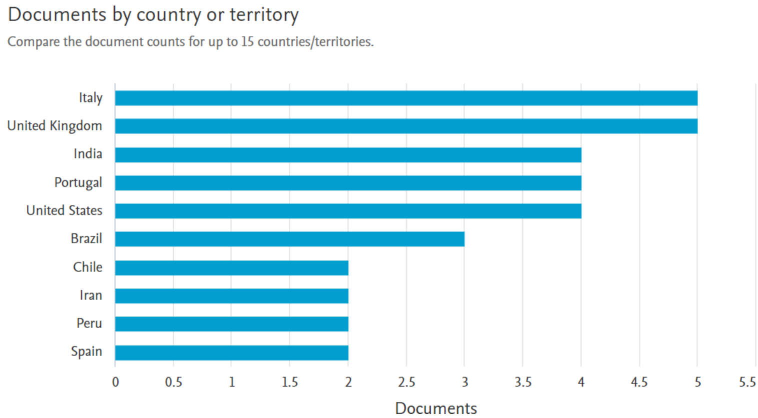

Figure 4. Number of publications by the country of origin.

By the countries of origin of the first authors of the publications (Fig. 4), Italy and the United Kingdom based academic institutions have produced the highest number of publications on these fields, followed by India, Portugal, and United States institutions.

Step 3
The third step was done for "Adobe", "Sustainability" and "Management" keywords together in *Scopus* database for last ten years in English language. Only two articles have been determined which are in those three fields. This shows that there is a huge gap in these interactive fields, although there is a necessity of utilization of natural sources and green solutions in scope of effective management styles against to environmental problems.

Step 4
At this step, the articles, determined in step 3, is analyzed. There are merely two articles, focusing Adobe, Sustainability, and Management in the peer-reviewed academic media

Publication Name	Authors	Publication Year	Publication Medium
Energy conservation and sustainability at Adobe Systems Incorporated [8]	Graebert,R. & Fischer, M.	2014	Facilities
Empirical analysis of the determinants of environmentally sustainable practices in the UK construction industry [9]	Akadiri, P.O. & Fadiya, O.O.	2013	Construction Innovation

Table 1. Articles mainly focused on "Adobe", "Sustainability" and "Management" keywords.

Table 1 shows the two articles dealing with three keywords at the same time. It can be seen from Table 1 that shows the studies are very scarce which focus on the early integration of Adobe, Sustainability, and Management. When the articles are analyzed a bit more, it is understood, each article has "adobe" keyword as software term while they focus Sustainability, and Management.

CONCLUSION

Waste is an inevitable consequence of construction industry in the project life cycle. Being a traditional and natural building material, adobe plays an important role for sustainable environment in terms of waste. Although, adobe is one of the oldest construction materials and technologically simple, it has the high potential to produce durable, healthy, ecological, breathable, high thermal capacity, re-cyclable, low sound transmission and flexible designed structures provided that it is protected from the physical effects causing its deterioration. In addition, adobe is an eco-friendly material which does not need extra energy sources for its production and application. In this aspect, it can be easily and fully re-cycled and evaluated as sustainable. When it is thought that the natural sources are so limited in today's world, it gains important to manage the processes of materials and sustainability to effective utilization.

In this study, it is aimed to visualize the research gap in Adobe, Sustainability and Management. The analysis can help to clarify the issues surrounding these three fields and identify untouched areas of interest for academic researchers in the context of the subject matter. It is obviously seemed in this study, management connection between adobe and sustainability is so weak, and there is no study which focuses on these fields together. So, in a further step, research field of management in terms of adobe and sustainability and other databases, such as Web of Science, can be taken into consideration for relating to the analysis.

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31- A Method Proposal for the Preservation and Widespread Useof Mud Brick

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ABSTRACT

Global warming, which is one of today's problems, and in this context, the effects of the use of materials that have high carbon emissions, contain chemicals, consume more energy in the production process, and tend to pollute the nature have begun to be discussed in detail in the world. Mud brick material is an important material due to its features such as shapebility with low labor force by taking materials directly from nature, drying with natural methods and not being waste in the nature after disposed. The mud brick material is defined by the Turkish Language Association [1] as "primitive brick, a mixture of straw and mud, which is poured into molds and dried in the sun for use in building walls". One of the most basic materials of rural architecture in Anatolian lands, mud brick should be preserved and transferred to the future with its values. Transferring mudbrick material to the future, learning it, and combining it with new and contemporary technologies will enable to obtain a material that will respond to the fundamental problems of the world. However, the most basic way of preserving mud brick material is to preserve the areas where it is used. The mud brick, which is used extensively in rural areas, is on the verge of disappearing as these areas tend to disappear in Anatolian lands. This study is based on the hypothesis that rural areas must be preserved in order to preserve mudbrick material and transfer it to the future. And it aims to develop proposals for the preservation of rural areas. When Development Plans and National Rural Development Strategies prepared by the relevant institutions of the Republic of Turkey [2–10] is examined. It is seen that it is aimed to take various measures to maintain rural areas. However, it is seen that the population in rural areas decreased rapidly in the period from 1927 to 2020. The decline of 10% in the rural population between the years 1927-1960 to the situation where only 6% of the population of Turkey lived in rural areas in the 2000s [2,9,11] shows us that the population in rural areas cannot be preserved, therefore rural areas cannot be preserved either. The most basic condition for the preservation of rural areas is the protection of the local people and their survival. Bektas [12] draws attention to the act of protection that cannot be carried out by freezing the past and creating uninhabitable cities for the people of the age. In addition, he draws attention to the fact that areas which do not catch up with the era and do not respond to new needs will disappear on their own. It is emphasized that preservation can only be made by ensuring that the existing user stays in the city. In this context, this study aims to examine the Rural Area Design Guides, which first protect the users of rural areas, then directly ensure the preservation of rural areas, and will ensure the preservation and transfer of mudbrick material to the future.

Keywords: Mud brick, village design statements, rural architecture

1. INTRODUCTION

1.1. THE USE OF MUD-BRICK AS A BUILDING MATERIAL, ADVANTAGES AND DISADVANTAGES

Mud brick is one of the oldest building materials that has been used in the world and in Anatolia since ancient times. It continues to exist as the most basic building material of traditional buildings, especially in rural architecture, in Anatolia [13]. The "mud brick" as a building material is an important part of our cultural heritage in Anatolia in the formation of the anonymous building group which is called "vernacular architecture" or "rural architecture in which its master is unknown, a public domain.

Today, due to the increase in environmental pollution and the global warming problem, which has arisen with effects such as the crises in the energy field, it has become important to reuse or widespread the use of "natural" building materials that do not harm the nature, that are recyclable and that do not emit carbon. At this point, it is important to preserve mudbrick, in order to examine its properties and to create possibilities for use due to its naturalness as a traditional building material and its being representative of the vernacular rural architecture, and its performance advantages.

The reason why the use of adobe in buildings is advantageous is that it is a healthy material as well as it is low cost and easily available and it has a simple production process with its raw materials. The heat and sound insulation of the building material and its fire resistance are important factors. According to DIN 4102 and DIN 18951, mudbrick building material does not burn, it is non-flammable, does not emit smoke and odor unless there is a flammable additive in it. It is sound-retaining and impermeable according to its material properties. Since its structure is porous, it takes moisture. It provides a good bioclimatic comfort in all seasons [14].

Properties of mudbrick material can be listed as follows:

-Due to the porous structure of the dough and its ability to retain heat well, it absorbs moisture from the air and keeps the indoor temperature and humidity in balance, creating a clean and healthy environment.

-Soil, which is one of the best energy-storing materials after water, collects the heating energy when it forms the walls surrounding the building as a building material. Thus, it protects the building from the unwanted hot or cold air outside.

-No facility is required for its production and its cost is low. No mechanical energy is needed during its production or use. It can be expressed as one of the sustainable building materials because it requires less energy during its demolition compared to other building materials and is an environmentally friendly material [15].

In addition to the positive aspects of the adobe structure, there are also negative features. Some of these are low compressive strength, high sensitivity to water, needing regular and continuous maintenance.

1.1.1. MUD-BRICK CONSTRUCTİON SYSTEMS

It is a material obtained by kneading clay and suitable soil with water, and sometimes adding some additives such as straw and vegetable fibers. Soil, which is the main material of mudbrick consists of clay, silt, sand and gravel according to their grain size. While clay acts as a binder, sand grains in the soil act as an endoskeleton.

For the improvement of mudbrick in Anatolia, straw is usually added to the adobe soil as an additive.

The mud brick obtained from a mixture of soil and straw does not show high strength values. Lime, blast furnace slag, cement, asphalt, plaster, and similar materials added to the adobe mortar improve the properties of mudbrick.

The mudbricks obtained in this way are called "improved mudbrick". Improved mudbrick obtained with additional additives has higher strength than traditional mudbrick.

There are three main ways to improve mudbrick.

-Mechanical improvement: Improving the density, mechanical properties and porosity structure of the soil by compaction.

-Physical Improvement: Improving the properties of the soil with different methods such as heating and drying.

-Chemical Improvement: It is the improvement made by adding additional additives to the soil.

Since mudbrick is homogeneous and compact, it is structural. Therefore, it can be used as a load-bearing wall material. When it gets wet, its structural property decreases. Depending on the type and amount of additives added into it, the strength of the material changes. It is resistant to bending, impact and abrasion.

The mudbrick construction systems in which traditional mudbrick materials have been used from past to present are basically divided into two as 'masonry mudbrick construction systems' and 'filled mudbrick construction systems between the post and lintel system'. In the masonry system, the walls built with mudbrick blocks act as structural material, while in the filled adobe system between the post and lintel system, timber posts and lintels placed inside the walls at regular intervals are structural material and mudbrick is used as filling material.

Mudbrick masonry systems are systems in which there are no timber structural materials between mubrick materials, and mudbrick blocks are placed on top of each other. These systems are more commonly seen in flat-roofed and low-rise buildings in rural settlements in Anatolia [16].

In the wooden lintel mudbrick masonry system, the ground floors are generally built with masonry stone walls up to the height of the basement. After the basement level, mudbrick materials are used. Timber is used as a lintel on the window and door openings and as a horizontal beam along the floors (15). Horizontal timber lintels pass through the upper and lower parts of the door and window openings and continue along the wall. According to the earthquake risk in the region, these lintels were also used at more frequent intervals inside the walls [16].

Today, mudbrick continues to be developed with different quality additives added to its mortar in order to popularize the use of mudbrick and to increase its strength.

2. MUD BRICK MATERIALS IN TURKEY

Mud brick was used instead of brick for the first time BC. as a building material in the Mesopotamian lands, where the stone was powered around 2500 BC. Mesopotamian lands, where the Assyrians built masonry with mudbrick material 6000 years ago, were also under the dominance of this material at that time [17–19]. Like all cultures settled in Anatolia from the Neolithic Period to the present, the Hittites used mainly mud brick materials in their structures. Wall remains made of mud bricks were found during the excavations. There is use of mudbrick material on the foundations made of crushed stones, but generally it has either completely disappeared, or the bottom part has been preserved. The remains that were exposed for a long time also created a disadvantage [20]. Especially in the Eastern Anatolia region, where the winter seasons are harsh, the use of stone and adobe materials is common. Among the reasons why it is common in this region are other construction materials such as wood are scarce and/or expensive, and the adobe construction method is a material and construction method that has been used for a long time [17].

In the Anatolian geography, mud brick is mostly used as the main building material in the Central Anatolian Region. However, it is common in other regions to use it together with stone and wood. While mud brick material is mostly used in masonry system, mud brick filling between timber post, lintel systems and mixed systems where both are used together [21], it is also used as plaster, mortar, and filling material.

The mud brick material can contain the unique materials of each region and the structural changes according to the properties of those materials. The regional changes are shaped by the knowledge of the person performing the construction work. In Turkish Standard 2514 [22], mud brick is a material that can be used in construction by mixing straw or other vegetable fibers, etc. or other additives with suitable soil and clay and in order to be shaped and dried in the open air by pouring into molds after kneading them with water. Straw and other herbal materials used in the definition are the materials added to the mortar to prevent the adobe from cracking, and other vegetable materials defined as similar substances are reed type, coarse grass, hemp fibers, straw, waste strawcollected from barn mangers, dry heather, pine needles, tree branches, saw and grater shavings [22]. It is possible to count lime and gypsum among other materials that can be added to the mud brick material. Lime affects the interaction of mud brick with water rather than its strength, and by this way adobe material that is more difficult to be affected by water is obtained [17]. The use of plaster in adobe material ensures that the material becomes more durable, less sensitive to water and moisture, and does not produce dust and dirt. During production molding and drying becomes more easy and cracking is reduced during drying [23].

As mentioned above, mud brick is a building material that is produced by various methods and techniques in Turkey and is mostly encountered in traditional architecture. Although academic studies have been developed on how to transform existing disadvantages along with its advantages, its contemporary use is not seen and cannot become widespread. Kafesçioğlu states that there was a break in this sense in the 1950s. Anatolia is the cradle of the earthen structures, that the earthen structuring was left behind after the bricks, but during the World War II, there was a return to the land, and in 1948, a study on the development of soil structure in Turkey at the Anatolian level, under the leadership of Mustafa Inan, with a team from Istanbul Technical University, including himself, started, and that study was started in Turkey with the aim of creating a database. In addition, the details of the mudbrick material were learned by meeting with local craftsmen at the same time, and that the materials were examined and documented in laboratories by Bekir Postacıoğlu and Vahit Kumbasar. These studies, which lasted until 1950, were shelved together with the changing administration's statement “It is not befitting for a developing Turkey to deal with land” [24].

3. VILLAGE DESIGN STATEMENT AS A METHOD RECOMMENDED FOR THE CONSERVATION AND SUSTAINABILITY OF MUDBRICK IN TURKEY

Village design statements ensure that the characteristics of rural areas that are worth preserving are maintained in today's conditions, and that they are transferred to the future with their original texture and identity. They are important because of their values below.

-It provides the context for a new development based on the local character and meaning of the settlement.

-It helps to manage change from the upper scale to the lower scale, regardless of whether the improvement will occur or not.

-It leads to the realization of a development plan in harmony with the values and characteristics of the settlement.

-It is prepared for the purpose of documenting and protecting the traditional identity of the city and making a positive contribution to the local environment.

Along with interacting with the relevant legal regulations, it is specially prepared for each rural area [25].

It is aimed to define the social, cultural and spatial character of the village and to present methods and recommendations for its preservation [26]. With the rural design guides, it is tried to create a tool that can provide input to the official planning systems in order to increase the quality of new developments in rural areas and manage the physical change in the settlements by the users having their own design guides [27].

Village design statements, which started to be prepared intensively in England in 1993, also found their place in the Turkish Zoning Law in 2013. With the article added in 2013 to the Zoning Law No. 3194 prepared in 1985, it is aimed to promote the use of village design statements in Turkey as a method that will contribute to rural protection, sustainability and development.

When the various village design statements prepared until today are examined, the following headings draw attention [17,26,28–40].

- Determining the aims and objectives of village design statements.
- Introducing other legal regulations related to the statements.
- Researching the geographical and historical values of the villages.
- Determining the current situation in terms of local people, economy and future possibilities.
- Evaluation of the resources of the village such as tourism and mining.
- Revealing the interaction of the surrounding settlements with the silhouette and the selected region.
- Determining the relations between the surrounding settlements and the village border.
- Listing of village and special environmental values such as antiquities, woodland or natural resources.
- To reveal the characteristic features of the settlement such as special regions, layers, roads and routes, open space texture, relations with other settlements, relations between structures and spaces.
- Determining the characteristics of buildings in villages such as building typology, height, scale, density, size, size, style and typology, borders, walls and separations.
- Research of construction systems and materials.
- Determination of transportation conditions, possibilities and impossibilities.

As can be understood from the above-mentioned titles, the village design statements provide all the information, documents, field researches and their results to be revealed, and one of these titles are construction technologies and materials.

In the village design statement prepared for the villages of Balıkesir in 2011, the use of mudbrick is given in detail under the title of building materials. It was emphasized that the use of mudbrick in the villages of Balıkesir dates back to ancient times and that it continues to be used in some villages. Especially in hillside and plain villages, some of the old houses are mostly mudbrick. The ground floor or the first 1, 1.5 meters of the houses were built using stone, and the first floor or later was built using mudbrick. The dimensions of the mudbrick blocks used are similar and are 30/33X11, 5/15X12/14 cm. [31].

After giving general information on the use of mudbrick in Turkey in the village design statement prepared for the countryside of Kayseri in 2011, it was pointed out that mudbrick was mostly used as a joint mortar in plaster and stone masonry in the region, and that the mudbrick building tradition left its place to tuff in the following periods. In addition, while the materials used in the building inventories were determined in detail, mudbrick was also included. In the project reports prepared for the statement, the materials available in the region, their properties, their chemical, physical, petrographic, mechanical, pozzolanic analyzes in the laboratory settings and their properties are given in detail [17].

In the Küre Ersizler Village Design Statement published in 2015, it was stated that wood, which is easy to find and easy to work in traditional buildings, is the primary building material in the researches on the rural architectural character of the Black Sea Region. An important reason why wood is preferred over materials such as stone, mudbrick and brick is that it has a better insulation value for moisture and heat transfers. And it has been emphasized that the use of mudbrick is not very intense in the region [26].

In 2015, in the village design statement prepared for the villages located within the borders of Küre Mountains National Park and connected to Bartın Province, a documentation study was carried out on the use of mudbrick as a material in the architectural texture analyzes made in some villages, and mostly included in the inventory slips [32].

When the village design statements published in Turkey are examined, it is determined that researches have been made on the regions where mudbricks are used, their usage styles and their construction methods. However, no attempt has been made to encourage its reuse. Or it is observed that no proposal has been developed for the reuse of mudbrick in new structures to be built to meet new needs.

Researches show that mudbrick has advantages that should be evaluated especially in today's world, which is getting more and more polluted by human beings every day. Its porous and heat-preserving structure makes it a material that keeps the heat and humidity in balance by absorbing the moisture in the air, creates a clean healthy indoor environment, and protects the building from the unwanted hot and cold air outside. It is an ecological and sustainable material due to its low production cost, natural structure, low energy requirement for its production, its ability to be produced in every region, pollution prevention and its low transportation cost, and recycling possibility. There are various researches on the solution of contemporary usage problems of the material, which has disadvantages as well as advantages. The main thing is to ensure the sustainability of the mudbrick produced with local materials, again through local materials. In this context, one of the solution proposals we come across is village design statements. Village design statements are guides that focus on a single rural area or region and also examine the area in terms of construction systems and building materials. Detailed reports of other available materials in the region are presented in the guide prepared for various regions. Detailed studies on the use of mudbrick in various regions have been found. However, no data were found in the statements on the use of mudbrick in new buildings to be designed in villages, in a way that would meet contemporary needs. However, one of the aim of village design statements is to preserve the traditional identity of the area and to reveal a development plan and method in harmony with the values and characteristics of the area beyond documentation.

In this context, the following titles are suggested for the dissemination of mudbrick for the preparation of rural design guides.

- Materials research: Investigation of natural materials in the region. Determination of chemical, physical and other properties by tests performed in laboratory environments.
- Documentation of the current situation: Determining the mudbricks prepared with traditional methods, investigating their construction and use. Determination of properties by tests carried out in laboratory environments. Determining the advantages and disadvantages that may arise when it comes to reuse in today's conditions.
- Experimental studies: Conducting studies and experiments on the materials discovered and researched in the region and the use of existing mudbricks in order to eliminate the disadvantages of their properties.
- Production and application areas: Testing the obtained material, revealing the methods for the dissemination of production and determining the application areas.
- Publication of the results: In line with the data obtained, publishing and disseminating the results regarding the improved mudbrick that can be used in the studied region, which is adapted to the requirements of the age, disadvantages have been eliminated as much as possible and supported by using local materials.

CONCLUSION

The research shows that village design statements can be a good tool for documenting, protecting, and maintaining villages and makes it possible to document the materials and construction techniques used as well. However, although there are researches on construction systems and materials in village design statements, there are very few studies on its use and development in today's conditions.

On the other hand, mudbrick is a material that is widely used in rural areas and creates a cultural heritage value in Anatolian lands. Although there are regional differences in the components and proportions in its content, it is quite advantageous in terms of being ecological, sustainable and natural. It is possible to ensure its sustainability with the studies carried out and / or to be carried out on its contemporary use. Village design statements can be an important resource for the maintenance of mudbrick.

When the researches to be carried out in areas where mud brick is used in rural design guides are handled in line with the above-mentioned titles, it is possible to create a good resource for learning and reusing the material. In order to implement the suggestions developed in this context, it is recommended to cooperate with the relevant institutions, organizations and individuals and to continue the studies by going beyond the documentation work in the preparation of rural design guides.

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32- Examination of Earthen Building Material of ModernArchitectural Examples

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ABSTRACT

Earthen materials have been used as a building material for a shelter since the existence of human beings. It is still used as the main building material in many geographies. Soil is an economical and nature-friendly material that can be easily processed. On the other hand, the act of building includes many parameters such as construction techniques, materials, and design. Today, because of increasing energy demands and deterioration of the natural balance, the concept of sustainable building has gained importance for the act of building with these techniques and materials.

Today, we are faced with many environmental problems such as the rapid depletion of natural resources, environmental pollution, increased energy consumption, and increased carbon dioxide emissions. The construction industry, which has a large share of this consumption and damage, has started to turn to sustainable construction techniques and materials. Changing living conditions bring along new construction techniques and materials. Earth, which is one of the traditional and sustainable building materials, is still a preferred building material among contemporary architectural examples.

In this context, the study's main purpose is to reveal the importance of natural building materials within the scope of sustainability. Within the scope of the study, the relationship between adobe obtained from the earth, which is the oldest known building material, with sustainability, and examples made up to date in this context, and with the development of technology today, it is to examine the techniques used to construct adobe in modern buildings.

In today's world, with the development of technology, it has been evaluated on the examples of buildings selected in different geographies, that were built using different construction techniques. The examined building samples were compared with the tables and suggestions were made to encourage the use of earth building materials for sustainable construction.

Keywords: Earth based material, sustainable materials, sustainability, modern architecture

1. INTRODUCTION

The act includes many parameters such as construction techniques, materials, and design. Changing living conditions bring along new construction techniques and materials. Today, the deterioration of the natural balance because of increasing energy demands has highlighted the concept of sustainable building. The danger of depletion of reserves because of rapid urbanization, increase in industrialization, and uncontrolled use of natural resources has brought the concept of sustainability to the fore in the construction sector, as in every other field, and studies in this field have increased [1].

Building materials are one of the important foundation stones for sustainable architecture. It is observed that the materials used in the construction of structures compatible with nature are mostly already available in that region and the construction process is based on local construction techniques. As a result, it is possible to see many positive aspects of the built structures within the scope of sustainability.

Today, the rates of greenhouse gases and carbon dioxide emissions are increasing with increasing energy demands. This situation also harms the ecological balance. The energy demand met by non-renewable sources tends to renewable sources as the reserves of these sources are limited and they harm the ecological environment. In this context, structures with low energy consumption gained importance. For these reasons, high-performance buildings that meet their energy needs from renewable resources are encouraged in the construction sector [2].

In this context, it stands out with the advantages of sustainable architecture. The concept of 'sustainability' is a multidisciplinary perspective that aims to meet the needs of today by taking into account the needs of future generations, leaving them a more livable world, and using resources sensitively without harming the environment. Making the concept visible in terms of architecture for a sustainable society; The concept of 'place' has a great meaning in the context of the continuity of culture and identity issues, as well as the continuity of local resources [1].

Sustainable architecture is an ideology that is dependent on climatic conditions and has goals at every stage from the project stage to post-construction using ground data. The first step in this regard was taken in 1987 with the Brundtland Report, 'Our Common Future', and the concept of sustainability was redefined architecturally. This report (United Nations World Commission on Environment and Development, 1991) was developed as a joint integration of the development ideology of the 1960s with the environmentalist ideology of the 1970s [3]. Especially after the industrial revolution, many policies, laws, and scenarios have been developed to minimize energy consumption and reduce losses against the increasing energy demands. Changes in this process; Increasing materials and manufacturing techniques necessitated using fossil energy sources more frequently. This has accelerated studies and research on natural environmental protection and sustainability.

Within the scope of the study, the oldest known building material, adobe obtained from earth, and examples of earthen based buildings related to sustainability and the techniques used in modern buildings with the development of technology today are examined. In addition to this, examples of the use of sustainable traditional adobe from the world and our country, in general, are given. In the study, first of all, the relevant literature was examined and the construction material in question was evaluated by considering its usage areas and today's production methods. It is aimed that the findings obtained as a result of the study and the suggestions developed will contribute to the widespread use of earthen-based materials in the context of sustainable architecture. Soil construction methods have features that can be used not only in rural areas but also with modern materials and systems.

2. EARTH AND ADOBE AS SUSTAINABLE BUILDING MATERIAL

Today, the ecological balance, which is deteriorating with increasing energy demands, has enabled individuals to turn to more sustainable ones in terms of material selection and construction techniques in building production. The use of soil or mud, which is a sustainable building material, is as old as human history itself. Mankind has benefited from the soil as a building material since ancient times. Soil is a material that is used in every geography, climate-specific, easily accessible and its usage techniques can be applied by everyone. With these features, soil-based materials are considered sustainable, environmentally friendly, and ecological building materials, with their features such as being completely recyclable and not creating waste. The reasons for this are listed below;

• Using local possibilities and very simple construction techniques, being easy to manufacture and not requiring any facility and/or qualified personnel,
• Ease in supply and manufacture, easy to process, and economical in terms of comfort,
• Does not harm human health in the production of space, does not leave waste to the environment in the building-life cycle,
• Providing thermal comfort, having high thermal insulation,
• Being recyclable, not polluting the atmosphere with harmful gas emissions such as CO_2, not threatening nature and the environment [4]

It has been used for thousands of years in the construction of elements such as walls, roofs, floors, etc., together with soil, mortar, and plaster as a building component. The adobe structures constitute the largest share of the traditional earthen structures. Today, much international scientific research; The construction process of adobe emphasizes its advantages in terms of ease of use, longevity, environmentalism, and sustainability. It is seen that the use of oil-based materials with new techniques and systems has become widespread [5]. Used as a local material in the past, adobe is a contemporary building material that can also be preferred for urban areas today. Earthen based materials and adobe are drawing attention once again with their capacity to be an important solution to today's social, economic, and environmental problems [6].

As a local material, adobe is used extensively in rural areas due to its rapid construction methods, being easily applicable and accessible by everyone, and today it continues to be used in modern buildings with new techniques. Adobe structures are seen in almost every continent in the world (Figure 1-3) [7]. Being a earthen based material increases its applicability in every continent. The places where adobe structures are used extensively are; It can be said as the lands of Africa, Central Asia, Central and South America, and Anatolia. Apart from these, examples of adobe structures are also encountered in different countries and regions. One of the cities that stand out in terms of the density of adobe building applications in the world is the state of Santa Fe in the USA (Figure 1). The adobe building architecture in Santa Fe, which developed under the influence of many different cultures; has been brought to the present day because of the works carried out by a group of artists and intellectuals at the beginning of the twentieth century, both with a sense of protecting traditional values and to protect local architecture from the negative effects of rapid construction. Bem Castle (Arg-ı Bem), located in the city of Bem in Iran, is referred to as the largest mudbrick structure in the world (Figure 2). Although most of the castle was destroyed after the 2003 Bem earthquake, it was later restored and entered the UNESCO World Heritage list in 2004 [8]. In our country, it is possible to see examples of adobe structures in every region. Anatolia has had many different examples of residential architecture since the early ages. The buildings in Çatalhöyük are planned as rectangular mud-brick houses adjacent to each other (Figure 3). There are no doors in the housesand they can be entered from the roofs. These houses meet the need for shelter [9].



Figure 1. Santa Fe [10]; Figure 2. Bam Castle [11]; Figure 3. Çatalhöyük [12]

2.1. EARTHEN BASED CONSTRUCTION MATERIAL PRODUCTION METHODS

Earth material stands out compared to other building materials with its availability in every geography and easy construction techniques. There are many different techniques in the use of soil as a building material. In today's modern buildings, mostly mold block brick technique, compressed soil technique, and earthen-based wall construction with prefabricated panels are encountered. In the traditional mold block masonry technique, the soil is mixed with water and additives. The muddy mortar is poured into the block molds and kept until it dries (Figure 4).

In the earth wall construction technique, also known as "rammed earth", the compressed earth forging technique, firstly, the inner and outer walls are covered with molds. Later, the prepared soil mortar is filled into the molds from the top. It is then compressed with a tool (Figure 5). This process continues until the wall is built. If the clay ratio of the mortar mixture is high, this ratio can be reduced with stones, sand, branch pieces, or plants. After pouring 10-12 cm mortar and beating, it can go down to 7-8 cm. After the mud is poured on all walls at the same level, first the edges and then the middle parts are pounded and compacted [13].

Today, another production method of earth construction material is the use of ready-made prefabricated products. This method, which is used to minimize the construction and drying time of the soil mix, is more common in Europe (Figure 6).


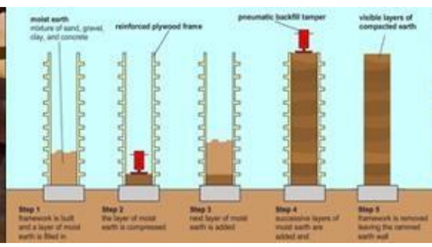

Figure 4. Mold block brick technique [14]; Figure 5. Rammed earth [15]; Figure 6. Prefabricated wall [16]

3. EARTHEN BASED BUILDING EXAMPLES

Within the limitations of the study, the compressed soil construction technique used in today's modern buildings and earthen based wall construction examples in different scales and different geographies were examined. Below are examples of buildings produced after 2000 using the mold block brick and rammed earth technique. In this context, the architectural and construction features of the Gando School, Bayalpata Hospital, New Delhi Boutique Hotel, and Anatolian AngelWomen's Training and Production Center buildings were examined. The energy-efficient, thermal comfort, low carbon emission, and sustainable features of the selected samples are at the forefront.

3.1. GANDO SCHOOL

Gando primary school was built in 2001 in Burkina Faso, Africa, by Francis Kere Architecture, using a combination of traditional and modern construction techniques (Figure 7). Francis Kere, who put forward a pioneering architectural style, made his first architectural project in his hometown. It aims to meet the needs by combining traditional construction techniques with contemporary engineering methods. The determining factors in the design of the school were cost, climate, resource accessibility, and construction feasibility. Clay, which is the most accessible material in the region, was chosen. To maximize results with few resources at hand, Kéré has tested a clay/mud hybrid structure that can withstand high temperatures and semi-arid climates. Traditional clay building techniques have been modified and modernized to create a more structurally sound structure [17]. The blocks were strengthened with cement placed in the clay. The structure consists of traditional load-bearing walls made of stabilized and compacted earth blocks.

Figure 7 Gando primary school view, construction phase and floor plan [18]

The architect of the project, Francis Kere, completed the building with the participation of the local people throughout the construction process. In this process, Kere also benefited from the knowledge of the local people and combined this knowledge with modern techniques. Gaps were left between the ceiling and the metal roof, and the heated air was expelled from these gaps by opening holes in the ceiling. Thus, a passive ventilation system was implemented (Figure 8). By separating this metal roof cover from the ceiling, besides providing passive ventilation, a shaded area was created inside the space and protected from rain [19]. Gando Primary School received the Aga Khan Architecture Award in 2004. After the school received the award, it encouraged efforts to build sustainable buildings in local areas with local materials.

Figure 8 Gando primary school roof view [19]

3.2. BAYALPATA HOSPITAL

Construction was started by Sharon Davis Design in 2014. The design team placed the structures around two courtyards (Figure 9). These courtyards serve as the core where medical programs take place. The courtyards also buffer between more public programs towards the south entrance, such as outpatient care and pharmacy, and more specialized programs to the north, such as the surgery and maternity ward. The buildings are built as single and double stories and use sunlight as passive ventilation. Except for the laboratories and the operating part in the complex, all units are passively heated and cooled [20]. The 4,200-square-metre facility gets its energy, thanks to a 100-kilowatt array of solar panels integrated into the roofs of the buildings.

Figure 9. Bayalpata Hospital appearance and site plan, construction phase [21]

Rammed earth was chosen in terms of thermal mass to support the passive design and to take advantage of local data. Thus, heat gain is maintained in winter, and it stays cool in summer. The soil is stabilized for more durable seismic resistance. For this purpose, the local soil was mixed with a cement content of 6%. Each of the five medical buildings uses a composite structure of cement and steel-reinforced rammed earth that supports lateral loads and integrated concrete columns. It not only provides containment but also acts structurally within the entire system. Energy use is reduced in low-rise buildings. Thanks to the low-rise buildings, there is no need for electrical elevators. Employees and their families live here, as commuting would be impractical for those working here [20].

Figure 10. Bayalpata Hospital courtyard and other units [21]

3.3. NEW DELHI BOUTIQUE HOTEL

It was built in India in 2019 by architects Ashwin Alva and Lalit Mangar. The soil itself was used as the primary building material for the rammed earth load-bearing walls, resting on a random rubble pedestal made of brown quartzite. The Northern Blocks are located at the same elevation. The load-bearing compacted earth walls of the guest rooms above are carried by the rubble walls on the ground floor (Figure 11). In the South Block, single-story guest rooms built on the ground are planned in parallel.

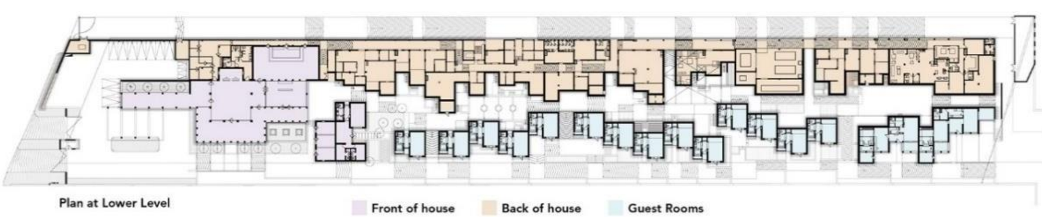

Figure 11. New Delhi Boutique hotel floor plans [22]

The area is 15.300 m^2 in size, 275 m in length, 10 m downslope, and descends into a valley 30 m lower. It is aimed to increase the thermal performance by leaving insulated spaces on the walls of 17 cm obtained from compacted soil. The continuous insulation blanket with minimum thermal bridges extends over 220 m of the property. It wraps over both vertical and horizontal faces, forming the world's largest insulated compacted earth structure. The design is arranged around a series of courtyards typical of the organic growth of Indian villages, with stepped sites connected in and around clusters of rooms. All rooms face south, which provides better flexibility in thermal control and increases winter sun exposure [23].

Figure 12. New Delhi Boutique Hotel Accommodations [22]

3.4. ANATOLIAN ANGEL WOMEN'S TRAINING AND PRODUCTION CENTER

It was built by Architect Özgül Öztürk in 2019 in the Keban district of Elazığ. The structure was formed by rammed earth in these molds using steel molds. Thus, smooth surfaces were obtained on the walls. Wall thicknesses consist of 45-50 cm. It expands inward at the window openings and lets the light in. Architect Özgül Öztürk defined this building as a sustainable architecture, produced with local and natural materials, consuming less energy, and economically maintained. In terms of its architectural features, the building provides energy from the sun. Its roof was arranged as a green roof, and it collected rainwater and used it in hydrophores and reservoirs (Figure 13). As in Anatolia, wet volumes were resolved outside the building. It also meets its electricity needs with solar energy. Architect Öztürk defined this building, which he built as an example of ecological architecture, as a structure that is produced with local and natural materials, requires less energy, is healthy, economical, and can be easily maintained [24].

Figure 13. Anatolian Angel Women's Training and Production Center [25]

4. EVALUATION

Earth, one of the main building materials from past to present, has been used in many buildings with different functions. As a building material, earth can adapt to different construction techniques. While earth bricks were used as bricks in the Gando primary school library, rammed earth walls were built in the Bayalpata hospital, reinforced with steel in molds. When we evaluate it as an area, it is seen that it is used in different building functions, from small residential buildings to large-scale cultural, library, and hospital centers. Earth material can be used in construction with many different techniques. The use of soil as a building material in all examined samples was obtained from the soil and stone quarries in their regions. Earth material has always taken its place in the design process with both architectural design and context. When we look at the contemporary structures built, the soil can quickly adapt to today's technologies and contribute to the design. One of the important parameters in the selection of building materials and techniques in all examined examples in economics. Locally made materials were used in all examples. Earth material has been successful in its use with many construction techniques and materials. In all examples, local and contemporary construction techniques were used by blending them. In addition, it is seen that the people of the region are involved in the construction process of these buildings. To minimize the disadvantages of the earth material, additions were made to the construction techniques (material, additives, etc.). Some features of the buildings examined within the scope of the study are shown in Table 1.

	Build Name **Designer**	**Date/ Place**	**Structure**	**Evaluation**
	**Gando School** / Francis Kere	2001 Africa-Burkina Faso	clay brick, earth and steel roof	During the construction, local materials and techniques of the region were used. Clay bricks made of soil were dried in molds and used. Passive ventilation is provided by leaving a gap between the ceiling and the steel roof.
	**Bayalpata Hospital** / Sharon Davis Design	2015-2019 Nepal-Achham	4.200m2 Steel-reinforced rammed earth	Due to the social situation brought by the geography where the complex is located, the building was built with the capacity to serve everyone and with sustainable building materials and methods. It is designed not only as a hospital, but also with the principles of social, economic and environmental sustainability.
	**New Delhi Boutique Hotel** / Ashwin Alva &Lalit Mangar	2019	15.300 m2 rammed earth	Considering the hot semi-arid climatic conditions, the design approach was based on the principle of being ecological. It improved thermal performance by developing an insulated space between 175 mm of compacted soil. An on-site laboratory was established to make soil measurements.
	**Anatolian Angel Women's Training and Production Center** / Özgül Öztürk	2019/ Elâzığ-Keban	rammed earth	Gray water is used in the building and the building is heated passively by solar energy. As the building is in Anatolia, the wet volumes were solved outside the building. It also meets its electricity needs with solar energy.

Table 1. Evaluation of Earth Based buildings

CONCLUSION

Earth, which has been used for shelter throughout history, has been applied in almost every region. It is among the preferred natural materials due to its easy workmanship, economy, and high thermal performance. Although it lost its importance with the realization of important advances in technology with industrialization, it has gained importance again intending to reduce energy consumption, where natural resources are being consumed rapidly today. According to the understanding of sustainable architecture, building materials that do not harm the natural environment, consume the least energy throughout their life cycle, and do not produce harmful emissions during the process from the production to the use and destruction of building materials are given priority. In addition to being economical, the soil material successfully adapts to the construction techniques that have emerged with today's technological developments. With the use of traditional techniques and contemporary techniques together, the usage area of earth material has increased.

When we look at the examples of different scales and functions examined within the scope of the study, it is seen that soil material is used in almost every country. Contemporary practices have further expanded the use of earth material. The earth material, which can meet the thermal comfort requirement in places with its structural features, is easy to use because it is suitable for both on-site and precast production. In our country, especially in rural areas, the use of adobe is very common in housing. It is possible to see examples of it in many regions, thanks to the fact that the soil is easily accessible and easily cultivated. In addition, it is possible to see individual examples as contemporary building stock. Considering the increasing energy demands in the building sector, the transition to more sustainable materials has increased the interest in the soil in our country. Although it has rich potential as soil, we can say that the existing building examples are few compared to the examples abroad. In this direction, awareness-raising announcements can be made to architects and society in general, such as encouraging the use of earthen building materials and organizing competitions for architecture students.

Within the scope of the study, it is thought that the value of earth material will increase gradually and gain importance in the construction sector as a result of the examination made of contemporary architectural applications built using soil construction materials in different geographies. Today, local material is applied in different ways by combining traditional construction techniques with current technology. It is ensured that the local materials and techniques continue to be included in the designs and that the architectural knowledge is not lost and kept alive.

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33- Lifestyle in Modern Construction & Earthen Constructionenvironments

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ABSTRACT

This abstract offers a brief enumeration and discussion of the strikingly different environments that are generated as consequences of the diverse architectural practices, techniques and methods carried out by Established (or Cement or Modern) Construction and Earthen Construction.Because of the nature of the topic the largest part of the chapter is covered by thematic comparisons; the last part comprises rather general considerations of important issues related to lifestyle.

Keywords: Social sustainability, Western and Islamic theories, religious functions, Yazd

1. INTRODUCTION

Architecture, as a static response to the human needs *1 has always been highly interconnected with human lifestyle. Architecture determined and at the same time reflected lifestyle. Architecture "holds within it a great power to uplift the way humans live their daily lives". *2 It goes without saying that lifestyle has always been a matter of great concern for humans, as it is directly linked to human health, feelings, sensations, spirit and ultimate wellbeing. As the physical surroundings are an extension of who we are as people, the built environment significantly modifies our life. *3

Modern Architecture has changed lifestyle tremendously while being also impacted by the rising socioeconomic needs of the modern societies; this is revealed in the famous assessment of the skyscraper, which was made around 1900 by the architect Cass Gilbert, namely that the high elevation building is "a machine that makes the land pay". *4

Being theorized as the eco-friendly architectural approach par excellence and having emerged to respond particularly to the urgent need for Green Building with minimal environmental footprint, Earthen Architecture today represents a reconsideration of all things architectural. It is therefore only normal that Earthen Architecture ends up with a tremendous contrast to Modern Architecture not only at the level of materials, practices, techniques, and methods but also with respect to lifestyle.

2. COMPARISON THEMATIC OF MODERN ARCHITECTURE AND EARTH ARCHITECURE

What follows is a thematic comparison of average lifestyles ensuing from both, Modern Architecture and Earthen Architecture. The list of themes encompasses five (5) basic axes, notably residence, transportation, social context, natural environment, and urbanism & architectural landscape. It must be said beforehand that the two strikingly different lifestyles can be categorized as per the fundamentally different theoretical conception of each architectural system, namely vertical (as regards Modern Construction) and horizontal (when it comes to Earthen Architecture).

2.1. RESIDENCE

With Le Corbusier's vision of cities as 'tidy vertical machines', lifestyle changed totally. Basic notions of humans' everyday life came to an end; the fundamental concept of the neighborhood disappeared with the high elevation buildings that pulled people apart from one another. For millennia, the notion of human residence was intertwined with the notion of neighborhood. For human lifestyle, despite all cultural differences between the North and the South, the East and the West, neighborhood was traditionally indispensable and commonly shared by all, irrespective of geographic location, ethnic origin, linguistic differentiation, social stratum and religious affiliation.

Yet, all of a sudden, for the sole needs of mid-19th c. architects and the 20th c. Modern Architecture theorists, human life had to be deprived from neighborhood and lifestyle had to be denied the chance and the privilege of a real sociality. The anonymity within a high elevation building replaced the eponymity of the traditional neighborhoods whereby the buildings never went beyond the limit of 3-4 floors and only exceptionally reached the limit of 9-10 floors. Modern Architecture came therefore as a dramatic break in tradition and as a social fracture.

Within the towers, residence became synonymous of isolation, dissociation from the other humans, disconnection from the nature, introversion, and self focused lifestyle. The trend was intensified as it also impacted negatively the family life, thus damaging another social cell.

Earthen Architecture stands at the very antipodes of Modern Construction when it comes to residence; in fact, it represents a return to and a reinstatement of the traditional lifestyle values and practices with the home inhabitants close to one another and the ages-old notion of neighborhood reinvigorated. This does not happen at the detriment of modernity and technological advance, because the Earthen Building can undeniably be the 'Adaptive House' envisaged by M. C. Mozer. *5 With its horizontal approach to the urban phenomenon, Earthen Architecture helps mitigate the excesses of modernity and fuse tradition with technology, thus preserving social values and long-cherished lifestyles. As an opposition to lifestyle ensued from Modern Architecture, Earthen Architecture promotes social inclusion instead of isolation, integration rather than dissociation, interconnection with in place of disconnection from the nature, extroversion, and shared lifestyle.

2.1.2. SAFETY

A particular aspect of residential lifestyle whereby differences between Modern Architecture and Earthen Architecture can be striking is safety. Risks from natural destruction are far greater for high elevation buildings than for earthen buildings. In fact, safety is a key disadvantage of towers and skyscrapers; in case of defective buildings or natural catastrophes, the extent of the damage caused on the ground by a tower block will by definition be immeasurably greater than that made by the largest earthen building in the world. In this regard, safety is a serious concern during the construction, the use and the demolition process of the building. Despite the advances made by Japan in the demolition systems for high-rises, *6 demolition work is still a serious concern in terms of safety, energy conservation, and environmental protection; in addition, in many cases, it is still conducted in old-fashioned ways in many parts of the world.

2.1.3. EVACUATION

Lifestyle is also impacted very differently by Modern Architecture and Earthen Architecture when it comes to issues of evacuation. High elevation buildings are more difficult to evacuate and the evacuation process can hardly be carried out safely; even for those present in lower floors at the time of an evacuation, always more serious challenges (ex. stampede) are at hand. Despite the progress made in disaster management and security planning, *7 building evacuation under conditions of adversity is still far safer and more successful to undertake in case of earthen building.

As far as high-rise building evacuation is concerned, it goes without saying that concerns are far greater for those living or working on higher floors. With regard to skyscraper evacuation, a recent and flagrant example was offered in the case of the Dubai building *8 named the Torch, which is a 79-story skyscraper swept by a blaze on February 21st, 2015. According to reports in the world mass media, "some residents said they had been told by staff that the building's fire alarms did not immediately sound and that reception staff at the Torch were alerted to the fire by people in an adjacent building."[The Torch receptionists] got a call from Princess Tower telling them the building was on fire. The alarms were not operating automatically," said Archibald Jurdi, a resident of the 76th floor". As per another report, *9 " witnesses said the fire started with a grill located on one of the building's balconies".

2.1.4. HOUSE PRICE & FAMILY / PERSONAL BUDGET

Lifestyle has a lot to do with the purchase of a house or apartment itself, which in turn makes an inevitable link with the family (or personal) budget. Today, in a great number of countries, the most common way to purchase or extend a house is a mortgage; in many countries, most of the debt borne by individuals has taken the form of mortgage. Only in the UK, mortgage borrowing passed the threshold of GBP 1 trillion in May 2006. *10 Gradually but irreversibly, lifestyle changed and adopted this practice (mortgage) which was not common at all before 100 years. However, this socioeconomic situation generated a bubble that went burst when confidence in the housing market failed, and economic trouble affected dozens of millions of families in the US and elsewhere.

Today, in a world of global economic hardship, lifestyle has to be adapted to the current socioeconomic conditions, if a bright economic future is to be sought after. When it comes to the housing market, Earthen Architecture is the alternative of choice for families, couples and individuals with limited budget and sensitive prioritizations. Earthen Architecture offers the most cost-efficient design of building that takes account of the building's impact on the natural environment; this is done by means of reduction of energy loss through the building envelope, and of reduction of electrical energy. Despite the existing differences of approach *11 to sustainable architecture (concern for nature or climate; scale of focus; scale of design; etc.), Earthen Building remains by far the most energy-efficient, eco-friendly, and healthy home for families, couples and individuals with an average income.

As a highly localized system of architectural methods and techniques, Earthen Architecture can draw on local experience and make it globally known and beneficiary to many across the world; an example is the traditional wind catcher, which is an architectural part of buildings in Yazd, Iran. Serving as a cooling system, the wind catcher *12 provides ventilation thanks to the renewable energy of wind. Modifying heat and adjusting the temperature of interior living spaces in regard to thermal comfort, the wind catcher could be equally useful in any other part of the world with similar climatic characteristics (hot, and dry or humid), thus offering the inhabitants the benefit of cost-effective ventilation and heat modification.

Epitomizing customer environmental awareness and motivation, Earthen Architecture is poised to bring forth the necessary lifestyle changes that are requested in today's urban consumer societies. Modern Construction-based lifestyle proved to be absolutely deficient and ultimately unsustainable; at present, only 2% of the world's land surface is covered by cities, but their inhabitants consume 75% of the resources consumed by mankind. * 13 In this regard, it goes without saying that Earthen Architecture associations, governmental bodies, and international organizations have to work hand-in hand to motivate people across the earth to shift to different, sustainable lifestyle concepts and to set up different priorities, when a family (or person) budget is made in view of house purchase plans.

2.1.5. TRANSPORTATION

Within the context of residence, transportation becomes an issue, particularly for people residing in sky scrapers and other types of Modern Buildings; their lifestyle involves extra expenses when it comes to transportation of heavy of ultra-size furniture and home appliances. When families or individuals need to hire movers to transport heavy furniture up to the 40th or the 70th floor, such as a piano, they face extra expenses and this situation only adds to their budget. In contrast, Earthen Buildings offer opportunities of lower cost transportation / relocation to the inhabitants.

2.1.6. COMMUNICATION

A major issue of lifestyle is communication among people residing in the same building and the surrounding structures and/or blocks. Here too, there is a vast difference between the impact made by Modern Architecture and the rebalancing effectuated thanks to Earthen Architecture.

Modern Architecture and its ultimate delivery, i.e. the high rise building, condition human communication with the outer world and make it depend almost exclusively on the elevator. Of course, this characterizes also everyone working in a high elevation building. In fact, Modern Architecture imposes a lifestyle burdened with restrictions because in case of elevator malfunction and unavailability inhabitants carrying heavy luggage or even just some bags will face a gravely hard experience. For cases of elder or invalid people, pregnant women, and children, such an inconvenience signifies isolation from the outer world or eventually home inaccessibility. As regards cases of emergency, namely illness and transportation to the hospital, elevator malfunction can at times cause death to the patient.

In striking contrast, Earthen Architecture makes available homes that allow the development of a more humane lifestyle, involving easy and 24X7 uninterrupted communication possibility with the outer world and the neighborhood. Earthen Building as residence grants occupiers the 'abilityto live with a satisfying balance of psychological, physical, spiritual, intellectual and emotional security; or in other words to live a generally fulfilling and happy life'. *14

2.1.7. FORCE MAJEURE

Also known as casus fortuitous, force majeure refers to extraordinary occurrences that can happen in the lifetime of a human being, namely wars, revolutions, riots, terrorist acts, strikes or natural disasters that are usually described by the legal term 'acts of God', involving blizzards, hurricanes, tornados, tropical cyclones, floods, tsunamis, limnic eruptions, avalanches, landslides, earthquakes, volcanic eruptions, wildfires, etc. * 15 These ominous developments can totally reshape the lifestyle of people in the areas where they occur; however, in most of the cases, evacuation plans are faster, easier and more effective to implement in case of earthen buildings than for high elevation structures.

2.1.8. SUSTAINABLE BUILDING

Today, when it comes to residence, the concept of sustainable building that implies low CO2 emissions and use of digital smart technologies represents the emerging lifestyle. In contrast with the Modern Building and the ensuing disregard for its environmental impact, Earthen Architecture can become the much needed vehicle that will usher today's global world into an eco-friendly, sustainable era of eco-conscious inhabitants, extended renovation-cycles, lower operation costs, digital smart devices, and soft services (such as instant information of the inhabitants on the current energetic well behavior of the building) that guarantee low energy consumption.

2.2. PUBLIC AND PRIVATE TRANSPORTATION

Lifestyle is highly marked by the public and/or private transportation that serves people willing to move from their homes to the school, the workplace, the supermarket and the various locations available for shopping and entertainment. With the transformation of modern cities in the middle 20th c. and the expanded phenomenon of urbanization, density of housing started having an impact on the way people move to workplaces, educational institutions and to shopping / entertainment areas. This caused a shift from public transport use to widespread car dependency.

In fact, low density cities show high mobile energy consumption rates as people depend on private transportation to move; contrarily, high density cities are relatively fuel-efficient because people prefer to either rely on public transportation means or walk / bike. Modern Architecture contributed to the formation of a lifestyle that hinges on high density cities and private car dependency, thus exacerbating environmental pollution and aggravating the health conditions of increased urban populations. As reaction to it, the concept of sustainable mobility or environmentally sustainable transport emerged. First to define the concept were the European Union (then European Communities) in 1992, and the Organization for Economic Cooperation and Development (OECD) in 1994. *16

In contrast, Earthen Architecture comes up with a lower density city model that can become integral part of a new, eco-friendly and green lifestyle; in addition, Earthen Architecture reflects rather principles of localism, concepts of decentralized societies and ideals of communalism and community-based lifestyle that seem to be far more relevant of today's world than of the conditions of the mankind before 50 years. Surveys demonstrate that improved public transport and the introduction of traffic restraint measures such as road user charges can affect the attitude of citizens and modify their lifestyle, adjusting it to the rising demand for sustainable development. * 17

2.2.2. SOCIAL – CULTURAL CONTEXT

As it becomes clear from the aforementioned, Modern Architecture set up a totally different built environment that affected lifestyle in many aspects. The socio-cultural aspects of lifestyle change due to Modern Architecture go beyond any description. The rhythm of the everyday life became incredibly speedier, daily habits were modified or forgotten, traditional behavior became obsolete, western trends spread across the world only to eradicate local cultures, the numerous and diverse identities were blurred, and long cherished values were disrespected. Uniformity of Architecture brought about uniformity of Lifestyle, and this occurred in direct contrast with the past.

The new lifestyle generated its own dynamics that only added to the deformation of the traditional, local human lifestyle that prevailed before the global diffusion of Modern Architecture. Without the earlier notion of neighborhood and the courtyard, children grew very differently in high elevation buildings and were exposed to television addiction, to video & video game addiction, and more lately to Internet and Computer addiction. This troublesome experience disconnected children and adults from one another, utterly modifying their mentality, health, attitude and socio behavioral system. Today's gravest social problems (drugs, bullying, organized crime, etc.) are certainly not due to Modern Architecture but to great extent they are owed to the ensuing lifestyle that was imposed because of the modern architects' disrespect of traditional prescripts, forms and concepts.

Earthen Architecture, in striking contrast, can alleviate all the socio-behavioral troubles ensued from Modern Construction-based lifestyle. Revitalizing local perspectives, reinstating traditional values, re-inventing the notions of neighborhood and courtyard, and restructuring the otherwise unsustainable modern architectural landscape, the Earthen Building marks by definition the long-awaited return to human-scale, sustainable lifestyle. In our times, of increased numbers of refugees and asylum-seekers, multi-ethnic, multicultural and multi-media societies and socio-cultural segmentation and mutation, this may be ecologically necessary, socially indispensable, and politically correct.

2.2.3. NATURAL ENVIRONMENT

Modern Construction affected lifestyle also with respect to the natural environment; the inhabitants of high rise buildings are genuinely disconnected from nature in many ways. People, who were used to grow their own foods in small gardens, found it impossible to continue their traditional lifestyle after they moved to a high rise building; those who were accustomed to gardening had to content themselves with indoor gardening only. Modern Construction-based lifestyle forces people to get dissociated from the natural environment, and in the best of the cases it is associated with artificially made landscape.

Even worse, Modern Construction-based lifestyle also involves the exposure to unnecessary and even unnatural environment. Mega-skyscrapers cast long shadows, forcing people to live and walk in a much unwelcome way. This proved to be very unpleasant for people living, working or passing by these high elevation structures. The extent of the problem is such that recently architects decided to check whether a shadowless building could be eventually designed; using computer modeling to design a pair of buildings, they designed one building that works like a gigantic, curved mirror. In that case, the glass surface of the northernmost building would reflect light downinto the shadow cast by the southern building. Ultimately, the carefully defined curve of that glasswould allow the reflected light to follow the shadow throughout the day. The reflected light wouldbe diffuse, not a focused lethal ray. *18

Similar issues may eventually be corrected thanks to advanced technology, but the original fact remains that Modern Construction-based lifestyle is an exception in the History of the Mankind in the sense that it severely detaches people from the natural environment. Contrarily, Earthen Construction-based lifestyle incorporates human habitat into the nature, thus offering the possibility to make the perfect match between architectural tradition and sustainable modernity. *19

2.2.4. URBANISM – ARCHITECTURAL LANDSCAPING

Modern Architecture and Earthen Architecture impose strikingly different lifestyle either in small or large scale. Whether we observe the dissimilarity at the level of family residence, which corresponds to the very cell of the society, namely the family, or we examine the difference at the overall level of urban agglomeration, Modern Architecture-based lifestyle is diametrically opposed to that characterizing people living in earthen built environment.

CONCLUSION

Due to the overwhelming expansion and wide acceptance of Modern Architecture, severalnegative trends emerged thus making of the modern city management a perplex undertaking. Theformation of clusters of cities, the decline of the urban life quality, the spatial expansion of cities,the socio cultural segregation, and the difficulty to ensure seamless interoperability of the diverseprocesses involved (environmental, economic, socio-cultural, institutional) turned most of today'scities into unhealthy realms, unmanageable entities, and unsustainable agglomerations. Thence rose the need of integrated approaches to the urban phenomenon; the target was the establishmentof an integrated assessment for sustainable cities in view of proper urban planning.

A holistic approach to urban planning led to the inception of the urban metabolism concept. Projects were subsequently developed in order to provide the respective authorities with integrated city planning tools and with a vision for sustainable development; an exemplary case in this regard was Maastricht 2030, a 4-year project launched in 1999. *20 When it comes to Urbanism, Earthen Architecture-based lifestyle involves energy efficiency, reduction of the housing density, and sustainable lifestyle patterns that could all be comprised within a city planning instrument which could help integrate the physical infrastructure, the social infrastructure, and the city economy.

Recent studies defined the morphological and infrastructure concepts of sustainable cities *21 and emphasized the design approaches to them, thus highlighting the importance of strategic framework able to pull modern societies far from the impasse where we were driven because of the unsustainability of Modern Architecture and Urbanism.

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34- Using Digital Fabrication Techniques with Earth-BasedBuilding Materials

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ABSTRACT

Although earth-based building materials have a variety of advantages in terms of environmental concerns of buildings, they require intensive labor to achieve the desired efficiency in construction time, cost, and quality. However, advanced and innovative construction technologies provide ease of construction with less labor, high quality, and less time. Furthermore, the development of robotic technologies in the construction industry offers unique and unlimited application methods. They also demonstrate the potential to broaden the limits of architectural design. This study mainly aims to explore earth-based building materials used with digital fabrication techniques for construction. It focuses on digital fabrication strategies for the construction of earth-based materials and the potentials and obstacles they provide. First, a systematic understanding of the earth-based building techniques is set forth through traditional, contemporary, and innovative perspectives. In this context, the background, development process, and future of robotic and digital fabrication technologies used with earth-based materials are examined following the footprints of existing applications. The potentials and disadvantages are then defined for future studies focusing on digital production techniques of earth-based building materials. In conclusion, the research reveals the capabilities of advanced digital processes within earth-based construction to produce cost-effective, self-constructed, sustainable design solutions by combining innovative digital fabrication techniques with local traditional materials.

Keywords: Earth-based building material, digital fabrication, robotic fabrication, 3D printing, construction technology

1. INTRODUCTION

Earth has long been the most common building material used in the regions with hot-dry and temperate climatic conditions. Even today, one-third of the world's population lives in earthen buildings, which is higher in developing countries [1]. It has proven that it is challenging to meet the significant housing needs of emerging economies with industrial building materials such as brick, concrete, and steel or with industrialized construction methods. However, the earth is the most abundant natural building material and is found almost everywhere. It is often taken directly from the construction sites by gathering from excavation works.

Architects and engineers are slowly transferring to digitally controlled production processes that provide options for achieving the required efficiency and complexity of the building form [2]. Since the 1980s, the term "digital fabrication" has been used in the construction industry [3]. However, in the last decade, the use of digital manufacturing technologies in the construction sector has increased by leaps and bounds. In general, digital manufacturing processes in construction include four main methods, which are subtractive, additive, formative, and assembly. Additive manufacturing technologies, mainly three-dimensional (3D) printing and robotic fabrication, are becoming increasingly popular in modern industries. They offer a wide range of applications together with technical and environmental benefits for various industries [4]. Studies have shown that a well-developed digital/automated process can significantly benefit the construction industry by increasing planning flexibility and productivity [5]. The construction industry is researching and developing digital manufacturing processes for large buildings and building components to benefit from these features. Today, the competition to build a fully automated construction process continues [6]. Some museums and galleries worldwide showcase digitally fabricated prototypes of full-scale building components, furnishings, and structures. Some universities and companies are also rapidly developing 3D printing processes to build full- size structures.

The construction industry is responsible for over 40% of global energy consumption and greenhouse gas emissions. Moreover, 50% of the raw materials processed worldwide are used in construction, while cement production is responsible for 5-8% of global CO_2 emissions [6]. These facts have created an urgent need to reduce the environmental impact of modern construction, which has led scientists to research alternative and more sustainable building materials. This research trend has caused the discovery and use of earthen building materials as alternatives to cement-based construction, which is associated with high CO_2 emissions, high energy use, and the depletion of natural resources resulting from their use. Unlike concrete, earth-based materials are usually a combination of earth and water, mixed with fibers occasionally, which have considerable thermal mass, resulting in efficient passive thermal performance [7]. Earth-based building materials are also much cheaper than other typical building materials such as concrete and masonry. However, earthen building materials are becoming less common in modern construction as concrete offers greater strength, faster construction methods, and is less labor-intensive. While concrete, timber, and masonry construction methods are undergoing a revolution with the development of digital manufacturing techniques such as 3D printing and robotic fabrication, earthen construction remains one of the least explored construction methods [8]. However, significant environmental benefits can be achieved by integrating digital manufacturing processes with earth-based building materials.

This research aims to recapitulate and analyze the current state of research on the digital fabrication of earthen structures, focusing on fabrication techniques as sustainable building methods. It also intends to provide a better understanding of the challenges that hinder the process of introducing this new construction method on an industrial scale. The paper begins by providing the basic knowledge of the traditional and contemporary earth-based construction techniques. Then selected case studies are examined within the context of innovative robotic fabrication approaches. Finally, a brief analysis for future studies is set forth to construct earth-based materials such as adobe, cob, and rammed earth through innovative applications. The outcomes of this research will help to fill knowledge gaps and provide essential information for the effective use of earth-based materials and digital processes in future construction. It is also aspired to encourage stakeholders to make better-informed decisions and explore further research and implementation of other digital techniques in the buildings.

2. TRADITIONAL EARTH-BASED CONSTRUCTION

Earthen architecture, as a subset of vernacular architecture, is a building style based on local materials, requirements, and the skills of local builders, in which buildings are constructed from a combination of earth and water and occasionally organic fiber [9]. Earth materials have been used in construction by following these basics for thousands of years. Earth-based construction incorporates various approaches. The main differences between these approaches lie in the combinations of materials and the characteristics of the building process [10]. The most applicable classification is based on the distinction between wet and dry compaction methods for producing earth-based mixtures and shaping the geometries [11].

The wet compaction approach explains the preparation of earth mixtures in a plastic state with a relatively high moisture content to increase mechanical strength through curing and compaction during the drying and shrinking processes until the appropriate moisture content is reached. For the dry compaction method, the earth mixture is put at the optimal proctor water content, and mechanical strength is given by compaction densification. The wet approach is used for adobe bricks, clay plaster, and cob, while compacted earth blocks and rammed earth components are produced using the dry approach [11].

Earth-based materials increase sustainability due to the relatively low energy input in material production and construction processes. Some studies have shown that most earth-based building techniques have relatively lower embodied energy than typical building materials such as concrete and masonry [12]. Indoor thermal comfort is another energy-saving property. Due to their considerable thermal mass, earthen buildings have long been thermally efficient, resulting in a delayed temperature cycle from the outdoor to the indoor environment [13].

3. CONTEMPORARY EARTH-BASED CONSTRUCTION

A modern building must have excellent quality in terms of detail, precision, workmanship, and repeatability. Therefore, the building process should benefit from the latest technological advances in equipment and materials [14]. Contemporary earthen buildings can be divided into two categories based on their construction methods. In the first category, modern mechanical machines powered by fuel or electricity are used in the construction process for material handling, mixing, pumping, casting, pressing, and mold making. Around the world, there are new examples of earthen buildings that meet the modern criteria described, where the construction process uses modern technology and the building offers excellent quality, increased performance, and up-to-date aesthetics [8]. Digitally fabricated earth-based construction is the second type of contemporary earthen construction. It involves the use of one or more digital fabrication techniques. The use of digital fabrication techniques in construction has increased over the last 20 years due to the search for more complex forms with less labor-intensive and faster construction processes [2]. In general, digital manufacturing processes can be divided into two categories as two-dimensional (2D) and three-dimensional (3D) [3]. 2D includes cutting technologies such as laser and waterjet nozzles, where the mechanical motion of the cutting head nozzle involves biaxial motion. 3D manufacturing processes are divided into four types: additive, subtractive, shaping, and assembly.

The use of digital fabrication techniques in modern construction, mainly automated manufacturing technologies, offers three key sustainability benefits [6]. First, material and resource efficiency in the manufacturing process is improved, with 25-60% material reductions and 30% time savings compared to conventional production methods. Secondly, it increases the predicted service life of the product as maintenance and renovation become easier than as it is in traditional construction. Third, it improves value chains by making production and supply networks simpler, shorter, and more local. On the other hand, the realization of these benefits depends primarily on the size and complexity of the construction project [15]. For small and/or simple projects, traditional construction methods are superior to digital approaches in terms of cost and even environmental efficiency. The innovative digital construction industry is enthusiastically shifting to cement-based practices, backed by leading cement manufacturers [15]. Combining digital manufacturing processes with earth-based materials allows for the sustainable and clean production of an alternative to compete with or replace some of the digital construction market share currently held by cement-based products [16]. While digital technologies typically promise to reduce the environmental impact of construction, the use of cement/concrete always harms the environment and thus the sustainability of future development.

4. EARTH-BASED CONSTRUCTION WITH DIGITAL FABRICATION

Integrating local natural materials into digital building processes was first proposed in 2004. The contour-making technique, now known as 3D printing, is also introduced simultaneously [17]. Numerous ideas have been developed for dwellings that can be manufactured remotely and autonomously using 3D printing technology and locally available materials. 3D printing technology is capable of producing both structural components and finishing. This novel technology was deemed suitable for construction on Earth and even on the Moon or Mars. Using 3D printing technology for space exploration emerged in 2010 [18]. The feasibility of 3D printing lunar regolith has been investigated to build future lunar habitats. Ash from the Bolsena volcano in Italy was used to create a facsimile of lunar regolith on Earth. The potential of these applications and the demand for more ecologically sound building materials have led other scientists to explore the digital fabrication of local natural materials in detail [19]. The recent studies on earth-based construction with digital fabrication have focused on clay, sand, adobe/cob, and rammed earth. The digital fabrication techniques developed for the earthen buildings differ depending on the manufacturing technique and formulation of the material mixtures.

4.1. CLAY

Clay has gained much focus in 3D printing applications for many years compared to other earth-based mixtures. The rheological properties which increase the controllability of the 3D printing process of the wet clay mix have caused that concern. Clay is also easy to obtain locally, easy to mix, and does not necessitate the use of a complicated 3D printing technology. With nozzle diameters as tiny as 4 mm, it may be utilized for small and big scale 3D printing applications. While some of the early attempts at clay printing were not for building purposes, the first reported project of 3D clay printing for construction purposes was performed by WASP, a 3D printer developer company, in 2014, which utilized red clay obtained on-site in the town of Ait, India [20]. Later, TerraPerforma was introduced in 2017 by the researchers from the Institute of Advanced Architecture of Catalonia (IAAC), which was constructed as a full-scale 3D printing clay wall, as shown in Fig. 1. The wall was divided into small modular blocks of 3D-printed clay,which took a modular approach to the construction. After assembly, the blocks were parametrically developed and adjusted to give high thermal performance and structural integrity [21].

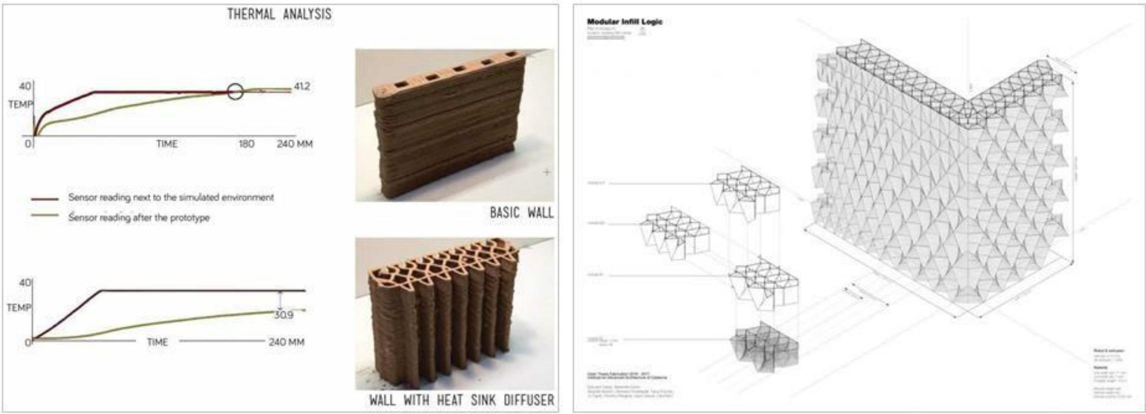

Figure 1. TerraPerforma [21].

Whereas prior research on clay manufacture has concentrated on 3D printing techniques, the Gramazio Kohler research group at ETH revealed two distinct ways of digital clay production. The first initiative, known as Remote Material Deposition, constructed building structures in situ, as shown in Fig. 2. (left), by robotically releasing brick-sized clay pieces in pre-calculated trajectories at specific mounting sites. This concept sought to give a less limited digital assembly process, but it confronts significant problems in terms of controllability over on-site environmentalchanges. The Clay Dome was the second project, as shown in Fig. 2. (right), and it was a cylindricalconstruction with an 11-meter diameter and a 5-meter height. The building was made up of 30.000soft clay bricks that were 15 cm tall and 9 cm in diameter. An on-site mobile robotic system was employed to gather the bricks one by one from a pickup station and then push them to the exact defined spot to construct successive layers [22].

Figure 2. Remote Material Deposition project (left) and the Clay Dome project (right) [22].

4.2. SAND

In 2012, a group of students from IAAC created a portable in situ robotic 3D sand and earth printing technology. The sand was the first earth substance to go through on-site manufacturing technologies. While the 3D printing machine was fueled by solar energy gathered from portable photovoltaic panels, the material was obtained on-site in a completely sustainable manner. Figure 3 (left) depicts the Solar Sinter project in Egypt and Morocco, which provided a new way for additive manufacture of sand utilizing solar sintering [23]. Another example, The Stone Spray Robot project, sought to develop ecologically friendly and effective methods of printing buildings in 3D using raw materials. This 3D printing technology generates geometry by mixing natural sand with liquid binders and spraying it directly onto the building platform through a customized nozzle [24]. The sprayed mixture solidifies rapidly as it accumulates on the print surface, forming successive layers that create the desired design, as shown in Fig. 3. (right).

Figure 3. Solar sintering of sand (left) [23] and stone spray robot (right) [24].

4.3. ADOBE/COB

The wet approach for the soil formation is used with adobe, cob, and clay. The fiber content added to the soil mixture distinguishes adobe and cob from clay. Adding organic fibers to the soil mixture, such as rice or wheat straw, increases the mechanical characteristics of earth walls, resulting in better thermal and structural performances. Traditionally, mud-brick and cob mixturesare made using comparable elements such as earth, straw, and water. The primary distinction between adobe and cob is that adobe refers to the construction of earthen walls using sun-dried earth bricks. In contrast, a cob is a technique that refers to the construction of monolithic earthen walls using flexible moist earth blocks [11]. However, a survey of the literature on the digital fabrication of earth-based materials reveals that the names adobe and cob are used interchangeablyin the context of the 3D printing process to reflect the same construction method. The researchersfrom the IAAC produced a prototype following the footprints of the adobe technique. They constructed an earthen wall with an embedded stair to further investigate the load-bearing potentialof 3D printing adobe. IAAC's wall prototype has a complicated cross-section design to support interlocking wooden parts that operate as stairs and floor constructions, as shown in Fig. 4. [25].

Figure 4. 3D printing adobe wall with built-in staircase [25].

4.4. RAMMED EARTH

There are few examples of mechanized rammed earth buildings compared to clay, adobe, and cob. Even though compacted soil provides superior structural performance compared to alternative earth-based systems, the dry nature of the building process and the requirement for formwork make experimentation with automation more challenging [10]. Lehm Ton Erde LLC, an Austrian company, established the first known method for mechanizing the production process of rammed earth in 2015 [26]. They employed an automated technology for earth distribution and compaction within the formwork to produce prefabricated rammed earth walls. Another method for producing rammed earth walls uses a fully automated robotic manufacturing process [27]. The fundamental building principle is similar to naturally compacted soil, in which mold and rammers are used to compress the soil mixture into consecutive layers, as shown in Fig. 5. The tamper and die are combined to produce a semi-closed cell controlled by the robotic arm. A collaborative feeding system applies a layer of soil mix along the wall course before the robotic tamper cell does compaction [8]. Compared to conventional compacted soil techniques, this automated technique seeks to give more accuracy, higher quality, and cost savings [27].

Figure 5. Robotic rammed earth production [27].

CONCLUSION

There has been significant progress in combining earth-based construction and new technologies in recent years. Previous works, prototypes, and projects in this area demonstrate the great potential of earth-based construction as an innovative method with numerous environmental and economic benefits. However, traditional /contemporary and digital fabrication applications of earthen building techniques have similarities and differences in materials, equipment, labor, and techniques, as shown in Table 1. Although these similarities and differences both have potentials and drawbacks, with a noticeable increase in the adoption rate of digital fabrication techniques in recent years, ongoing and planned works are expected to bring better solutions to currentchallenges by using these potentials.

Technique \ Technology	Traditional/Contemporary Applications			Digital Fabrication Applications			
	Adobe	**Cob**	**Rammed earth**	**Clay**	**Sand**	**Adobe/Cob**	**Rammed Earth**
Material	earth, fibrous organic material (straw or dung), water	earth, fibrous organic material (straw), lime, water	earth, aggregates (gravel, sand, silt), clay	clay, fibers, water	sand, water	clay, water	earth, clay, sand, gravel, stabilizer
Equipment	hand tools			3D printer and robots			robots
	molds		molds				
Labor	manpower-based			automation-based			
Technique	wet compaction		dry compaction	wet compaction			dry compaction

Table 1. Comparison of earth-based traditional/contemporary and digital fabrication applications.

This research focuses on digital fabrication techniques for earthen building construction and the potentials and obstacles they offer. Digital fabrication techniques and technologies are becoming increasingly crucial for the production processes, and robotic manufacturing has shown promise for expanding design. A new understanding of construction is spreading rapidly, driven by the goal of combining low-cost and sustainable materials with the emerging digital construction sector. This new perspective incorporates local knowledge as the basis for current digital innovations. Over the past decade, the development of digitally-produced earthen buildings has succeeded in unlocking the potential of earthen structures and expanding the scope of digital manufacturing in construction beyond cement-based materials. The collective work has provided a roadmap for bringing digital earth engineering closer to an industrial scale and closing the gap between earth engineering and modern digital practice. Highlighting the potentials and challenges impeding progress in this area is critical to establishing a strong framework for the future development of digital fabrication. The detailed exploration and standardization of terms in this research aim to bridge knowledge gaps between different areas of study and provide crucial and coherent information for improved future use of digital approaches in earth construction.

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35- Evaluation of Adobe Materials in Rural Architecture in Kırklareli

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ABSTRACT

Adobe material is the oldest building material used from the first settlements of the earth to the present day. It has been used for many years because it is easy to process, easily accessible, and has a structure compatible with human health. With industrialization, the use of adobe materials began to decrease. Especially, the production of materials with higher strength properties by firing the soil such as brick can be shown as an important factor for this decrease. Brick material has provided construction of multi-story, durable, and relatively more aesthetic masonry structures compared to mud-brick material and have partially replaced adobe. It is not possible to construct adobe structures that could respond to the requirements of today's big cities, but mud-brick structures still exist in small towns and villages. Adobe material deserves to be re-evaluated since it is environmentally friendly and harmless to human health. For this purpose, a field study was conducted that could be a source for the use of adobe material not only for structural purposes but also for insulation, coating, etc. purposes. Within this scope, the rural residences of Kırklareli, which has the highest surface area among the three provinces in the Thrace Region and has different characteristics with its geographical location, were chosen as the study area. In rural houses in Kırklareli, adobe, stone, and wood construction techniques were used together. According to the geographical locations of the settlements, the houses in plain villages are made of adobe, the houses in forest villages are wood, and the houses in the villages between the plains and forest villages are stone. In some settlements, there are mixed construction techniques in which these techniques are used together. In this study, the adobe material used for different purposes in the houses was identified and analyzed. The use of adobe in various building elements, as well as how and for what purpose, has been investigated. Thus, it is aimed to produce an alternative to the use of adobe material in today's buildings. It is expected that the study will contribute to the production of soil-based building components/elements of adobe material, and it will be explained with examples that adobe material has a much wider usage area compared to its alternatives.

Keywords: Adobe material, Kırklareli rural houses, adobe building, building materials

1. INTRODUCTION

Adobe material has been utilized as a building material since the dawn of civilization. The 90-meter-high Etemaniki Ziggurat tower in Babylon is composed of mud brick. In addition, adobe was used to construct the palaces and dwellings of the entire Urartu civilization, the palace walls of the Lydian king Croesus, and the tomb of Mausolus, King of Caria, in Bodrum, which is one of the world's seven wonders [1]. In Anatolian geography, the first examples of adobe use can be found in a variety of villages. The Neolithic Age Çayönü Hill near Diyarbakır Ergani, the Çatalhöyük in the southeast of Konya, the Hacılar Tumulus in the southwest of Burdur, the Chalcolithic Age Alacahöyük in Çorum, the Aşıklıhöyük near Aksaray, and the adobe-walled

Çayönü Hill near Diyarbakır Ergani. Today, we can observe the usage of adobe in rural areas for different purposes. Rural dwellings and their annexes made of adobe are widespread in practically every region of our country. However, adobe buildings are more widespread in Central Anatolia, Eastern Anatolia, and Southeastern Anatolia in comparison to Marmara and Aegean regions. Adobe houses can still be seen throughout the Aegean and Marmara regions, though they are not as common as they once were. In the Mediterranean region, adobe is commonly utilized as a construction material, for example in rural settlements in the Antalya plains and Çukurova [2].

One of the reasons for the common usage of adobe material is its ecological advantages. The heat conductivity of adobe material is calculated to be 0.40 kcal/m°C, which is lower than that of alternative materials [3]. The thermal insulation feature allows buildings to use less energy throughout their operation, reducing pollution caused by energy use. Similarly, when the humidity in the space increases, the adobe material quickly absorbs the extra moisture, and when the humidity lowers, it releases moisture from its body. As a result, the moisture balance inside the constructions made of mudbrick material is always appropriate for human health [4].

Mudbrick is the primary building material in historic Ergene basin buildings in the Thrace region. Mudbrick has lost its role in the load-bearing system in mountainous and forested places such as the Yıldız Mountains, where alternative building elements have taken their place. The use of mudbrick in rural buildings in the Thrace Region was determined and analyzed in this study from an ecological perspective. Field research was conducted to document the building elements and the usage areas of the adobe material were documented. Also, the determined mudbrick material utilization patterns were assessed from an ecological perspective. The information gathered is expected to guide the use of adobe material in modern buildings.

2. RESEARCH AREA

The study was conducted in the province of Kırklareli in the Thrace Region, which contains a variety of topographical and microclimatic variables as well as traditional construction techniques. Kırklareli is located between 41° 14' and 42° 00' north latitudes and 26° 53' and 23° 23' east longitudes in the Marmara Region's Istranca (Yıldız) Mountains and Ergene Plain parts. The north and east are mountainous and forested at an altitude of 203 meters above sea level, while the rest is mostly flat land. With its general appearance, Kırklareli does not reveal a plain perspective; its north and northeast sides are obstructed by the Yıldız (Istranca) mountains, which reach northwest and southwest. These mountains have the highest peak of 1030 meters; however, it is just 250 meters high. By spreading out over a high ridge, it reaches an elevation of 750 meters. A dominant perspective is formed by the Ergene plain and the low plateaus connecting it to the Yıldız Mountains [5,6].

The climates of the Marmara, Danube, and Black Sea are all represented at Kırklareli. Although various climates have a reciprocal influence, one of them can occasionally become dominant and make its presence felt. In the northeastern region of the Yıldız Mountains, the effect of the Black Sea climate is noticeable. The effect of the Danube and Aegean climates may be noticed in the western and southwestern regions of these mountains. The interior areas of the country, far from the sea, have a continental climate [6]. The Thrace Region is a site where severe cold, snowfall, and freezing events occur in the winter due to its location at the crossing point of cold airwaves originating from the Balkans. The mountains and hills along Thrace's Black Sea coast, the mountains to the south, and the Saros Bay area are all forested to some extent. Many parts of the Ergene boat in the middle are also agricultural areas, as are the majority of the southern coastal districts (Figure 1) [7].

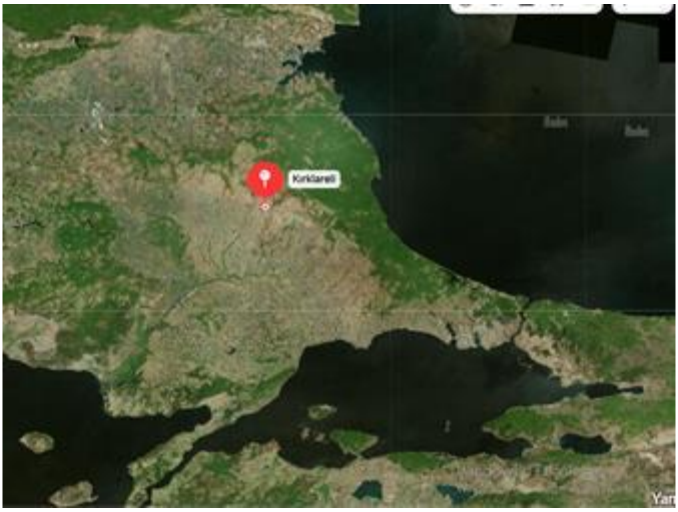

Figure 1. Satellite view of the location of Thrace Region and Kırklareli

3. USE OF ADOBE MATERIAL IN KIRKLARELİ RURAL ARCHITECTURE

The traditional buildings were constructed by using earth material in the Ergene Plain region of Kırklareli, while the buildings in the mountainous forest area in the Yıldız Mountains region are constructed with wood and stone. However, the stone material was only used in the construction system in the plateaus area in the transition zone between the Ergene Plain and the Yıldız Mountains. Adobe material was employed in all these construction systems, though for different goals and ways. The use of adobe material in building elements are examined in this part, as well as the advantages of the usage of adobe material.

3.1. THE APPLICATION OF ADOBE IN THE CONSTRUCTION OF A LOAD-BEARING MASONRY WALL

Masonry mud-brick walls are made of stone up to the foundation level so as not to be affected by water and humidity. Adobe walls with a thickness of at least 50 cm produce an impermeable barrier with a high thermal insulation value, reducing energy losses and gains via the outer shell (Figure 2). The front facade walls and partition walls of certain structures constructed with the adobe masonry technique are formed of adobe bricks between timber-framed skeletons.

Figure 2. Adobe masonry wall examples

3.2. COMBINATION OF ADOBE WITH DIFFERENT MATERIALS ON LOAD-BEARING WALLS

The masonry and some timber-framed walls could be composed of different materials. On the external side of an adobe masonry wall, for example, brick material is utilized because it is more resistant to atmospheric impacts such as water and humidity. Similarly, in the case of the masonry wall supported by a timber-framed skeleton, the stone was utilized on the exterior and mudbrick on the interior (Figure 3, 4).

Figure 3. Adobe block - brick layered masonry application (Brick outside, use of mudbrick inside); Figure 4. Adobe block - brick layered masonry application (Brick outside, use of mud-brick inside)

3.3. USAGE OF ADOBE AS INFILL MATERIAL ON A TIMBER-FRAMED SKELETON WALL

In Kırklareli's rural architecture, adobe infill is extensively employed in timber-framed buildings. The north façade of some buildings was preserved by thicker walls different from the other façades, contrary to Anatolian geography, and the outward-facing half was rebuilt with bricks. Mudbrick was preferred inside of the walls because it has a better thermal insulation value than brick (Figure 5, 6).

Figure 5. Filling adobe blocks on a timber-framed skeleton wall; Figure 6. Filling adobe blocks with brick blocks on a timber-framed skeleton wall

Filling mortar is another application of adobe material in the timber-framed skeleton system. Between timber-framed skeletons, adobe material was utilized as filler mortar between brick, stone, or branch knitting (wattle and daub) applications (Figure 7).

Figure 7. The use of adobe mortar between the stone, brick, wattle, and daub filling on the timber-framed skeleton wall.

3.4. USAGE OF ADOBE AS INSULATION MATERIAL IN A TIMBER MASONRY WALL

Since the thermal insulation provided by only timber material was deemed insufficient, and to prevent possible air leaks from the joints between timber elements, 2-3 cm diameter tree branches were driven diagonally from the inside of the wall, and the spaces between tree branches and tops were filled with adobe mortar in the timber masonry buildings in the region. As a result, the wall received a higher level of insulation while also obtaining a flat surface that could be whitewashed (Figure 8).

Figure 8. Views of the timber masonry wall from the outside and inside

3.5. USAGE OF ADOBE AS TIMBER FLOORING, CEILINGS, AND ROOFS

On the mezzanine and ceiling floor, mud-brick plaster, and coating: Tree branches position alongside each other and between the floor beams, so this system provides significant thermal insulation. The upper part of the tree branches is coated with a thick layer of soil (5 cm above the floor), while the bottom of the branches is coated with a thin layer (1.5–2 cm in thickness). Usage of adobe as a thick plaster layer provides the formation of a hot-contact floor covered with compressed soil. In some structures, carpets, rugs, and other floor coverings are not installed on these types of floors, but rather left uncovered. Thus, the flooring stores heat and return it within the specified time frame. Most of the mezzanine flooring system is made of beams with tree branches covered with earth; this allows the mezzanine floor to benefit from the soil's heat-holding capacity. As with the mezzanine floors, ceiling floors were made by covered floor beams with tree branches with mud mortar from the bottom and top. As a result, the basic principle of the floor system design was to produce a heat-impermeable layer (Figure 9, 10).

Figure 9. Top and bottom views of the ceiling

Figure 10. Adobe coating on timber flooring at the mezzanine level

Use of adobe on roof surfaces: Adobe bed plate is created on the roofs of some houses both to prevent thermal insulation problems that may occur due to the lack of ceiling tiles and to lay the tile cover more easily. The adobe bedplate is composed of more frequent perpendicular branches laying on the roof trusses. The adobe mortar covers the adjacent branches to form a flat surface of equal thickness. The tile is put on the top of the adobe mortar. This provides both good insulations also a smooth platform for installing tiles by leveling the tops of the tree branches beneath the tile (Figure 11).

Figure 11. Applications of plastered and unplastered roof surfaces from below

3.6. THE USE OF ADOBE AS A PLASTER MATERIAL FOR CEILINGS AND WALLS

Adobe was used as inner and external plasters in timber, stone, and adobe structures. The plaster thickness is thicker in the walls in comparison to ceiling tiles (Figures 11, 12, 13).

Figure 11. Adobe plaster on a wall; Figure 12. Adobe plaster on the ceiling

Figure 13. The Baghdadi wall is being filled and plastered with adobe mortar

CONCLUSION

Mudbrick was utilized in all building parts in Kırklareli rural architecture, from the foundation to the roof. The qualities of adobe material are the fundamental reason for this preference. It's utilized for thermal insulation on floors and ceilings, for example, under the roof tile cover. Another reason for the common usage of adobe is its simple to obtain and process. Adobe is made by mixing straw and other materials into clay soils from habitation areas. It is simple to process and apply, and it's also simple to make. These features indicate that adobe is commonly used with minimal processing and has a low energy content. Furthermore, because they are obtained entirely locally, none or very little transportation energy is consumed.

Many other building materials are either inappropriate for recycling or have a limited capacity to be recycled. However, adobe material can be pulverized and reused at the finish of the usage phase, or it can be mixed with the soil over time to continue its natural cycle.

Considering the above-mentioned characteristics, adobe is regarded as an environmentally friendly and ecologically friendly material. The adobe material, which has numerous advantages over other building materials, could not be used in new projects due to the proliferation of contemporary building materials and was regarded as an archaic and primitive substance. The usage of adobe, which has important ecological properties in the field of sustainability design, is regarded to be leading the way that adobe is brought back onto the agenda. The information presented here can be used in the search for alternative building materials. Experimental research can be used to create adobe-based walls, floor panels, and other structures.

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36- Investigation of rural adobe houses for determining principlesof earthquake-resistant designs

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ABSTRACT

Adobe blocks are one of the most well-known and commonly used construction components. In the world and Turkey, adobe is widely used, particularly in rural areas. The adobe rural houses were designed based on the experiences of local people in time. Risk factors in the region, especially earthquake experiences, had given way to various plan and facade geometries, wall types, etc. Adobe construction has various advantages, like as good thermal and acoustic properties, in addition to its low cost and simple building process. On the other hand, they are prone to natural disasters such as earthquakes, rain, and floods. Traditional adobe structures withstand lateral loading poorly, resulting in major structural damage or collapse. The study aims to determine the effect of geometry and plan configuration on the resistance of rural adobe masonry houses. Within this scope, adobe masonry houses in different plan organizations in Kırklareli Rural Area, Turkey are documented, the varieties in geometry are determined. Adobe houses in Kırklareli are documented, the plan geometries, position of partition walls, and space forms are examined. Then, the effect of varieties in geometry on the behavior of houses under lateral loading is simulated by non-linear pushover analysis. The method uses a combination of static analysis together with conventional methods of architectural conservation. The work is undertaken in three phases: documentation of the characteristics of the houses; analysis of plan configurations and examination of the analysis results. Displacements and crack-widths under lateral loading are determined depending on the configurations.

The advantages and disadvantages of the varieties in geometry on the behavior of adobe houses are discussed. While designing adobe masonry houses, the key factors to improve the seismic performance of adobe masonry will be determined. Thus, the data gathered from rural houses could be base for the new adobe designs, it will help the organization of the intervals of partition walls, intersecting walls in the plan layout of the adobe houses.

Keywords: Adobe houses, plan configuration, rural, Kırklareli, resistance

1. INTRODUCTION

Adobe blocks are one of the most well-known and commonly used construction components. In the world and Turkey, adobe is widely used, particularly in rural areas. The adobe rural houses were designed based on the experiences of local people at the time. Risk factors in the region, especially earthquake experiences, had given way to various plan and facade geometries, wall types, etc. Adobe construction has various advantages, like as good thermal and acoustic properties, in addition to its low cost and simple building process. On the other hand, they are prone to natural disasters such as earthquakes, rain, and floods. Traditional adobe structures withstand lateral loading poorly, resulting in major structural damage or collapse.

To evaluate the resistance of adobe houses, experimental [1-5] and computational methodologies could be preferred [6-10]. In a computer environment, seismic analyses can be done by nonlinear static pushover analysis [11,12] and nonlinear dynamic time history analysis. Both approaches are effective in determining the structural seismic response such as crack formation and displacement. However, the usage of nonlinear dynamic time history analysis in engineering practice is complicated and requires a high level of computing cost, time, and labor. Nonlinear static (pushover) analysis is commonly used in the assessment of structural resistance [6].

In computational methodologies, continuum finite element models [13-19] and discrete element models [20-21] have been used. The finite element models and block-based models were used for the nonlinear pushover analysis. In the nonlinear static pushover approach, the examined structure's seismic behavior is generalized as an equivalent single-degree-of-freedom system. The seismic response of the structure must be dominated by a single-mode. A pushover analysis consists of applying the gravity load and lateral loads and pushing the structure under the load pattern. Depending on the application method of the lateral loads, the pushover analysis can be classified as monotonic or cyclic [6].

The study aims to determine the effect of plan configuration on the resistance of rural adobe masonry houses by nonlinear static pushover analyses. This study presents a pushover analysis of adobe masonry structures: adobe houses with a foundation on grade, adobe masonry walls, and a timber roof. Within this scope, adobe masonry houses in different plan organizations in Kırklareli Rural Area, Turkey are documented, and the varieties in geometry are determined. House types with different plan layouts and space divisions were selected and analyzed to understand the effect of geometry on the strength of adobe houses. The adobe houses in the rural area of Kırklareli were examined and grouped and 4 types with different characteristics were determined. 2 types are square, and 2 types are rectangular planned.

2. METHODOLOGY

Plan layout of the adobe rural houses in Kırklareli is documented, and the position of the partition walls and space forms are examined. Then, the effect of varieties in geometry on the behavior of houses under lateral loading is simulated by non-linear static pushover analysis. Analyses of the one-storied adobe houses were done by using the Diana Fea. The work is undertaken in three phases: documentation of the characteristics of the houses; analysis of plan configurations and examination of the analysis results.

2.1. DESCRIPTION OF THE ADOBE HOUSES

The adobe houses were grouped according to their plan geometries and the positions of the cross walls, and 4 types were determined to be examined. While determining the types, first, the general plan layout was taken into consideration. Two plan types are approximately square (type1: 650x750 cm; type4: 970x790 cm), while the other two types (type 2: 790x500 cm, type 3: 420x1320cm) are rectangular. In rectangular planned types, cross-walls divided the plan scheme into square-shaped interior spaces (395x400; 450x420 cm). In type 2, which has a nearly square plan, the entrance part is separated by a porch (*sundurma*), and the interior spaces are divided into two rectangular planned (550x375 cm). Unlike other types, type 4 does not have a symmetrical organization. The space was divided into three inner spaces. The form of the spaces is different from each other. There is a long, thin rectangular space not supported by any cross walls (Fig.1;

Type 4).

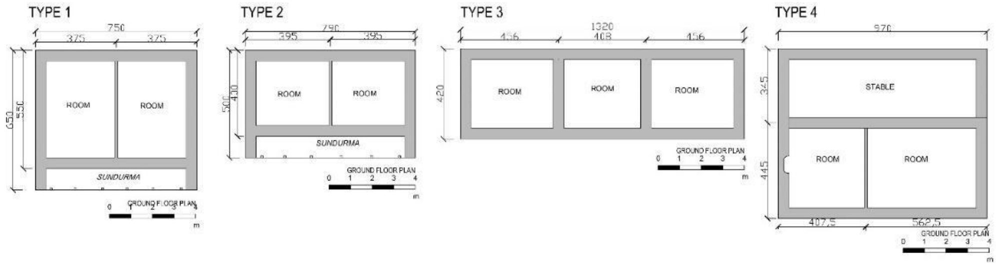

Figure 1. Plan types of adobe houses

2.2. ANALYSIS

The nonlinear static pushover analyses of one-storied adobe houses were done by using the Diana Fea software. Adobe houses with different plan types are modeled with a foundation on grade, adobe masonry walls, and a timber roof. In Diana Fea, a three-dimensional continuum model was prepared with solid brick elements. The foundation is 0.5 m thick and supported by an interface that considers the behavior of the soil. The roof's timber beams are rectangular, measuring 0.2 m in height and 0.05 m in width. The thickness of the timber roof plate is 0.18 m. Nonlinear pushover analysis is performed till collapse. The results for the phase just before divergence are collected using the near-collapse output tool. The modal parameters of the model are identified through eigenvalue analysis. The initial eigenvalue analysis was performed to learn about the behavior of the buildings, as is a standard technique for earthquake simulations. The eigenvalue analysis is carried out by solving the structure's motion equations under free vibration. Analysis results provide a direct view of the structural dynamic qualities and can be used in further investigations [6-10]. Five different computation modes have been identified. The structural nonlinear analysis includes self-weight and pushover load. The pushover load is increased until the house falls from the X direction. The pushover load is applied in 1000 increments with a factor of 5. Arc length control was used to trace the route of response till failure. In this study, only the first mode of Eigenvalue analysis was studied for pushover analysis. The Secant (Quasi-Newton) approach was used for the equilibrium iteration procedure with a maximum of 50 iterations since it has a decreased chance of underestimating the stiffness [Table 1].

Load step	Self-weight	10
	Monotonic pushover	1000 (5 mm per step)
Iteration method	Max number of iterations	50
	Iteration method	Regular Newton Raphson

Table 1. The procedure of monotonic pushover analysis

2.3. MATERIAL PROPERTIES

The material properties used in the model are listed in Table 1 [5, 22]. Diana Engineering Masonry model was used. In this material model, the tensile strength, compressive strength, and fracture energies related to the direction normal to the bed joints were taken into consideration [Table 2]. The Young's modulus in both head-joint and bed-joint directions, compressive strength, and shear properties of the adobe masonry are obtained from the experiments that were carried out by Porto, et. al. [5].

A boundary interface was added to the bottom of the model. Coulomb Friction model was used. The element class was selected as structural planar interfaces. The interface symbolizes the contact between the foundation and the soil, and the houses can slide over the supports. For the mesh, the element size was 0.3 m for the roof plate and beams the walls and the foundation.

Adobe masonry bricks [5]		
Young modulus (bed joint direction)	3.0E+9	N/m^2
Young modules (orthogonal to bed joint direction)	6.0E+9	N/m^2
Shear modulus	1.875E+9	N/m^2
Mass density	1.85E+3	Kg/m^3
Head-joint failure type-diagonal stair-case cracks		
Bed joint tensile strength	0.15E+6	N/m^2
Fracture energy in tension	35	N/m^2
The angle between diagonal stepped crack and bed joint	0.54	radian
Compressive strength	8.0E+6	N/m^2
Fracture energy in compression	5.0E+3	N/m
Factor to strain at the compressive strength	4	
Unloading factor	0.8	
Friction angle	0.64	radian
Cohesion	0.4E+6	
Fracture energy shear	20	N/m
Stone for foundation [22]		
Young modulus	6.7E+10	N/m^2
Poissons' ratio	0.25	
Mass density	2600	Kg/m^3
Timber for roof plate [22]		
Young modulus	9.0E+9	N/m^2
Poissons' ratio	0.15	
Mass density	2.5E+3	Kg/m^3
Timber for roof plate [22]		
Young modulus Ex	9.0e+9	N/m^3
Young modulus Ey	9.0e+9	N/m^3
Young modulus Ez	9.0e+9	N/m^3
Poissons' ratio	0.3	
Shear modulus Gzy	4.0E+6	N/m^3
Shear modulus Gyz	5.0+E+8	N/m^3
Shear modulus Gxz	5.0+E+8	N/m^3
Mass density	3000	Kg/m^3
Soil interface [22]		
Normal stiffness	1.0E+8	N/m^3
Shear stiffness	1.0E+6	N/m^3
Cohesion	1.0E+6	N/m^2
Friction angle	0.52	rad
Dilatancy angle	0.10	rad

Table 2. Material properties

3. RESULTS

The results from the eigenvalue analysis were compared with total displacements DtXYZ for the first mode and the five determined eigenfrequencies. The modal properties and mode shapes of each numerical model are presented in Fig. 2. The fundamental mode shows the vibration of the whole structure in the z-direction. Bending of the roofs in the z-direction was seen. On the other hand, type 4 with wide wall lengths has more deflection on the floor.

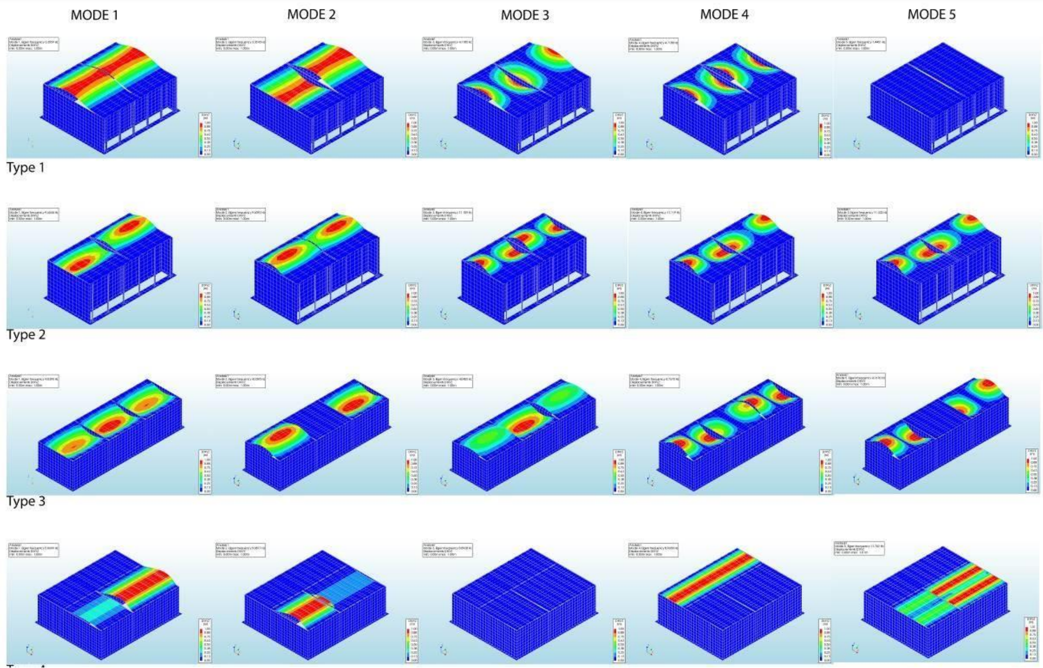

Figure 2. Result of eigenvalue analysis

In Figure 3, the color maps of total displacements and crack widths in the X direction for failure were shown. The crack width was shown in max layers of the walls at the failure state. In type 1, analysis diverges in load step 28 and the peak load factor is 6.0918. The maximum horizontal displacement is 0.58 m. The maximum crack width was calculated as 0.53 m. Rocking failure was seen; the house is overturning. Diagonal cracks were seen at in-plane walls and horizontal cracks were seen at out-of-plane walls. Rocking failure was seen, and the house is overturning. Diagonal cracks were seen at in-plane walls and horizontal cracks were seen at out-of-plane walls. In type 2, analysis diverges in load step 26 and the peak load factor is 1.7951. The maximum horizontal displacement is 0.23 m. The maximum crack width was calculated as 0.37 m. The cracks were seen on the upper parts of the walls. In type 3, analysis diverges in load step 216 and the peak load factor is 150.26. The maximum horizontal displacement is 0.19 m. The maximum crack width was calculated as 0.25 m. Horizontal cracks were seen at out-of-plane and in-plane walls. Due to the bending of the out-of-plane walls, the in-plane walls were deflected. In type 4, analysis diverges in load step 393 and the peak load factor is 85734. The maximum horizontal displacement is 3.34 m. The maximum crack width was calculated as 1.32 m. Bending was seen on out-of-plane walls, and diagonal cracks have been seen on the walls near the corners.

	Displacement (m)	Crackwidth (m)
Type 1	0.53	0.58
Type 2	0.18	0.33
Type 3	0.19	0.25
Type 4	3.34	1.32

Table 3. Results of the pushover analysis of adobe house types

The wall length exceeds 5 meters in type 1 and types 4. In these examples, it was observed that the long walls deflected. In Type 4, since the longwall cannot be supported by a cross wall, it is seen that there are serious displacements and cracks in the long wall. The diagonal cracks at in- plane walls and horizontal cracks at out-of-plane walls caused deflection of the long walls. In type3, which has a rectangular plan with a long side of 1320 cm, the crack-width and displacement are smaller in comparison to type 4 (970x790). The cross wall, dividing into spaces at equal intervals, has increased the resistance of the long wall. Therefore, the displacement and cracks of type 2 and type 3, which are divided into square spaces, are smaller than types 1 and 4.

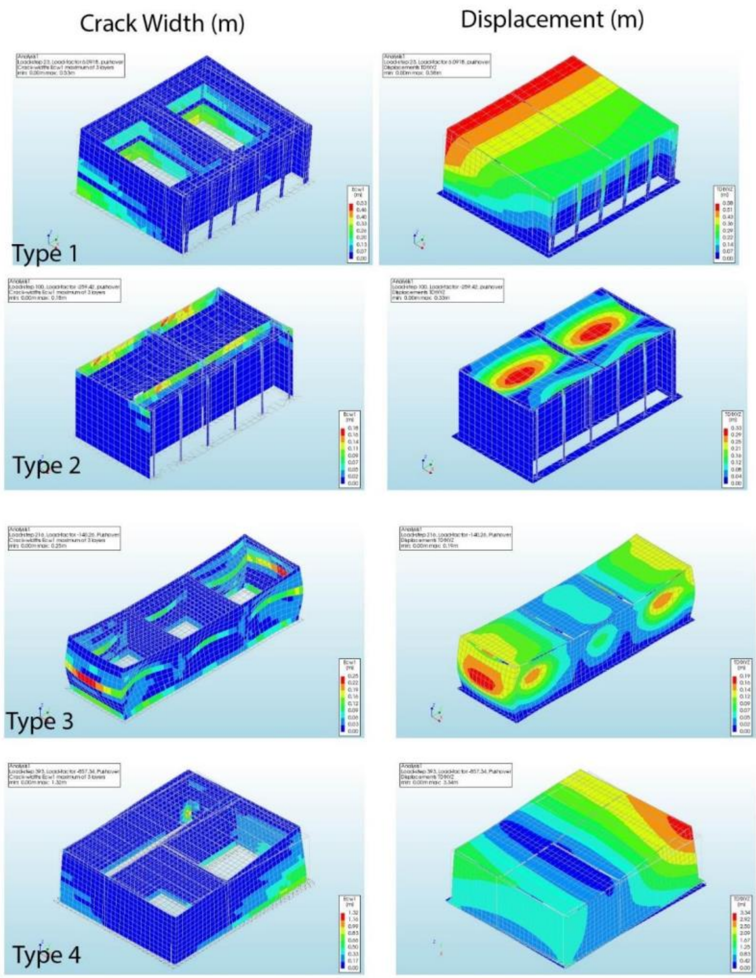

Figure 3. Total displacements and crack-width

It was observed that there were no serious cracks and displacements in the walls below 5 meters in length. The wall thickness of the houses is 45 cm and cracks and deflections have started to appear on the walls longer than 500 cm. This shows that the walls that are shorter than 10 times the wall thickness are more durable, and it has been observed that the spaces that are square-planned prevent cracks.

CONCLUSION

The study determines the effect of plan configurations on the resistance of rural adobe houses. Both plan layout and geometry of the inner spaces are evaluated in the analysis. It has been seen that the factor that is effective in the behavior is the plan configuration formed by the cross-walls rather than the general plan layout. The strength of the houses with a rectangular plan divided into equal spaces by their partitions is higher than square planned houses. The diagonal cracks at in-plane walls and horizontal cracks at out-of-plane walls cause detachment in the long walls not supported by cross walls. There were no serious cracks and displacements in the walls below 5 meters in length. Thus, when reinforcing existing historical adobe houses and designing new adobe houses, the walls should be supported with cross walls at equal intervals. A squat house with a regular, compact design with frequent cross-walls is the safest construction style for adobe masonry. Crossing walls at regular intervals in both directions should be planned. An unsupported wall length should not exceed 10 times the thickness of the wall. Also, long walls should be strengthened with different techniques such as fiber-reinforced polymer composites, steel wire meshes, etc. In further studies, the reinforcement techniques will be planned to analyze to sustain the integrity of the long adobe walls.

In future studies, plan configurations with different openings and roof types, etc. will be aimed to be evaluated.

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37- Masonry Construction Education with Workshops for Architecture Students: Cube-Sugar Instead of Stone, Glue Instead of Mortar

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ABSTRACT

Rules for masonry structures made of stone, brick or briquette are described in many disaster regulations. It is necessary to comply with many rules such as not forming vertical joints, having a certain amount of fullness, static support of the walls, minimum support lengths and wall thicknesses in T or L-shaped joints. Instead of making architecture students memorize all these rules, setting up workshops where they can experience masonry construction has great benefits in ensuring permanence in education. It is possible to experience masonry construction by preparing scaled and impressive models with the help of using glue instead of mortar and sugar cubes to represent these masonry materials. For this purpose, in the 6-year period from 2013 to 2018, a total of 8 workshops were held in scientific organizations in different cities of Turkey. "Sugar Tower" in Dokuz Eylul University Faculty of Architecture in 2013, "Sugar-Sophia" in ISTYAM in 2013, "Sugar Tower-II" in Gebze Institute of Technology in 2013, in 2014 "Sugar Tower-III" in Köyceğiz Architecture Students Meeting, "Sugar Apollon" in Didim in 2015, "Sugar Smyrna" in İzmir Chamber of Architects in 2016, "Sugar Maiden's Castle" at Mersin Science Festival in 2016, "Şekerden Anıtkabir" model workshops were held at the Mersin Science Festival in 2018. The purpose of this study is the sharing of the experiences gained in these workshops and the contribution made to the education of the students in a scientific symposium. Within the scope of the paper, the aims of these workshops, which are held chronologically, the findings and the results, are shared. This study takes part the themes of the conference as 'Traditional construction techniques'.

Keywords: Architectural education, masonry construction rules, masonry construction education, model with cube-sugars

1. INTRODUCTION

In many architecture departments in Turkey, the rules of the masonry construction method, which is one of the traditional construction methods, are explained in the construction lessons of the 1st year. In the Disaster and Earthquake Regulations issued on different dates, these rules and restrictions that should be observed are mentioned. It includes many rules as the wall thickness should be at least 50 cm when stone material is used, 24 cm in case of brick material, L-shaped outer corners should be filled at least 150 cm from the axis, at least 100 cm fill between two gaps in T-joints, load-bearing walls should be maximum 5.5 every meter with support walls, if no support wall is used doing a maximum of 4 meters reinforced concrete vertical beam, masonry structures can be built with maximum 2 floors, the walls are flattened with horizontal beams every 1.5 meters, the door and window gaps on the facade do not exceed a certain rate, preventing the formation of vertical joints, using lintels or arches on door and window spaces [1]. After transferring this theoretical knowledge to architecture students, practical studies are carried out to enable students to draw different architectural projects using this knowledge. However, it is observed that students cannot easily internalize this information and cannot imagine it in three dimensions. The method of making three-dimensional models and eliminating the observed problems in facilitating the understanding of the subject is a method frequently applied especially in architecture schools.

Model, in the most general sense, is a scaled-down version of large-sized objects; in architecture, it can be defined as a three-dimensional prototype prepared before the building is built. In Hasol's book "Ansiklopedik Mimarlık Sözlüğü" published in 2010, the model that has passed into our language from the French word maquette; "A small-scale three-dimensional example of a building as an existing or designed model, a model." briefly explained [2]. It is thought that this definition, which can be accepted as correct in terms of architecture, may be incomplete for some professions and in some other cases. For example, the scale used in models of some objects, living things or organs that we cannot see with the naked eye should not be small, but large. In Akgün's book "Mimari Maketler", published in 2003, he described the model with an explanation in the form of "Even if the designer thinks in three dimensions, he puts all his determinations on paper or on the screen in two dimensions. He does not yet know what kind of three-dimensional architectural reality he will encounter while starting the application, or rather the construction. For this reason, if he works by making a three-dimensional but reduced model of the space he imagines, parallel to the drawing from the beginning of the design, he will be able to see it more concretely. This is what we call an architectural model" [3]. The model enables to construct what appears in the mind in an abstract and blurry way, somewhat intuitively, in a three-dimensional way, and simultaneously appeals to the visual and tactile senses. Therefore, it is a frequently used tool to trigger exploration by doing in architectural education [4].

Architectural education is an applied and difficult education based on the master-apprentice relationship. Just as the apprentice, who traditionally starts working with the master, completes a certain process by trial and error and becomes a journeyman and becomes a master when he gains more experience, architecture students live their apprenticeship period with the lecturers and graduate from the university as a journeyman., In addition to the professional architects in the market, they rise to the master level in time with their work experiences.

No publications have been found in the literature suggesting that sugar cubes are used as model material and that these models can help explain the rules of masonry construction to students. Therefore, the subject of this paper is quite original.

Demonstrating the experience of constructing a masonry building in practice by the mason at the construction site and asking architecture students to build some walls will be very useful for internalizing the subject. However, it can be physically challenging and intimidating for students who are anatomically incompetent to carry building components such as stones, bricks and briquettes and to produce components such as adobe at the construction site. In addition, it is no longer possible to find areas where we implement such structures in cities. The idea of transferring masonry building rules was tried with different method for the first time in 2013 at Dokuz Eylül University Faculty of Architecture. This method is to organize a workshop for architecture students who have not made a three-dimensional design before, who are trying to experience the two-dimensional drawings of the three-dimensional structure in plan and cross-section for the first time, and where they can both enjoy and reach the final product in three dimensions. Instead of heavy materials such as stone, brick and briquette, cube sugar, which is a cheap, light and easily available material; Instead of adhesive mortar, models of the buildings were made in accordance with the exact masonry construction rules, using solvent-based adhesives that can be easily found in every stationery store.

Within the scope of the paper, the experiences gained in the workshops held with different architecture students in different cities of Turkey during the 6-year period from 2013 to 2018 are included. In each new workshop, the model making technique was advanced one more step and quite impressive works of art were obtained.

The purpose of the study; with the help of workshops we have been conducting in different cities since 2013, it is possible to convey the model making technique developed to teach architecture students about masonry construction methods in a pleasant environment.

Method: It is the transfer of experiences gained in workshops held with architecture students in different events held in different cities in Turkey between 2013-2018. In addition, it is the explanation of the innovations followed in the development process of the model making method together with the use of different types of sugar. With the help of the pre-test at the beginning of the workshop and the post-test at the end of the workshop, the increase in the knowledge level of the students was tried to be determined.

2. STAGES OF WORKSHOP

In order for the workshops to progress in a healthy way, studies are carried out in 4 main stages while they are being built. The first stage is the preparatory stage and it is the most important and difficult stage. At this stage, issues such as which building will be modelled, which event will be held, the number of students required and the construction period are considered in great detail. Preliminary preparation should be made on issues such as the selection of the building to be modelled, the existence of plan and facade drawings, the scale of the model, and it should be determined how many boxes of sugar cubes and how many adhesives the model can be made. By measuring the width and height of the sugar cubes sold in the market, which brand sugar will be used, the drawings of the plan and facade should be prepared in Autocad according to the dimensions of these sugar cubes. The second step is to determine the appropriate place where the model will be made and enough students. The works at this stage are handled by the local authorities in the place where the workshop will be opened. The third stage includes meeting at the workshop, a pre-test application with short questions about the building to be modelled and the model making method, and then the explanation of the rules for the masonry construction system. Then, the students are divided into several groups and it is determined which wall or floorthey will make of the model. Then, the prepared building elements are combined and the model iscompleted. In the fourth and last stage, it is illuminated with led lamps in order to increase the visual effect and show the model in the real colour of the building. At the end of the workshop, the same questions asked in the pre-test are asked again as a post-test and the increase in the knowledge level of the students is tried to be determined.

3. FINDINGS

In the 6-year period from 2013 to 2018, a total of 8 workshops were held in scientific organizations in different cities of Turkey. "Sugar Tower" in Dokuz Eylül University Faculty of Architecture in 2013, "Sugar-Sophia" in ISTYAM in 2013, "Sugar Tower-II" in Gebze Institute of Technology in 2013, in 2014 "Sugar Tower-III" in Köyceğiz Architecture Students Meeting, "Sugar Apollon" in Didim in 2015, "Sugar Smyrna" in İzmir Chamber of Architects in 2016, "Sugar Maiden's Castle" at Mersin Science Festival in 2016, "Şekerden Anıtkabir" model workshops were held at the Mersin Science Festival in 2018.

3.1. SUGAR TOWER

It is a workshop organized within the scope of Architecture Week festivities on May 1, 2013, within the Faculty of Architecture of Dokuz Eylül University. It is a continuation of the workshop called Mega Tower, which was held the previous year. In 2012, models of many buildings in the form of 3D puzzles were made, and in 2013, these models were tried to be made of sugar cubes. 42 students participated in 7 groups of 6 people. The models were completed in about 4 hours. One of the models made belongs to the Parthenon, and the construction process and the final product are shown in the 'Fig. 1'. Due to the short duration of the workshop and the fact that the sugar cube was used as a model material for the first time, the product that came out could not bedetailed. However, it is important because it is a source of inspiration for future workshops. 'Number 100' sanding sheet was used to shape the sugar cubes, and solvent-containing adhesiveswere used as adhesives. Although water-based adhesives are more preferred for health reasons, they cannot be used due to their melting properties of sugar cubes. There was no pre-test and post-test application in this workshop.

Figure 1. Images of the production process and the final product at the Sugar Tower model workshop

3.2. SUGAR SOPHIA

A scaled model of Hagia Sophia was made from sugar cubes in a workshop hosted by the Istanbul Historic Peninsula Application and Research Centre (ISTYAM) on October 1-2, 2013. With the participation of 26 architecture students from four different universities, the model was completed in a 2-day study using 25 boxes of sugar cubes, 5 boxes of brown sugar cubes and 20 pieces of glue. For the filing of the cylindrical minarets, sanding sheet 'Number 100' was used, which was adhered to the wooden wedges. Brown sugar cubes were used for the construction of the minaret with brick material, which was built during the reign of Fatih Sultan Mehmet. Thus, it is stated that it is different from other minarets in terms of colour. In addition, for the first time, a double curvature surface (dome) was tried to be created 'Fig. 2'. In both the pre-test at the beginning of the workshop and the post-test at the end of the workshop, the students were asked questions about Hagia Sophia and making a model with sugar cubes. It was observed that the success rate, which was around 50% in the pre-test, increased to 93% in the post-test.

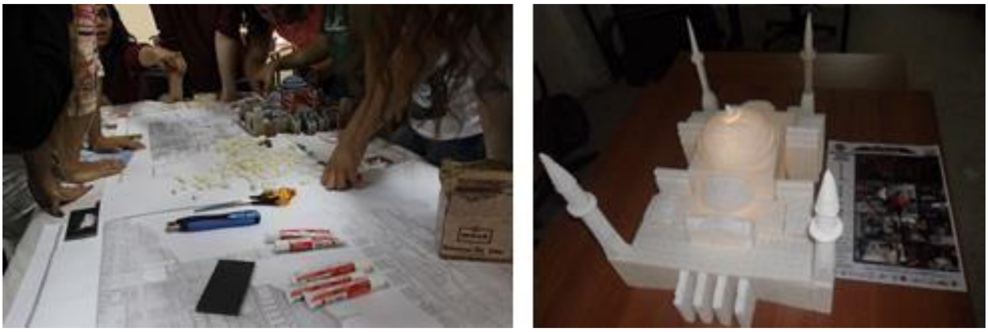

Figure 2 Images of the production process and the final product at the Sugar Sophia model workshop

3.3. SUGAR TOWER-II

It is a one-day workshop held at Gebze Institute of Technology, Faculty of Architecture on November 15, 2013. Together with 30 students from the Faculty of Architecture, models of the Maiden's Tower, Galata Tower and Tower of Pisa were made from sugar cubes. In order to create the cylindrical structure of the Galata Tower and the Leaning Tower of Pisa, each sugar cube was filed in a trapezoidal section and glued with its small edge inward. In addition, it has been observed that the structure is more robust and the stone texture is more realistic in the absence of a continuous vertical joint. As in the previous workshop, brown sugar cubes were used to give the colour of the tile on the roof of the Maiden's Tower. All three models were illuminated with amber coloured LEDs and an impressive appearance was obtained 'Fig. 3'. In both the pre-test at the beginning of the workshop and the post-test at the end of the workshop, the students were asked about the properties of sugar cubes and the structures that were modelled. It was observed that the success rate, which was around 40% in the pre-test, increased to 95% in the post-test.

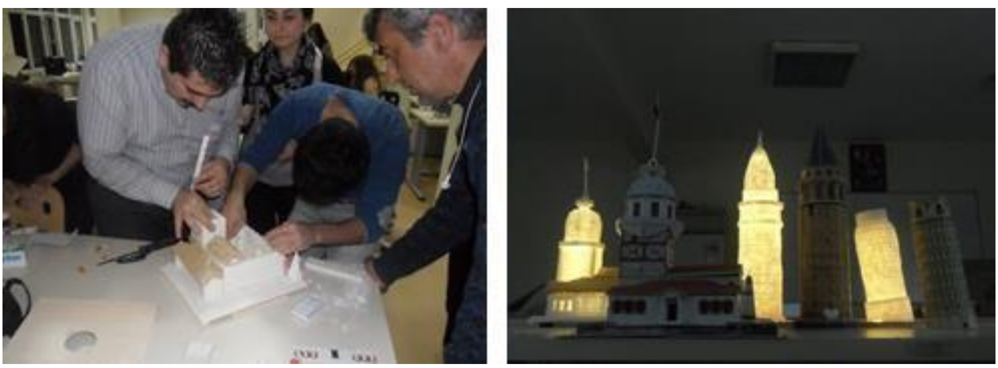

Figure 3 Images of production process and the final product at the Sugar Tower-II model workshop

3.4. SUGAR TOWER-III

A meeting open to undergraduate and graduate students of architecture and interior architecture from all over Turkey took place in Köyceğiz, a charming town of Muğla, between 19-26 June 2014. 70 students from 24 different universities across Turkey participated in the meeting. The theme of the meeting was determined as "Think-Find-Confuse", and workshops, trips to the surrounding area, as well as fun and creative activities were carried out in seven days. One of the workshops organized within the scope of the meeting was the cube sugar model making workshop titled "Sugar Tower-III. The fact that the models planned to be made in this workshop were chosen among the important buildings in Muğla, was preferred primarily in terms of promoting Muğla to both architecture students and local and foreign tourists coming to the city. In this context, it was decided to build scale models of Muğla Clock Tower and Halicarnassus Mausoleum, one of the Seven Wonders of the World, in the workshop attended by 19 students. In the workshop that lasted for 2 days, 4 students made a model of Muğla Clock Tower and 15 students made a model of Halicarnassus Mausoleum. There are 36 columns in the mausoleum and a student was assigned to make these columns so that the handwork does not change. The rams on the pillars are symbolically formed with a sugar cube. Muğla Clock Tower is illuminated with amber LEDs and the Mausoleum is illuminated with blue LEDs. 'Fig 4'. At the beginning of the workshop, they were asked about their expectations from the workshop in the pre-test, and in the post-test, they were asked to share their experiences in the workshop. All students made very interesting inferences. In addition, news about the workshop took place in the local press.

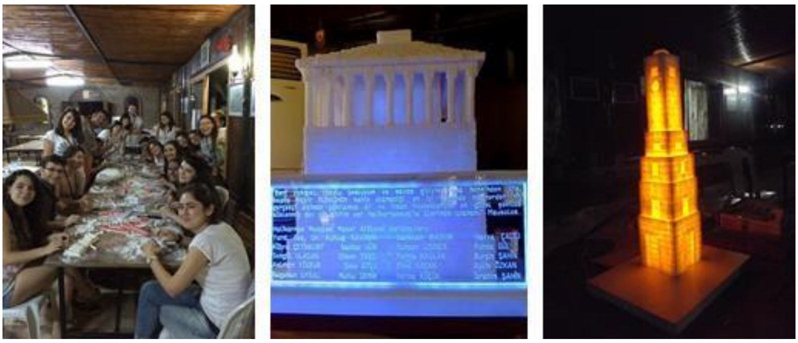

Figure 4. Images of production process and the final product at the Sugar Tower-III model workshop

3.5. SUGAR APOLLON

It is a two days' workshop organized by Didim Municipality on 21-22 November 2015. A model of the Temple of Apollo from sugar cubes was made with 29 students from Dokuz Eylül University Faculty of Architecture. On the first day, a trip to the Temple of Apollo was made and information was given to the students in the well-preserved temple. Afterwards, the task was shared by going to the workshop. Since it is a 1/100 scale model, 40 boxes of sugar cubes and 30 pieces of glue were used. Since the temple has very high walls, the construction of the walls was tried to be completed on the first day and they were dried and hardened until the second day. In order to prevent the architraves on the columns from deflection over time, they are supported against tensile stress with a transparent fishing line. On the second day, a hair dryer was used to accelerate the drying of the glued structural elements. In addition, for the first time, an angle grinder was used to prepare cylindrical columns, greatly increasing the speed of construction. The model is illuminated with blue LEDs, and the interior where the priests are located is illuminated with red LEDs 'Fig.5'. The Sugar-Apollon model is exhibited in Didim Municipality.

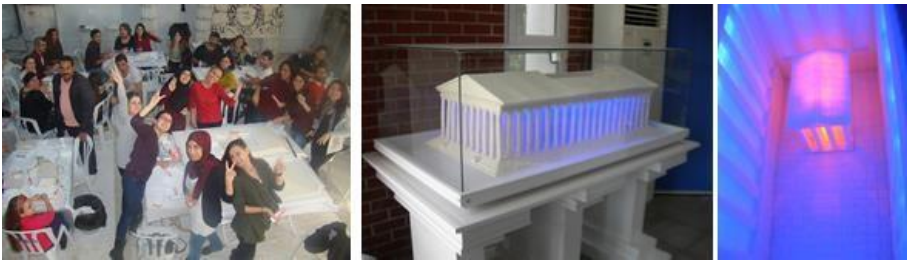

Figure 5. Images of the production process and the final product at the Sugar Apollon model workshop

3.6. SUGAR SMYRNA

It is a two-day workshop organized by the Izmir Branch of the Chamber of Architects on 12-13 March 2016. Together with 30 students from Dokuz Eylül University Architecture Faculty, models of two important buildings, which are the symbols of Izmir, were made from sugar cubes. These structures are the Izmir Clock Tower and the Temple of Artemis. At the beginning of the workshop, a 7-question pre-test was conducted. Then, information about the structures and how tomake a model from sugar were transferred. Izmir Clock Tower was built by two students and 28 students worked on the model of the Temple of Artemis. Since it is a 1/100 scale model, 40 boxesof sugar cubes, 10 boxes of brown sugar cubes and 40 pieces of glue were used. Brown sugar cubes were used to represent the pediments, friezes and decorations on the bases of the 32 columnsat the entrance. The drums of the columns are prominent.

Figure 6. Images of the production process and the final product at the Sugar Smyrna model workshop

Unlike the Temple of Apollo, there is an Artemis Statue in the inner courtyard. Angle grinder was used to file the columns. The model is blue, the Artemis statue inside is illuminated with amber coloured LEDs.'Fig.6.

3.7. SUGAR MAIDEN'S CASTLE

It is a two-day workshop organized as part of the International Mersin Science Festival on September 29-30, 2016. Together with 20 students from Mersin University and 2 students from Dokuz Eylül University Architecture Faculty, a model of the Maiden's Castle, which is the symbol of Mersin, was made from sugar cubes. At the beginning of the workshop, a pre-test with 10 questions was made about the Maiden's Castle and masonry buildings. Then, information was given about the building and how to make a sugar model. Since it is a 1/100 scale model, 30 boxes of sugar cubes and 25 glues were used. The castle is located on an island and is surrounded by rocks. Since the concept is sugar, the counterpart of the rocks in the model is determined as white almond sugar. While forming the walls of the castle, attention was paid to obfuscate the vertical joints. Otherwise, the walls are not durable enough. A very realistic night view is obtained by illuminating the model with amber coloured LEDs.'Fig.7. At the end of the workshop, the post-test application was made and an average of 95% accuracy was achieved. The Maiden's Castle Model is exhibited at Mersin University.

Figure 7. Images of the production process and the final product at the Sugar Maiden's Castle model workshop

3.8. ŞEKERDEN ANITKABIR

The idea of making a sugar model of Anıtkabir in the Anıtkabir garden was a subject that I worked on for many years and matured until the stage of getting permission from the General Staff. When the proposal to hold the workshop in Mersin came from Mersin University, it was accepted by us and a comprehensive study was carried out. It is a four-day workshop organized between September 28 - October 1, 2018 within the scope of the 3rd International Mersin Science Festival supported by TÜBİTAK and Horizon 2020-MERSCIN supported by the European Union. A 1/100 scale model of Anıtkabir was made from sugar cubes with 20 students from Mersin University Faculty of Architecture. At the beginning of the workshop, a pre-test consisting of 12 questions was conducted, including the Anıtkabir and the properties of sugar cubes. After giving information about the building and how to make a sugar model, the students were divided into groups and task sharing was made. 40 boxes of white cube sugar, 40 pieces of glue, 10 boxes of brown cube sugar, 10 boxes of cyanoacrylate glue and 2 packages of coconut sugar were used. All the walls and columns of the building were made with white sugar cubes and illuminated with amber LEDs to give a yellowish travertine colour. The structures around the ceremony area and the roofs of the towers were created with brown sugar cubes.

Figure 8. Images of the production process and the final product at the Şekerden Anıtkabir model workshop

Especially for this model, an image of an Atatürk silhouette and signature was created by people inside the ceremony area. In order to create this silhouette which has never been tried before, with sugar, which is the concept material, a method was developed by experimenting with sugars for about 4 months. In addition, special techniques have been developed for the world's highest flagpole to be located in Anıtkabir and to make this flagpole out of sugar in the model 'Fig.8'. At the end of the workshop, the post-test application was made and an average of 90% accuracy was reached. After the workshop, the Şekerden Anıtkabir Model started to be exhibited permanently in Mersin Atatürk House.

CONCLUSION

Only 8 of the workshops where we tried to teach the construction methods of masonry buildings to architecture students with fun were presented within the scope of the paper. Models of many masonry structures were made in 8 workshops carried out in a 6-year period. Details were not given enough in the first models. Models with continuous vertical joints are very prone to breakage because they do not have enough strength. In the later models, the models became more efficient with methods such as not creating vertical joints, supporting the walls and roof with support walls, supporting the bottom of the beams with fishing line.

The sanding sheets used in the first workshops were later replaced by angle grinders. White cube sugar used as model material was developed in the form of models using brown sugar cubes and even coconut sugar. The technique of making silhouettes with coconut sugar is a unique technique that has been developed with great effort. The resulting products are very impressive. While the column heads in the first models were made of sugar cubes that were not chipped, in the models made in the following years, ram heads could be made with details closer to the real ones.

As the process progressed, very impressive models were obtained by experimenting with the hand tools acquired, the methods developed, and the use of different colours and types of sugars. The latest models were put on permanent exhibition in the city where they were made. In addition, the news about the workshop and the sugar models in the print media arouse the interest of the readers and cause the widespread effect to increase. Although the workshops had to be suspended for a while due to the pandemic that affected the whole world, it is hoped that sugar model making will continue in the new normal process with new dreams, new students and new projects.

In the feedback given by the students at the end of the workshop; there are statements that they had a very enjoyable time, learned by having fun, and are looking forward to attending the next workshop. In addition, although the average success rate in the pre-tests is low, it is observed that the success rate in the post-tests is above 90%. The experiences gained due to the good memories during the workshop take a little more place in the memories and become more permanent.

ACKNOWLEDGMENTS

We would like to thank hundreds of architecture students, whose names I cannot list here, who participated in the sugar model workshops during the process, for their efforts and support.

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38- Earthen architecture and earthquake resistant techniques inItaly: A literature review

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ABSTRACT

Traditional cultures world-wide have put up local strategies to face seismic hazards, by developing endemic earthquake- resistant techniques. Earth construction in South-eastern Europe is not an exception. Specific architectural and structural elements can be identified in all areas of Europe more exposed to earthquakes.

In Italy, especially in the regions of Abruzzi, Piemonte and Calabria, where both earthen and seismic resistant architecture are found together, diverse features were developed empirically by local communities creating a seismic culture that can be appreciated in diverse architectural typologies. Italian seismic vernacular earthen architecture contains valuable cultural knowledge and efficient use of available resources. This must be recognized, learned and transferred to future generations.

Earth, despite being an ancestral material that has forged heritage in the whole world, is burdened with huge prejudices about its fragility, in Italy as in many other seismic countries. The recognition of the wisdom with which it was used might be an important contribution to the preservation and the retrofitting of existing construction, as for the construction of the future and the confrontation with the current climatic crisis.

This work aims to describe and value this constructive culture, showing its diversity, and particularly the seismic intelligence that local cultures have demonstrated trough time. Through the review of data available in literature this paper presents the most common traditional techniques present in Italian vernacular heritage relating it to the traditional seismic cultures around the world.

Keywords: Local seismic cultures, vernacular architecture, earthen techniques

39- Literature Review on Fiber Reinforced Adobe Materials

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ABSTRACT

The use of adobe, a traditional building material, dates back about ten thousand years from today. Mudbrick material is an ecological building material that showing natural and sustainable properties. These environmentally friendly and sustainable features provide a variety of advantages versus contemporary building materials. This material is not harmful for the environment, and it is also completely recyclable. It has superior properties such as low energy usage and low emission rate of harmful gases such as CO_2. On the other hand, adobe has a negative side compared to modern materials. It shows low resistance to water and low compressive strength. Due to these reasons, differences have started in material usage lately.
With the development of the materials industry, adobe ceased to be used in the city, but still used in rural areas due to its economic reasons. Modern materials have produced a unfavorable impact on environmental conditions. The negative effects of these materials on the environment are not only limited to the production process, but also continued during the usage and consumption period. In this perspective, it is possible to consider the use of traditional materials instead of contemporary materials.

Nowadays, research is being conducted in the ''manufacturing and construction sector for materials and technologies'' that expend energy saver and pollution preventer. There is a tendency towards research that combines the positive sides of traditional and contemporary materials. The researcher's interest has turned to traditional materials such as local plant fibers and soil composites. Therefore, efforts should be made to improve the physical properties of adobe materials during the production process. In this study, national and international studies aimed at ''improving the mechanical and physical properties of adobe'' have been investigated. Physical and mechanical differences between traditional adobe and reinforced adobe have been revealed. It is stated that other additives such as lime, gypsum, cement, puzolan and fiber involved in the mudbrick mixture increases the strength values. Chemical additives, on the other hand, can have both positive and negative effects on the material. Natural fibers were considered for this investigation because they are recyclable and have no negative effects on the material structure. With the use of local plant fibers, the development and dissemination of the use of adobe material, which is a sustainable construction material, may be considered.

Keywords: Earthen construction materials, adobe reinforced with fiber, comparative review

1. INTRODUCTION

Today, when the building and construction industry is one of the most critical concerns of our century, with global energy usage responsible for 36% of carbon emissions and energy efficiency accounting for 40% of that, global warming is a severe concern [1]. Furthermore, development and demolition operations disrupt the natural equilibrium of the environment. The need for sustainable, reusable construction materials is increasing in order to reduce the environmental effect of buildings. Earth might be considered a building material in this context.

For ages, adobe has been used as a wall element in various constructions such as homes, barns, and coops. It is an eco friendly and long-lasting construction material. Moreover, adobe is a waste-free and 100% recyclable material. It provides various advantages, including being healthy and cost-effective, being easily produced using local facilities and basic equipment, requiring little energy to create, and releasing no hazardous gases into the atmosphere, like as CO2. Adobe, although being a superior material with several qualities, has a low water and pressure resistance. Because of their low compressive strength and vulnerability to water, traditional bricks have lost its appeal in preference of contemporary construction materials. Despite this, because of its low cost, it is still widely utilized in rural regions.

Currently, research is being performed on sustainable materials and technologies that consume very little energy and emit fewer pollutants when used in the production and building industries. Traditional materials used in pre-industrial times have attracted the researchers' interest, including local vegetable fibers and earth composites. These composites can be produced using locally available fibers or with chemical stabilizers. In this context, research has been carried and is still being done to improve the physical properties of the adobe material used in the manufacturing process. These can be gypsum [2], cement [3], lime [4], fly ash [5], and other chemical stabilizers. Because of the high energy manufacturing process, cement, for example, increases the embodied energy of the building element. It also has a negative impact on recyclability due to the chemical reactions it generates [6]. Thermal properties can also change with lime and cement-based stabilization, according to certain research. The utilization of these stabilizers can cause the structural element's vapor permeability and moisture balance to be disrupted [7]. Chemical additives can have both positive and negative impacts on the material. Soil composites made from vegetable fibers will be investigated in this study since they are recyclable material that do not react chemically with the soil. The research focuses on alternative additives to chemicals in general. Research was conducted on relevant publications in the Science Direct, Researchgate, and Web of Science databases for this purpose. The researchers looked at 20 studies that were take apart from soil-fiber composites created between 2008 and 2022.

2. LITERATURE REVIEWS OF SCIENTIFIC STUDIES

Plant or animal origin fibers can be used to stabilize the soil, although plant origin fibers are preferred since they are more accessible. Because of their inexpensive cost, these fibers are being used more often to produce material composites with improved properties. Additionally, the utilisation of plant fibers results in less contamination of the environment. It's also environmentally friendly and ecology because it's recyclable [8]. The materials produced by this stabilization procedure are also beneficial to human health, and the constructions built from these blocks are likewise comfortable. Researchers have recently focused their attention on fiber-soil composites due to these advantages. Fibers are commonly used in research aimed at improving soil properties: hemp straw [11], fonio straw [12], jute fiber [13], doom fibers [14] red millet, [15], wheat straw [16], kenaf [17] and specific vegetable fibers [18], etc.

Vegetable fiber has been adapted to the soil since ancient times to strengthen its durability and prevent cracking. In the adobe, with organic fiber plant additives, homogeneous and balanced drying takes place. Fractures and shrinkage decreases appear as the stabilizing process progresses. Tensile-stressed fibers prevent drying fractures while simultaneously increasing material cohesiveness (Cohesion / Adhesion). As a result, the material's scructure system is reinforced.

Together with the vegetable fibers utilized, the main features that have a substantial impact on the physical, mechanical, and durability behavior of soil composites are: the type, tensile strength, and durability of the fibers, as well as their length and volume percentage in the composite mixture [10]. The soil-fiber cohesiveness is weakened by water absorption in the adobe.

Fiber Type	Fiber Source (W/BY)	Conducted Studies	Year	Location of Study	Ref
wheat stalk	W/BY	M D	2008	Turkey	[16]
coconut	W	M	2008	India	[19]
straw	W/BY	M D	2010	Italy	[20]
pineapple leaves	W	M D	2011	Malaysia	[21]
oil palm fruit	W/BY	M D	2011	Malaysia	[21]
hibuscus cannabinus	-	M T D	2014	France	[22]
coconut husk Bassage oil palm fruit	W	M D	2014	Ghana	[23]
kenaf	-	M T D	2015	Burkina	[17]
banana fibers	W	M	2016	Egypt	[24]
oat fibers	W/BY	M T H	2016	Portugal	[25]
oat fibers	-	M T	2017	Portugal	[26]
rice husk	W	M D	2017	Iran	[27]
pine needles	-	M	2018	Spain	[28]
wheat straw	W/BY	M T D	2018	Italy	[29]
lavender straw barley straw	W/BY	M T D	2019	France	[30]
fonio	BY	M T D H	2019	France	[12]
red millet	W	M T D	2020	Cameroon	[15]
Straw	-	M	2021	Iraq	[31]
Doum fiber	-	M D H	2022	Morocco	[32]

Table 1. Natural additives and fibers added to soil material are classified according to their qualities. Waste substances (W), by-products (BY), including two states (W/BY), not stated in the article as a source of additives (-). mechanical characteristics (M), durability (D), hygroscopic (H), and thermal properties (T).

Fiber Type	Sample Dimensions (mm)	Fibers (%)	Fiber Length(mm)	Ref
wheat stalk	100x100x100	0.5	50	[16]
coconut	38 dia & 76 high	2.0-2.50	10-30	[19]
straw	310x460x130	0.00-0.75	2.0-8.0	[20]
pineapple leaves	100x100x100	0.25-0.75	10	[21]
oil palm fruit	100x100x100	0.25-0.75	10	[21]
hibuscus cannabinus	295x140x200	0.2-0.8	30-60	[22]
coconot husk	295x140x100	0.2-0.6	50	[23]
Bassage	295x140x100	0.2-0.6	38	[23]
oil palm fruit	295x140x100	0.2-0.6	80	[23]
kenaf	295x140x100	0.2–0.8	30	[17]
banana fibers	240x120x90	0.35	50–60 70–80 90–100	[24]
oat fibers	40x40x160	1.0	10-20	[26]
rice husk	22x22x7 22x11x7	0.3-0.9	-	[28]
pine needles	290x140x100	25	1.42-4.46	[29]
wheat straw	150x150x150	3	-	[30]
lavender straw barley straw	15x15x15 50 mm dia & 50 mm high	3.0-6.0	-	[31]
Fonio	40x40x160	0.2-1.0	20-100	[12]
red millet	100x100x30 40x40x160	0.0-4.0	2.0-5.0	[15]
Straw	240x110x75	2.5-5.0	20-60	[32]
Doum fiber	40x40x50	0.0-2.0	35-40	[33]

Table 2. Physical properties of fibers and methods of producing samples

3. REVIEW AND ANALYSIS

Compressive strengths were investigated using fibers in different combinations with variable straw content and soil from five distinct sources in a study done by Şükrü Yetgin et al (2008). As a result, the effects of varying quantities of fiber (straw) on compressive stress and strength were investigated. Comparisons were also conducted with fiber-free samples, with the findings evaluated against the materials physical qualities. The water content, specific gravity, and tensile ratio of fibrous and non-fibrous adobe samples were evaluated in the context of pressure behavior and strength in the tests. Tensile experiments were also included in these researches. As a result, an attempt was made to formulate a conclusion on the materials' workability and applicability.

The studies revealed that when the adobe content of the fiber increases, so does the tensile, but the compressive strength decreases. The obtained compression test results demonstrate three common features for fibrous specimens:

- Because fibers absorb water, the water content should be raised as the fiber content increases for processability.
- The weight of the sample and hence its strength decreases as the water content rises.
- Plastic tendencies increase as clay content rises. However, because to an increase in fiber content, an early fracture is detected. The material that dries quickly is more brittle.

The following are the findings of compression tests and tensile tests performed on various adobe samples with and without fiber.

- As the fiber content increases, the compressive strength reduces.
- During stress, fibers (straw) having a circular cross section and a hollow structure demonstrated flexibility.
- Fiber level in normal adobe mixes should be managed at around 0.5 percent by weight.
- The rate of shrinkage diminishes as the amount of clay and water in the mixture increases.
- The shrinking rate reduces as the fiber content increases.
- By increasing the fiber content, tensile strength decreases while compressive strength and unit length increase [16].

According to Millogo et al. (2015), kenaf fibers were utilised in the soil stabilization in their investigation. Fibers 30 mm long were prepared and put to the soil mixture at a rate of 0.2-0.8 percent. The prepared soil mixture produced samples sized 29.5x14x10 cm. The mechanical properties of adobe blocks made from a mix of soil and fiber have been examined. The samples compressive strength values range from 0.5 to 3.7 MPa. In blocks with additional fiber at a rate of 0.4 wt%, the compressive strength was obtained to be optimal. The compressive strength increases by 16 percent at this optimal value. Fibers are added to the soil for two main reasons: to prevent fractures during the drying process and to boost the flexural strength of the blocks produced. As a result, flexural and tensile tests should be carried out. The samples flexural strength was measured to be in the range of 0.9-1.9 Mpa. It was revealed that it improves the flexural strength of the fibers as a result of the tests conducted. However, adding more than 0.8 weight percent fiber to the soil can weaken the soil-fiber matrix, resulting in a reduction in strength. Soil blocks that haven't been reinforced with fibers are brittle, but those that have been reinforced with fibers are ductile. The soil's ductile behaviour results in a rigid state in the event of an earthquake, as well as limiting fracture formation. As a result, the fibers retaining the fractures are linked to the increased ductility of the reinforced samples [17].

Ouedraogo et al. (2019) conducted research on the physical, mechanical, thermal, and water impact properties of fonio fiber and soil composites. The by-product foino fiber was added to the soil mixture with a length of no more than 1 cm and a ratio of 0.2-1.0 wt percent. The sampleswere prepare 4x4x16 cm blocks and dried for 21 days. Compressive strength values of 2.3-2.6

Mpa were obtained as a consequence of the tests performed on the samples. The sample series with the greatest strength had a fiber contribution of 0.4 wt percent and a value of 2.6 Mpa. After this ratio, the compressive strength of a series of samples was shown to diminish. In the situation of flexural testing, the strength ranges from 0.3 to 1.3 Mpa. In the series when 0.2 percent wt percent was added, the maximum strength was attained. The flexural strength began to decline once the optimal value was reached. The porosity increased in samples with an excess of fonio fiber input, according to microscopic investigations. The hydrophilic characteristics of the cellulose in the fiber boosted capillary water absorption by up to 0.4 weight percent. The soil-fiber cohesiveness is weakened by water absorption in the adobe. Swelling and curing of the fibers causes pores in the material. The thermal conductivity was observed to decrease with the addition of fiber as a result of the experiments. This is owing to cellulose's insulating properties [12].

In research, Chan (2011) researched at the physical and mechanical qualities of adobe bricks. Two local fibers were added to the soil and water combination in a ratio of 0.25-0.75 percent as additives. The fibers were obtained from pineapple leaves and palm fruit bunches. In addition, a soil of 5-15 percent cement was utilized. Baked and uncooked adobe blocks are among the samples. Experiments were conducted to see how additives affected the physical and biological qualities of adobe blocks. Experiments were used to assess the compressive strength, water absorption amounts, and biological features of the produced samples. Due to the fibers' ability to absorb water, samples with a higher fiber content tended to dry faster. According to the outcomes of the investigations, the best value for cement compressive strength is 0-5 wt percent. The samples exposed to temperature had the maximum compressive strength, whereas the compressive strength of the cement-containing samples declined as the temperature increased [21].

Fiber Type	Fiber Properties			Compressive strength (Mpa)	Flexural strength (Mpa)	Absorption %	Ref
	Length (mm)	Diameter (mm)	Content (wt%)				
wheat straw	50	3	0.72-3.84	0.5-3.7	0.15-0.7		[16]
Kenaf	30	0.13	0.2-0.8	2.3-2.8	0.9-1.9	307	[17]
Fonio	100	0.15	0.2-1.0	2.3-2.6	0.3-1.3		[12]
Pineapple leaves	10		0.25-0.75	2.0-6.0	1.9-3.5		[21]
Palm fruit bunch	10		0.25-0.75	3.0-9.0	2.55-4.6		[21]

Table 3. Physical properties of fibers, strength values of the produced samples and water absorption

CONCLUSION

The purpose of this study is to investigate at the studies that have been conducted on using vegetable fibers to improve soil parameters. Vegetable fibers are added to the material in varied amounts and with varying qualities in the research analyzed. Many of the researches that have been conducted with these fiber additions have focused on the soil' mechanical and thermal qualities. When mechanical characteristics are evaluated, it is observed that the pressure and flexural strength increase to an optimum value with the addition of fiber, but that once this value is reached, the strength data begins to decline. The basic reason for this is that the higher fiber content causes faster water absorption in the material and faster drying of the sample. In the research [21], cement additive was also combined with pineapple leaves and palm fruit bunch fibers. When compared to using only fiber, this has resulted in better results in strengthening the soil' strength qualities. The soil, however, disturbs the moisture balance following the loss of energy in the cement manufacturing process and the contact it makes with the material, which has negative consequences in terms of recyclability and sustainability. While increasing the strength values, it may cause certain drawbacks. Although the use of vegetable fiber in the production of soil dates back to ancient times, scientific research on the subject is relatively new. Work to improve and increase the usage of adobe material that can provide users with comfortable conditions on its own is still being performed and should be conducted. The importance of adobe, which is a cost-effective and ecologically friendly construction material, should be recognized, and its usage should be promoted.

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40- Consolidation a Mud-Brick Tomb against the earthquake: AnExperience from Ardakan, Iran

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ABSTRACT

Mudbrick has been used as a building material in the urban and rural fabrics of many of the hot and dry climate zones of the world. In the architecture of the Central Plateau of Iran, mudbrick has many applications due to its appropriate compatibility, economic benefits, ease, and speed in preparation. An important issue with most mud-brick buildings is their earthquake instability. Recent earthquakes have shown that, in general, unreinforced masonry structures are vulnerable to tensile loads and need to be consolidated. The purpose of this study is to introduce the measures taken to consolidate a historic mud-brick tomb in the city of Ardakan (Iran). This tomb dates back to about 100 years ago and is the burial place of one of a famous cleric's family. The measures taken to conserve this mud-brick building are important because it has been done in full compliance with the construction techniques and materials characteristics of traditional Iranian architecture. These solutions include consolidating mud-brick walls and ceilings with natural date palm fibers and strengthening the structure with wooden beams, which has improved the performance of the building against tensile loads.

Keywords: Consolidation, tombs, mud-brick, earthquake

1. INTRODUCTION

The use of mud-brick materials in the construction of buildings has been common in Iran for centuries and in many cities and most rural areas located in hot and dry areas, mud-brick buildings are the majority of buildings [1]. Experiences gained from past earthquakes have shown the improper and destructive behavior of mud-brick buildings as a result of the earthquake [2].

Ardakan city is located near Yazd-Ardakan fault with an approximate length of 60 km. This fault starts from the north of Yazd city and extends to the north of Ardakan city [3]. According to the historical evidence, the Yazd-Ardakan plain is considered relatively calm from a regional tectonic point of view [4]. However, there is a possibility of an earthquake in this area.

This study aims to introduce conducted measures that have been done to consolidate a mud-brick dome from the experimental point of view. These measures could be considered as examples for similar mud-brick buildings.

2. CASE STUDY

Ardakan 'Fig. 1' is one of the cities of Yazd province in central Iran and with 23,478 km^2 is the largest city in the province. Ardakan city is located at 53° 48' E longitude and 32° 20' N latitude and the average altitude of this city is 1234 meters above sea level [5].

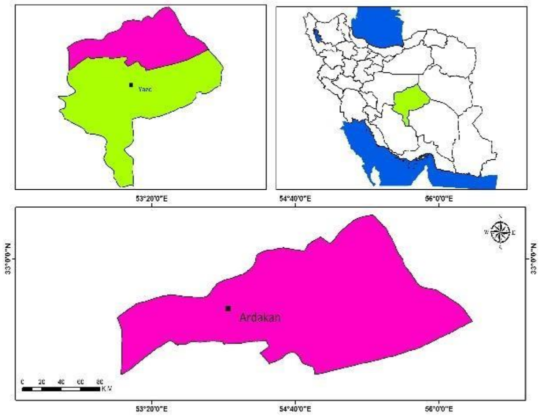

Figure 1. Location of Ardakan in Iran

The studied mud-brick tomb 'Fig. 2' is the burial place of Katami's family, a famous cleric of Ardakan, and it has been built about 100 years ago. The tomb is located in the west of Ardekan cemetery.

Figure 2. Location of the tomb in Ardakan cemetery

3. BUILDING PATHOLOGY

3.1. FOUNDATION

Based on the stratigraphy of the basement of the building, it was revealed that the building does not have a solid limy or stone foundation. Its main reason was the existence of many graves adjacent to the tomb. Since the presence of lime accelerated the corruption of corpses and is not correct according to Islamic law, the architect had to not use the lime. Furthermore, the columns of the building were located on old graves which has led to the looseness and emptiness of the soil under the columns.

3.2. STRUCTURE

As shown in 'Fig. 3', the main columns have drifted due to the lack of a tensile element or backing in two positions, including west and southwest. In other words, the western side has projected more than 10 cm. This drift has caused vertical cracks in the legs of the arches on the north and south sides and dome as shown in 'Figure 4'. Controlling this drift and correcting the geometry should be one of the priorities of the consolidation plan.

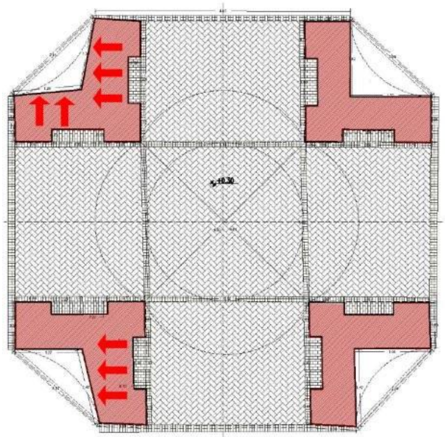

Figure 3. Drift diagram

Figure 4. Cracks in the legs of the arches and under the dome

Hollow spandrels (Konu) have been broken due to drift. They should be removed from the arch surface and reassembled.

3.3. MATERIALS

Most surfaces of the building are covered by a cob layer that has been spoiled in many places due to the presence of termites. This issue has caused the possibility of falling off the eaves on the north as shown in 'Figure 5'.

Figure 5. Possibility of falling off the eaves on the north

The exterior of the building has a 20 cm plinth of brick, which is executed in the form of a porcelain vein brick, and from the inside, square bricks have been added later. The plinth inside the building is very weak and has been damaged in different places as shown in 'Figure 6'.

Figure 6. External and internal plinth

4. PROPOSED CONSOLIDATION PLAN

As mentioned earlier, this building has no foundation. For preventing further subsidence, it is necessary to use vertical wooden piles that connect the structure to the ground. According to 'Figs 7 and 8', eight grooves were created in the eight corners of the building.

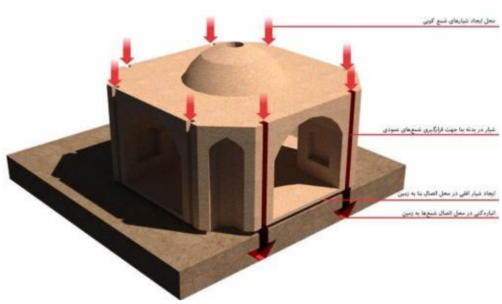

Figure 7. Simulation of vertical load path

Figure 8. Wall grooving

As seen in 'Figure 9', posts were embedded in the eight grooves and dipped into the ground at a depth of 1 meter. Also, a hole for each pier foundation was dug and they were filled with lime mortar. Old electric poles that have high resistance to rot and termites were used as the post. To control the drift, the posts should be jointed in two parallel rings, a plinth beam on the floor level and a tie beam on the roof using wooden beams. This type of joint acts like a tie. Date palm fibers were wrapped around the posts and beams so that they have a better connection with the structure and the joinery, as shown in 'Figure 10'.

Figure 9. Simulation of lateral load path

Figure 10. Embedding the posts in the grooves and jointing them to the beams

The hollow spandrels have been removed from the arch surface and reassembled as shown in 'Figure 11'.

Figure 11. Removing the hollow spandrels and reassembling them

Due to the subsidence, structural cracks had been created in the dome of the tomb. Thus, the dome had to be removed. A new dome was rebuilt with the remaining mud-bricks as shown in 'Figure 12'.

Figure 12. Removing the old dome and rebuilding the new one

In order to integrate the building components, the roof was covered with a net of date palm fibers as seen in 'Figure 13'.

Figure 13. Removing the old dome and rebuilding the new one

To kill the termites, holes were dug into the floor and walls, and then poison was injected into the holes as shown in 'Figure 14'.

Figure 14. Making the holes and injecting the poison

As seen in 'Figure 15', 60 cm plinth was executed using bricks inside and outside the tomb.

Figure 15. Executing plinth inside and outside the tomb

CONCLUSION

This paper was devoted to the conducted measures for consolidating a mud-brick tomb against the earthquake in Ardakan, Iran. Initially, a pathology was carried out to determine the foundation, structure, and material issues. Then, some solutions were considered in response to the problems in accordance with the character of the building as below:

- Using vertical wooden piles to connect the structure to the ground;
- Digging a hole for each pier foundation and filling them with lime mortar;
- Jointing posts in two parallel rings using wooden beams to control the drift;
- Removing the hollow spandrels and reassembling them;
- Removing the old dome and rebuilding the new one;
- Covering the roof with a net of date palm fibers to integrate the building components;
- Making the holes and injecting the poison into the floor and wall to kill the termites;
- Executing plinth inside and outside the tomb.

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41- Yard structure in Safavid and Qajar houses in the historic cityof Yazd with a focus on climate change

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ABSTRACT

This article aims to compare the structure of yards in the Safavid and Qajar houses in the historic city of Yazd, Iran. Its results also demonstrate the similarities and differences between yards in a sub-climate over time. In order to achieve accurate results, the position of the yard in houses is selected the same in both periods, and the yard type is a courtyard. The main question is how climate change has impacted the structure of yards in both periods and what the significant changes are. Therefore, five houses from each period are studied through descriptive and comparative research methods. The yard form, its proportions, depth, elevation, the human field of view, the ratio of closed to open space, the area of greenery and water, its materials, and the color of the yard's wall have been comparatively analyzed. All data has been collected by sketching, field observation, drawing, analytical tables, and graphs. The results show that although the courtyard is a vital element in Safavid and Qajar houses and has a central role in the house's spatial organization, there are also structural differences. In other words, although the same type of yard placement can be found for both periods, the structural differences include differences in height, depth, the field of view to the yard, proportions, percentage of open space in the yard, and yard wall materials are inevitable.

Keywords: Courtyard, Safavid houses, Qajar houses, climate change, Yazd

42- Smart Technologies for the Formation of Landslide Slopes,Odessa

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ABSTRACT

The conscious formation of the anthropogenic landscape of Odessa contributed to the creation of a unique model of sustainable socio-natural development in the first half of the 19th century, oriented towards the future. The problem of slopes is the same age as the city. The territory of the future Odessa had been once steep rocky terrain, dissected by ravines and natural drains. According to geological data, the classic front landslides don't allow the land to come to rest and the process of abrasion will never disappear. Sea transgression causes increased coastal erosion.

The fight against landslides for many years has been carried out in three main areas: 1) protection of slopes from landslides (removal of groundwater using drainage tunnels and drainage galleries), 2) stopping landslides of soil masses (removal of standing rain and underground channels), 3) protection coasts from erosion (building dams). Coastal protection by a breakwater structure was first introduced in Odessa.

The landscaped boulevard slopes with terraces and retaining walls, drainage system of groundwater, based on alluvial port area - this was the first complex of measures on such a grand scale aimed to strengthen the terrain.

Thanks to the competent solution of challenging utility problems - strengthening the lifeless clay cliffs, their improvement, construction of engineering structures - Odessa received its unique "sea" facade and landscaped park already in the first half of the XIX century. Considering adverse environmental factors, a model of sustainable development of the relationship between man and the natural environment was solved, future-oriented

Keywords: Smart technologies, landslide slopes, Odessa

43- Determination of the mechanical and thermal properties of theCompressed Earth Block (BTC) reinforced with plant fibers, namely corn cob

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ABSTRACT

Sustainable development finds its full meaning in the sense that it promotes the use of renewable resources, available in sufficient quantity to meet the diverse needs of a society in the present and in the future. This concept includes social, economic and environmental factors which must all be taken into account because they are decisive in the absolute availability of the resource.
The cob is the part of the maize which bears its seeds and which, after shelling, is thrown away as vegetable waste. Corn is a food grain of the Gramineae family, whose tight kernels on a long cob are rich in sugar and gluten. This plant grown in Africa and around the world whose use of its different parts is varied. Corn was probably domesticated in southern or central Mexico.

In recent years and in the context of the need to use renewable resources, the use of locally available raw materials has literally exploded, particularly in the field of construction. At the originof the research, we find first of all the desire to valorize the corn cob. It is dried and then reducedto a powder whose particle size is determined before use.
It is also a question of appreciating the mechanical and thermal properties of the Compressed Earth Block (BTC) with the reinforcement of vegetable fiber by valuing the cob of corn which is a biodegradable natural product as reinforcement in the manufacture of the ecological BTC which meets the standards. international.

The composite material obtained was characterized mechanically and thermally. The mechanical properties comply with the values of the standards in force. Similarly, the results show that thermal conductivity and diffusivity decrease with the introduction of corn cob flour while effusivity increases.

Keywords: Compressed earth, corn, corn cob flour, mechanical and thermal properties, conductivity

44- Sustainable Architecture and Sustainable Building Elements

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ABSTRACT

Sustainable architecture includes sustainable building elements and systems, sustainable design, and project and construction strategies. Sustainable building elements include materials and technical tools. The basic principle of sustainable architecture can be stated as the minimum use of existing energy resources and the construction of structures that are compatible with nature and do not harm human health. In the field of architecture, some researchers have highlighted the differences between the definitions of sustainable architecture and green architecture. However, most researchers treat these two definitions as interchangeable terms. There are many definitions such as "Green, sustainable, ecological, climate and eco-friendly, high performance, smart,passive, carbon-zero building". The aim of this architectural movement is human respect for nature. Today, there is a risk that future generations will not be able to sustain their lives. In this context, sustainability can be defined as "meeting today's needs without harming the resources thatfuture generations will need" and "transferring today's resources to future generations".

When the definition of "sustainable city" is considered in terms of "livability", we can understand that an increase in the quality of urban life is defined. In this context, one of the most important architectural practices of the 21st century has been the phenomenon of "sustainable city" and "green architecture". With green architecture, the amount of energy consumed in the construction, use, and operation of the building is reduced. The amount of pollution and waste arising from the building is reduced. At the same time, many stages such as sustainable energy use and construction with natural building materials reveal the green architectural feature of these buildings. Another purpose of green architecture is to bring people living in the city closer to nature. Houses, which are one of the important building blocks of traditional and rural architecture, reflect many qualities of green architecture. These structures, in harmony with nature, carry the sustainable features that have been going on for centuries. Within the scope of the study, the definitions of "Sustainability" and "Green Architecture" will be discussed. In addition, the connections between traditional residential architectur and green architectural structures will be investigated.

Keywords: Sustainability, green architecture, traditional housing design criteria

1. INTRODUCTION

The concept of "livable city" has been studied by theorists together with population phenomenon since Plato. In the period of Greek civilization, cities are seen where all the people of the city are together and all decisions can be made together (Sennett, 2011). ,2007:13, Pacione, 2005; Newman and Kenworthy, 1999).

The need for sustainable urban development aimed to protect both the city and single buildings in a common living relationship with their natural surroundings. In this context, to establish sustainable environments, it is necessary to change people's lifestyles, production habits, and resources, and to develop new design approaches on a small or global scale.

Sustainability; social, cultural, economic, ecological, and psychological aspects are interconnected. Many objectives have been determined for the formation of a sustainable city, such as increasing the use of urban resources, reducing solid waste, and increasing the quality of life (Utkutug, 2011; Kıstır and Kurtoğlu, 2008,).

It is possible to see traditional houses as the pioneers of environmentally friendly and sustainable bio-climatic architecture. By examining the characteristics of traditional houses, mistakes made in modern period buildings can be eliminated. How traditional buildings are "intertwined with nature", "how they are built with materials compatible with nature", and "how heat controls are successfully achieved" can only be understood by investigating these structures in detail.

2. SCOPE AND METHOD OF THE STUDY

Scope of work; Green architecture and sustainability concepts and their place in architecture will be discussed. The main objectives of sustainable and green buildings will be determined. The concept of "Green Architecture" seen in Anatolian traditional housing and its sustainability will be discussed.

The aim that is planned to be reached within the scope of the article is to understand the common points of rural and traditional architecture with green and sustainable architecture applied today. In this context, it will be suggested that the determined common points add a new perspective to new architectural designs.

3. SUSTAINABILITY AND GREEN ARCHITECTURE

The basic principle of sustainable architecture can be stated as the minimum use of existing energy resources, the construction of structures that are compatible with nature and do not harm human health (http://ekolojist.net/cevreyle insanla-uyumlu-bir-mimari-bicimi/).

In the field of architecture, some researchers have highlighted the differences between the definitions of sustainable architecture and green architecture (for example, Hengrasmee, 2005; Kwok and Grondzik, 2007). However, most researchers consider these two definitions to be used interchangeably (Chansomsak & Vale, 2008).

The aim of the architectural movement, which appears under many definitions such as "green, sustainable, ecological, climate and environment friendly, high performance, smart, passive, carbon-zero building", is human respect for nature. Today, there is a risk that future generations will not be able to sustain their lives. In this context, sustainability can be defined as "meeting today's needs without harming the resources that future generations will need" and "transferring today's resources to future generations". However, sustainability is defined as a set of social, economic, and environmental principles for the harmony of human generations and ecosystems, on a local and global scale, today and for centuries to come (Utkutuğ, 2011, 2007).

Sustainable architecture includes design and construction methods and building materials that are not harmful to the ecosystem or social environment. This philosophy supports the compliance of the social, economic, and environmental sustainability principles so that today's construction does not have negative consequences for future generations.

Roy (2008) defines green architecture or green design as a design method that reduces harmful effects on human health and the environment. The architect or designer who designs a "green building" uses environmentally friendly building materials and construction practices. It disposes of its waste in a way that supports the protection of nature. It carries out designs to protect the air, water and soil, stone, and living things in natural life. Sustainable architecture includes sustainable building elements and systems, sustainable design, and project and construction strategies. Sustainable building elements include materials and technical tools.

Sustainable design, project, and construction strategies are "site selection and development, transportation effects, various layouts and orientations of the building, reuse, sustainable product and material selections, renewable energy use and energy savings, conservation and renewal of water resources, land, and its surroundings. human health-friendly sustainable approaches such as optimization of the potentials (operation, maintenance, and repair of the building), clean air, human comfort, etc.

This environmental movement, which has become widespread since the 1970s, advanced in the 1980s in the direction of environmental awareness and sustainability as the second wave of environmentalism. In the context of environmental studies of different countries in 1972, the "United Nations Declaration on the Human Environment" was adopted in Stockholm. The term "sustainability" was included in architectural concepts in this process. In the report of the United Nations Environment and Development Commission in 1987, sustainability "meets today's needs" "To meet the needs of future generations without depriving them of their ability to meet their own needs" (Atalan, 2017).

4. ECOLOGICAL DESIGNS IN TRADITIONAL ARCHITECTURE

Green buildings are the whole of the activities and practices to be done with the designs made in this direction to reduce the energy needs of the buildings and to protect the ecological balance. In the designs of ecological and green buildings; "The direction, form, location of the building and its place in other structures, the materials used in the building" are the important factors of the design. At the same time, solar panels and wind turbines to be installed in houses or cities are important energy sources for generating energy, while geothermal energy is an important energy source for home heating. There are many applications such as grass roof or terrace roof application in buildings, collecting rainwater and using it in various areas.
The most important factors in the construction of traditional residential architecture have been the environment, topography, and climate data.

Figure 1. Afyon Bolvadin traditional Houses

The local people, who evaluated the environment, topography, and climatic conditions for years, developed their traditions of construction techniques. Local structures in different techniques and materials have been built in many parts of the world and Anatolia. These structures have different architectural features, such as people speaking different languages. However, there are common features seen in these local structures. Apart from the spaces and areas created by different living cultures, the main features observed can be stated as the physical and ecological harmony of the building with its environment, its functionality, and its aesthetics in harmony with nature.

In general, the features seen in the direction of sustainability in local architecture are as follows:

- Building Design Integrating with Nature and Compliant with Topographical Conditions:

The buildings are shaped according to the organic texture of the streets and the topographic conditions of the city. As we can see in Kula-Manisa, Kütahya, Eskişehir, İzmir Şirince, Uşak or Safranbolu houses, the ground floors were built in parallel with the street texture. With the overhangs made on the upper floors, the square and rectangular form desired to be created in the interior spaces has been achieved.

In the stone-paved streets, rainwater is collected both as it mixes with the soil and in canals collected in the middle of the streets or on the sides. The courtyard layout of traditional houses offers a life intertwined with nature, with trees and plants. The high walls around the courtyard both provide privacy and protect people and animals from the cold and wind.

- Design Based on Climate Data:

Traditional Anatolian Houses are generally oriented to the south. The ground floors of traditional wooden carcass houses in Anatolia were made of stone in a masonry system. The ground floors used as service spaces are approximately 50-60 cm. thick stone walls keep these sections cool. The walls of traditional houses were built entirely of stone, as seen in Mardin, Şanlıurfa, Tarsus, and Aegean Anatolia. Traditional houses are generally built on 2 or 3 floors. Mezzanine floors in traditional three-storey houses were used as living spaces in winter. The use of these floors is effective in reducing heat loss.

The sun, air, and warmth enter the building with the windows of traditional houses extending towards the sun with bay windows. Since the windows are directed to the street and the courtyard in the traditional house, there is no need for artificial ventilation and air conditioning systems.

- Structure of Functionality:

The effective use of space and square or rectangular building design is seen in traditional residences affect functionality and energy efficiency. Similar approaches to traditional houses, such as simple building forms and not having too many spaces, also contribute to functionality and energy efficiency.

The places that needed to be kept cold were located on the ground floor and especially the insulation with stone walls provided the necessary energy savings for the 18th and 19th centuries. However, the fact that the service spaces were together and the living parts were separated provided a functional living opportunity for that period.

The plan types of traditional Anatolian houses are sometimes designed with an inner sofa and sometimes an outer sofa. The windows of the rooms open outwards to the sofas. While the windows in the rooms provide double-sided lighting, they allow different uses according to the function. The outer sofas, seen in the Aegean and Inner Aegean Regions, open to the courtyard. Since the courtyard is both an open and a partially closed section, it appears as a comfortable living space on hot summer and spring days.

The interior sofas and the sustainable designs for this, seen in the traditional house, usually appear in later periods. In the plan types with inner sofas, which are frequently seen in terrestrial climatic regions, the proximity of the spaces to each other draws attention. For this reason, traditional houses with interior sofa plan schemes reflect energy-saving and functionality in designs.

- Use of natural building materials and local construction techniques:

The construction materials used in Anatolia were durable, long-lasting, and easy to construct, implement and repair. In traditional buildings, local stones, bricks, adobe, and wood were used extensively. These materials can sometimes be reused or replaced with a new one. During the production and transportation of these materials, less energy is required.

Since there are no different chemicals in the wood, stone, or soil materials used in traditional Anatolian Houses, it offers a natural environment to people. These structures have been sustainable with their construction materials. It can be reused or replaced with a new one. It does not harm the ecology during its production. In traditional houses, mud brick, which is local material, is often used as a traditional construction material as an economical, recyclable, and harmless material. The fact that these materials (adobe, wood, etc.) breathe and provide thermal insulation reveals the sustainability feature of the traditional house. The damage to the environment and the energy consumed in the construction, use, and sometimes destruction of traditional Anatolian houses have been low.

Figure 2. Afyon Bolvadin traditional Houses

Figure 3. Afyon Bolvadin traditional Houses

5. EVALUATION OF SUSTAINABILITY CRITERIA AND DESIGN PRINCIPLES IN TRADITIONAL ARCHITECTURE TOGETHER

- Saving energy and energy resources

In traditional housing architecture, water and energy resources have been saved. Most of the time, rainwater from the roof was collected or water extracted from the ground was used. The stone and adobe walls in the buildings preserved the heat inside the building and did not let the hot outside air inside. Since traditional life continues collectively, energy consumption has been saved. In traditional life, small cattle or bovine animals, which usually have a few in each house, contributed to the production.

- Green design in building material and construction technique

Anatolian traditional houses have provided energy savings in production and application as they use the construction system and materials of the geography they are in. It has a long life and is durable, renewable, and recyclable. Stones extracted from the local quarries or the environment were used in the building material and construction technique. Wood material was also obtained from trees obtained from the immediate environment. The people who built the building were the masters and architects who lived in the region and knew the living conditions and the material.

Figure 4. Afyon Bolvadin traditional Houses; Figure 5. Afyon Bolvadin traditional Houses

Figure 6. Afyon Bolvadin traditional Houses

- Sustainability of cities and harmony with human scale

The sustainability feature of cities with a traditional texture draws attention. Streets, monumental buildings, residences and spaces, and even the elements and details of the building have been in harmony with the human scale. Due to the technological conditions of the period, the buildings were built with low floors. For this reason, the height of the structures is in harmony with human ergonomics. Streets, monumental buildings, residences, courtyards, and spaces are intertwined with nature.

- Intertwined with nature and user health

Afforestation and landscaping elements are both pleasing to the eye and healthy products can be grown. The users are brought together with the open air and natural environment with spaces such as the courtyard and the open sofa.

- The combination of technology and nature and user comfort

The technology of the period in which the buildings were built and natural materials were used together. While the buildings are being built, the protection of nature is the primary goal.

Especially between the 18th century and the 20th century, energy, materials, materials, goods, etc. Since many elements as such are difficult to find, human and animal garbage, waste, etc. reused or converted.

- Conservation of nature

While the buildings were being built, the protection of nature was the primary goal. By using waste materials collected from the environment or drying trees, the protection of nature was supported while the building was being built

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- Disposal and recycling of garbage and waste

Especially between the 18th century and the 20th century, energy, materials, materials, goods, etc. Since many elements as such are difficult to find, human and animal garbage, waste, etc. reused or converted.

Figure 7. Antalya Kaleiçi traditional Houses

- Good maintenance and consolidation of structures

During the period of use, the buildings were repaired many times and well looked after. The building materials that were removed from the demolition of the buildings could be reused.

- Developing the level of consciousness for the protection of nature

In the 18th, 19th, and 20th centuries, which is the construction process of the traditional house, the relationship between natural life and humans was very high. For this reason, people living in that period made great efforts to protect nature. They have improved their level of consciousness toward the protection of nature.

In the construction process of the traditional house, the wisdom and mastery required to build the building were transferred from generation to generation, while the teaching of respect and protection for nature became the main criterion.

CONCLUSION

Today, the awareness of sustainability is a necessary understanding of life for the survival of humanity. The traditional houses in the Anatolian geography chosen as the research subject are local architectural elements formed by natural, cultural, topographic, and sociological factors. Landforms, climate, and natural materials in Anatolia have created a unique design language by meeting with the social, cultural, and economic structure of Anatolia. The design and sustainable features of these traditional structures and textures, based on ecological balances, carry many features that should be taken as an example.

In general, the following sustainable features and traditional housing bear ecological traces. In traditional housing architecture, water and energy resources have been saved. Anatolian traditional houses have provided energy savings in production and application as they use the construction system and materials of the geography they are in. In the building material and construction technique, materials belonging to the region or obtained from the environment were used. Streets, monumental buildings, residences and spaces, and even the elements and details of the building have been in harmony with the human scale. The height of the structures is in harmony with human ergonomics. Streets, monumental buildings, residences, courtyards, and spaces are intertwined with nature.

Afforestation and landscaping elements are both pleasing to the eye and healthy products can be grown. The technology of the period in which the buildings were built and natural materials were used together. The comfort of the user is ensured with the search for different solutions in minimum spaces. But most importantly, the aim was to protect nature while planning and constructing the buildings.

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45- Considering the Role of Local Building Craftsmen of EarthenArchitecture for Sustainable Development

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ABSTRACT

UNESCO underlines that culture needs to be considered a significant issue in sustainable development. The UNESCO 2003 Convention for the Safeguarding of the Intangible Cultural Heritage, UNESCO Recommendation on the Safeguarding of Traditional Culture and Folklore of 1989, and UNESCO Universal Declaration on Cultural Diversity of 2001 have underscored the importance of intangible cultural heritage as a mainspring of cultural diversity and a guarantee of sustainable development.

The knowledge, skills, and practices of local building craftsmen that have continued in local building tradition in the rural settlements of Anatolia constitute a significant part of intangible cultural heritage. The documentation and transmission of know-how, skills, techniques, and methods of the masters as the practitioners of the building tradition are compulsory for their conservation and the continuity of tradition. Considering 17 goals highlighted within the 2030 Agenda for Sustainable Development published by the United Nations General Assembly in 2015, the continuity of local building tradition is especially significant for providing sustainable development in historic environments throughout the rapid change process and the development of tourism.

In recent years, the traditional building ways, particularly, earthen architecture, have gained importance in the discussions on sustainability; and the number of studies on the use of local building materials in the design of new buildings has noticeably increased. In the publications issued by the World Heritage Center, the availability and economic quality of adobe material is regarded to contribute to sustainable development. Among the risks to earthen architecture, the absence of traditional conservation measures is particularly emphasized. As a result, it is emphasized that earthen constructions require special attention in terms of conservation. The sustainability of the earthen architecture throughout the restorations and new buildings is linked with the transmission of specific knowledge, and skills of master builders related to earthen architecture to the new generations. Therefore, it is necessary to find the living experienced building masters and documentation of their specific knowledge about traditional construction techniques. This study tries to put forward a specific methodology for documentation of the knowledge of local building masters experienced in earthen architecture from Konya. The study uses a mixed methodology composed of architectural and folklore documentation methods, specifically, in-depth interviews, and observation, to document both tangible and intangible aspects of traditional craftsmanship.

Keywords: Earthen architecture, local building craftsmen, traditional construction techniques, traditional craftsmanship, sustainable development, Konya

1. INTRODUCTION

Traditional architecture is a valuable source to discover the ecological and sustainable principles with regard to its inclusion of a variety of nature-friendly designs, the usage of local materials, and the creative building methods of local building masters (Karakul, 2016, 68). Traditional earthen architecture has been constructed in a process through which local building masters have used their specific techniques, know-how, and skills by considering cultural values that survived in local building tradition. The knowledge and practices of building masters and local people on construction, maintenance, renewal and repair, and ornamentation that have continued through the building tradition in historic earthen settlements in Anatolia constitute a significant part of intangible cultural heritage.

In terms of the preservation, repair, and sustainability of traditional buildings, it is critical to understand and develop traditional construction techniques and builders' technical knowledge. In order to carry out applications based on the accurate "technical knowledge" for the protection of cultural heritage, more research on masters who know traditional construction techniques is needed. Starting with this problem, this study tries to learn from traditional builders' technical knowledge, analyzes traditional building technology in a holistic way, and transforms it into information to be used in current conservation studies and restorations. It documents traditional earthen construction techniques and methods in this setting by contacting construction masters still living in Konya and its environs and documenting their knowledge, skills, and behaviors.

The documentation and transmission of know-how, skills, techniques, and methods of the masters as the practitioners of the building tradition are compulsory for their conservation and the continuity of tradition. The UNESCO 2003 Convention, has mainly focused on the measures of its conservation of intangible cultural heritage. While the conservation process of tangible heritage includes documentation, analysis, and preservation measures, the conservation of intangible cultural heritage is intimately linked with its practice and its transmission to new generations [1], besides their documentation. On UNESCO's official website, the decline in the number of practitioners of traditional craftsmanship is recognized as one of the biggest threats to the viability of intangible cultural heritage. In this regard, Article 2.3 of the UNESCO 2003 Convention places "transmission" among the safeguarding measures aiming at ensuring the viability of this heritage. Because the conservation of intangible cultural heritage necessitates the continuous practice and the transmission of the knowledge to future generations, living practitioners need to be identified, and the appropriate ways for practicing need to be provided.

In the United Nations' 42nd General Assembly in 1987, the term "sustainability" was defined as "filling today's requirements without jeopardizing future generations' ability to meet their own needs" (Karakul, 2016, 67). Steele (2005: 6-7) expands on this concept in his thorough research of ecological architecture by breaking it down into eight aspects as resource equity, traditional wisdom, institutional transformation, energy, global community, economics, renewability as well as technology. Traditional wisdom, which can be related to the value of learning from traditional and local architecture, which has arisen out of numerous trial-and-error attempts to cope with nature must be respected to achieve sustainability of traditional architecture.

Considering 17 goals highlighted within the 2030 Agenda for Sustainable Development published by the United Nations General Assembly in 2015, the continuity of local building tradition is especially significant for providing sustainable development in historic environments throughout the rapid change process (UNITED NATIONS, 2015). Considering these goals with the traditional craftsmanship, the continuity of local building tradition and craft production process is especially significant for providing sustainable development in historic environments throughout the rapid change process and the development of tourism (Karakul, 2019c).

In recent years, the traditional building ways, particularly, earthen architecture, have gained importance in the discussions on sustainability; and the number of studies on the use of local building materials in the design of new buildings has noticeably increased. UNESCO WHEAP (World Heritage Programme on Earthen Architecture) [2] strives to improve the protection and management of earthen architecture sites around the world. On the website of WHEAP, it is stated that the earth material's availability and economic quality suggest that it has a lot of potential to help with poverty reduction and sustainable development. Among the risks to earthen architecture, the absence of traditional conservation measures is particularly emphasized. As a result, it is emphasized that earthen constructions require special attention in terms of conservation. Earthen structures deserve special attention in terms of conservation and maintenance because they are increasingly threatened by natural and human impacts. The disappearance of traditional conservation practices is highly emphasized as a threat to adobe architecture.

The sustainability of the earthen architecture throughout the restorations and new buildings is intimately linked with the transmission of specific knowledge, know-how, and skills of master builders to the new generations. Therefore, it is necessary to find the living experienced building masters and documentation of their specific knowledge about traditional construction techniques. So, this study tries to document traditional construction and maintenance techniques of earthen architecture based on the information of the experienced building masters for the conservation and sustainability of earthen architecture. The knowledge of building masters is especially useful for both restorations of traditional buildings and the construction of new buildings made of local building materials to achieve the sustainable development of historical environments.

2. LOCAL BUILDING MASTERS OF EARTHEN ARCHITECTURE IN KONYA

Konya's earthen building culture is so specific as the embodiments of both the practices, knowledge and know-how of local building masters on adobe construction and maintenance techniques. The method used for the documentation of earthen construction techniques is based on literature research and field research. Within the scope of the field research, it is aimed to document the knowledge, skills, and behaviors of traditional building masters, their techniques and methods, tools and equipment, and their reflection on building elements in traditional architecture, architectural elements, decorative elements by using architectural documentation methods and folklore methods together.

Field surveys were carried out in Konya and its surrounding rural settlements, Sarayönü, Kadınhanı, and Hüyük districts and villages in July and August 2017 [3]. Within the scope of field studies, traditional architecture and local construction techniques were examined, and photographic documentation was made. Interviews were carried out with the building masters and local people living in the working areas, and audio recordings were taken to compile information about the technical knowledge and construction techniques they used.

İbrahim Can, Hakkı Dağlı, and Mustafa Küçüksarı, who were the building masters interviewed in the Kadınhanı, Sarayönü, and Hüyük districts, gave detailed information about the traditional building construction processes in their districts. Although the construction systems used in all three settlements are similar, the construction techniques, materials, and tools used vary depending on the region.

İbrahim Can was born in 1959 in Çavuş Village. He is a primary school graduate. He started to work as an apprentice at the age of 12-13 with his father, who was a builder. There are many buildings built by İbrahim Can, who is a farmer as well as a building master in Çavuş Village and nearby villages, and 29 buildings in the village of Sonsuz Şükran, built nearby.

Hakkı Dağlı was born in Ladik in 1952. He is a primary school graduate. He started to work as an apprentice at the age of 13 with his father, who was a builder. Hakki Dağlı, whose grandfather, father and brother are also masters. Working with a team of 4 masters and 4 workers, including his brother and children, Hakkı Dağlı built approximately 50 traditional buildings, schools and mosques and 150-200 new brick structures in Ladik, Sarayönü, Konyadağ and the surrounding villages. Hakkı Dağlı tells that the builders in Ladik completed the construction from the foundation to the roof, and completed all the works except plastering. Hakkı Dağlı has trained 10-12 masters.

Mustafa Küçüksarı was born in 1958 in Kadınhanı. He is a primary school graduate. He started to work as a master at the age of 22, after completing his military service in 1980. He has worked as a farmer, service driver and shepherd in addition to mastery, and, now given up mastery. His elder brother and father are also masters. He has built many buildings in Kadınhanı and Osmancık.

3. KONYA'S EARTHEN ARCHITECTURE

Konya's earthen architecture is a significant resource to discuss sustainability and sustainable development with regard to its inclusion of a variety of nature-friendly designs, the usage of local materials, and the creative building methods of local building masters. According to the information obtained from master builders, the techniques and methods used during the construction and repair of earthen architecture can be investigated to be sustained in restoration and new building processes as specific technical knowledge. The rural settlements studied mostly consist of flat earthen roofs that cover wooden beams and were built using the stone masonry technique and the adobe masonry technique (Karakul, 2019a, 2019b) (Figure 1-3).

3.1. CONSTRUCTION PROCESS OF EARTHEN ARCHITECTURE

Building masters begin the process of traditional building construction by excavating a pit for the foundation walls. Because mud-brick is not water-resistant, the stone is used in the construction of foundation walls, which must be water-resistant, and ground floor walls up to the subbasement level to protect adobe masonry walls from water. The foundation walls of rubble stone are begun to be constructed when the foundation pit is dug at least 60-150 cm below ground level to the point where the hard earth is located, and they are erected up to a height of at least 50 cm from the ground level.

The building masters of earthen architecture construct adobe masonry walls using mud-brick blocks as masonry materials and earth and mortar mixtures as binder materials after digging the foundation pit. Adobe is formed by mixing soil with an organic binder material, such as hay or animal hair, to form blocks that are then dried in the sun. The process of making adobe blocks is divided into three stages: sludge preparation, molding-cutting-casting, and drying.

The external walls of traditional adobe buildings are usually constructed by stone masonry technique up to 50-60 cm height from the ground level. During building up the masonry of the mudbrick walls, the large blocks and small blocks are placed side by side and the gaps between them are filled with mud mixed with the fragments of mud bricks. The wall thicknesses are generally 60 cm with a main and two small adobe blocks and an air gap, and the inner walls are 40 cm with a main and a small adobe block. During the construction of the mudbrick walls, the main and small blocks are placed side by side and the gaps between them are filled with mud mixed with mud bricks.

In the rural environment of Konya, particularly in Hüyük district and its immediate surroundings, in two-story houses, local building masters place wooden pillars under wooden beams, inside an adobe wall to support the structural system of the earth buildings [4]. The timber frame system, which is connected to each other in such a way as to remain standing even when the adobe wall collapses, increases the earthquake resistance of the buildings. The timber frame system, built into the adobe masonry system, is a system in which the pillars made of juniper or poplar wood are placed inside the adobe walls from the floor to the roof and connected with wooden beams at the upper level.

Figure 1. A traditional adobe building in Hüyük

Figure 2. A traditional adobe building in Sarayönü

Figure 3. A traditional adobe building in Bulgurpınarı Village

According to local building masters, during the construction of the flat roofs in the villages inspected in Konya, wooden beams are first placed under the slab beams on the adobe walls (Karakul: 2019a). Depending on the economic position of the host, round wooden beams are placed on them, the mat layer is procured from Beşer, Akşehir, or the surrounding area, and a reed layer is spread on the mat. The soil is put in varying thicknesses depending on the region over the reed layer, and after soaking, either salt or a soil type called *çorak* is applied to restrict water penetration by compressing the soil surface and becoming rugged. After laying salt, the earth layer is compacted by using a cylindrical stone, called *yuvak*.

3.2. MAINTENANCE AND REPAIR PROCESS OF EARTHEN ARCHITECTURE

Regular maintenance is essential for the preservation of adobe buildings, as it is for all historical structures. At regular intervals, the renewal of the mud plaster applied to the wall surface, which is built from the earth and has a lower degree of water resistance than stone and wood, increases the building's life span. The maintenance methods in the traditional earth buildings in the rural environments of Konya, where the investigations were conducted, are a three-stage procedure consisting of the creation of earth plaster by building masters, the application of sludge called *yalabıtma* by local people in Çavuş and Değirmenaltı Villages, and painting.

The first stage of maintenance applications is the application of mud plaster by the building masters as the last stage of the construction process of traditional mudbrick buildings. According to the statements of the building masters [5] in Çavuş Village of Hüyük District, the soil brought from Söğütlüdere Region was mixed with straw and water and then kept on the first day, then mixed from time to time for three days, and then used as a plaster on the fourth day after reaching a normal consistency. It is taken into account that the soil used in the plaster preparation is cored, and the straw used in the mudbrick construction blocks is thinner. Following the completion and drying of the craftsmen's plaster, the peasant women use the sludge plastering technique, which entails soaking the soil in straw and water for three days, relaxing, and trampling [6].

CONCLUSION

In recent years, the adobe construction technique and earthen architecture have gained importance within the discussions of ecological architecture and sustainability; as well as a growing number of research on the use of adobe materials and techniques in new construction. In this regard, traditional earthen architecture in Hüyük, Sarayönü, and Kadınhanı, which is accepted as a significant information resource for identifying rural architectural tradition in the nearby environment of Konya, has been investigated to identify the knowledge, know-how, techniques used by building masters to be used for providing the continuity of the historic environments throughout the restoration and new building activities.

The sustainable development of the historical environments of Konya necessitates the identification and documentation, conservation, and sustainability of traditional construction techniques through new building activities. The adobe building tradition has unique value both as an architectural ornament as well as the way it is implemented in terms of technique, materials, and tools, as intangible cultural heritage to be conserved. From this perspective, earthen building tradition and the related practices of building masters need to be documented and conserved holistically considering its tangible and intangible aspects. In this regard, local building masters' role as practitioners of this building heritage is especially important in achieving sustainable development of historical environments. This study can be performed in other Konya rural settlements to identify and convey master builders' knowledge and practices in the earthen building tradition to future generations and to provide the sustainability of the environment.

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ENDNOTES

[1] On the UNESCO website, "safeguarding" of intangible cultural heritage is explained in four titles as "involvement of communities, inventorying intangible heritage, transmission, legislation". (See http://www.unesco.org/culture/ich/index.php?pg=00012).
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46- Hasanlu Historical Hill (Hassanlu Tappe) an Earthen Heritagein the Mountainous Region

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ABSTRACT

Cultural Heritages narrate human evolution throughout history as the symbol of identity, culture, art, architecture, and civilization. Hassanlu Hill (Hassanlu Tappe) has a global reputation as an earthen heritage and one of the most significant sites in Iran and the ancient world. It dates back to 6,000 BC. Now it is included in UNESCO's Temporary World Heritage List.

During the excavations by Iranian and American archaeologists, many valuable objects, including the Hasanlu Golden Cup, have been discovered at this archeological site, which are kept in the museums of Iran, Azerbaijan, France, and the United States.

Despite most of the earthen heritages, which are located in hot and dry areas, Hassanlu Tappe is located in a rainy and cold climate and mountainous region in northwestern Iran, which has been constructed with earthen materials (soil) containing clay and adobe. The purpose of this research is to illustrate the diversity of climates and contexts related to earthen heritage by introducing the Hasanlu historical site and analyzing its historical, archeological, and architectural values and potentials using Field study and Library research methods.

Keywords: Cultural heritage, earthen architecture, Hasanlu tappe, climate diversity

1. INTRODUCTION

Having left the cave, the caveman experienced life as his first shelter and gradually discovered how to build windmills in different areas of clay-based and mud houses. Across the plains of eastern Turkey, Syria, northern Iraq, and parts of Iran to southern Russia, the remains of ancient construction and traces of the first mud buildings have been observed. [1] According to a UNESCO report, adobe buildings are including about 10 percent of the world's cultural heritage, of which 75 percent of them require special attention. [2]

Despite the importance of clay-based architecture, it has received less attention than other types. Some types of these structures have not been introduced and recognized as much as their different values. While we know soil/ clay has been one of the most common construction materials in the world, which has been used in important structures such as the Great Wall of China.

As the most abundant building material from the earth's crust, the soil/ clay has left valuable architectural manifestations in different climatic zones of Iran over the years. However, it is much believed that earthen architecture must be limited to desert areas and hot, dry climates, Hence, as a result, the remaining earthen heritages of these areas are mostly identified, introduced, and protected than other climatic zones. The Hasanlu historical site is one of the lesser-known treasures of adobe heritage and a clay-based structure is located in the western part of Iran in a cold, rainy, and mountainous climate.

The present study aims to expand the boundaries of earthen architecture and explain the current position of clay as efficient constructing material in various climatic and geographical areas. Consequently, Hassanlu historic hill has been introduced as an instance of earthen heritage in the mountainous area of Iran, with an analytical architectural approach.

2. EARTHEAN HERITAGE

Earthen Heritage refers to either the buildings or structures that have been built utilizing the soil, clay or mud and adobe as a module or other different techniques and methods which have passed through the history up to the current time. Research on historical earthen heritage with the aim of protection and preservation is expanding worldwide.

Nowadays, in many developed countries, soil/clay is encountering new and technological construction approaches and techniques that are introducing it as a green, sustainable, and eco-efficient substance in architecture and human life. Therefore, recognizing the historical background of this material and related techniques, both geographically and physically, seems essential.

Most of the common techniques in the mud buildings of the world can be found in the following four methods:

- Mud modules, like adobe buildings
- Semi-pasty mud, like cob buildings
- Using timber structures or provisional works, like wattle and daub Rammed earth buildings.

Most of the common techniques in the mud buildings of the world can be found in the following four methods:

In Iran, earthen architecture has a long history. Most Iranian knowledge and civilization have been based on adobe, which means a valuable and diverse earthen heritage from historical periods must have been left. The most prominent examples of Iranian earthen heritage are Bam Citadel, the largest adobe structure in the world, and Sistan burned city, which is registered on the UNESCO World Heritage List.

According to the common perception, earthen heritage and architecture probably must be limited to the desert area with hot and dry climates in the central plateau of Iran. However, in any other climatic zone such as cold, rainy, and mountainous climate, earthen heritages are remained and observed, including the Hassanlu Tappe.

3. HASANLU HISTORIC HILL (HASSANLU TAPPE)

3.1. GEOGRAPHICAL LOCATION

Hassanlu hill is located in the northwest of Iran, West Azerbaijan province in Soldoz plain, 12 km southwest of Lake Urmia and 9 km, northeast of Naqadeh city and Hasanlu villages in 37° 00' N and 45° 13' E geographical position. [3]

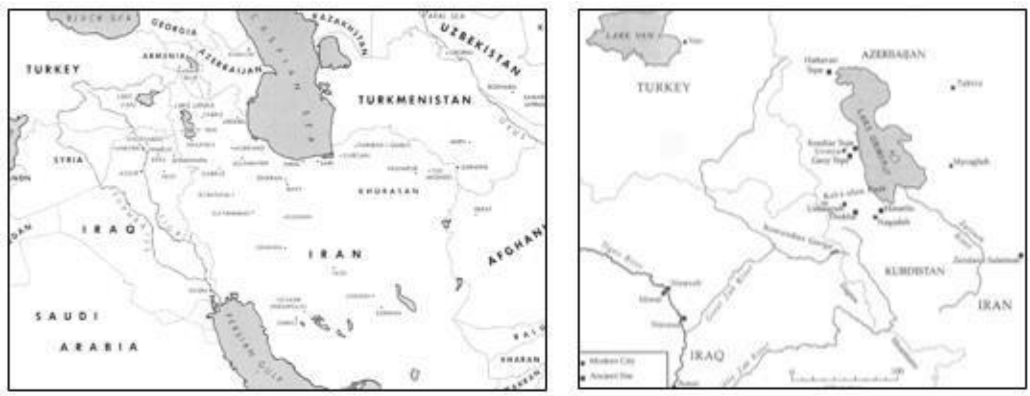

Figure 1. Location of Hassanlu hill [4].

Due to its high latitude and mountains, most of the rangelands of this region are located in mountainous parts. Throughout the province border area, mountain ranges stretch like a wall from north to south, and most of them are between 2000 and 3000 meters high. As a result, the area is cold and has a high average rainfall compared to other parts of Iran. The weather temperature of the province is between 40 Celsius degrees in summer and minus 30 Celsius degrees in winter.

Figure 2. The aerial photogrammetry of Hassanlu Site.

Many other ancient hills (approximately 14 ancient hills) exist around Hasanlu hill. Hasanlu is the most significant ancient among them in the Soldoz plain.

3.2. ARCHAEOLOGY RESEARCH OF HASSANLU

The archeological studies of the Oshnaviyeh and Soldoz areas depend entirely on the Kaleh Shin inscription. It was found on the mountain Kaleh Shin in northeastern Iraq, about 200 meters apart from the Iranian border, engraving text in Urartian and Assyrian languages, which dates back to about 800 BC.

Many types of research and excavations have been done on this site. The systematic and scientific excavations were conducted through the joint projects between the University of Pennsylvania, the Metropolitan Museum of Art of New York, and the Iranian Archaeological Service, by leading of Professor Robert Henry Dyson [6].

During the excavations by Iranian and American archaeologists, more than 14,000 ancient objects have been discovered and preserved in museums of Ancient Iran, Azerbaijan, America, France, and other countries. Hassanlu golden cup is the most important object which is discovered and is preserved in the National Museum of Iran [5].

It is noticible; most of the glorious buildings and structures of Hassanlu castle have been burned and its buildings have been collapsed by an unknown enemy during a sudden violent attack in the eighth century BC [5].

3.3. HASSANLU ARCHITECTURAL PROPERTIES

This hill consists of two main parts:

- Sidehill is 8 meters in height and 600 meters in diameter, which has been specified by the blue color in Fig 3.
- Central hill, 25 meters in height and 200 meters in diameter, includes the formal, spatial, and architectural elements such as columned halls. This zone has been specified by the red color in Fig 3 [3].

Figure 3. Topographic map of Hasanlu hill [6]

3.3.1. CITADEL WALL

Hasanlu historical castle had been surrounded by an adobe wall with a stone foundation of 3 meters in width and 9 meters in height. Twelve or thirteen towers in square shape had been built to protect the castle, at a distance of 10 meters from each other.

3.3.2. CENTRAL COURT-YARD

There is a wide courtyard in the center of this complex, which is surrounded by columned halls. The dimensions of this yard are about 29×19 m^2. The crucial point of studying Hasanlu's spatial organization indicates that the buildings inside the citadel had been built on two stories and in three separate parts with the same architectural style.

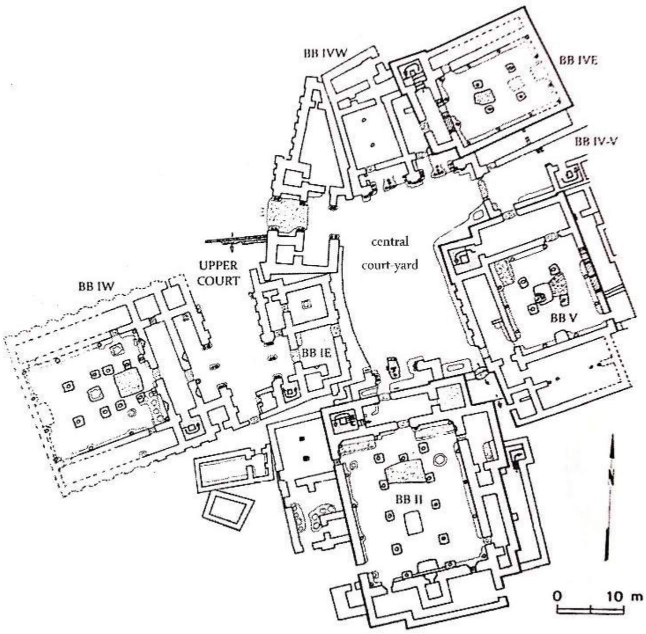

Figure 4. The plan of Hassanlu architectural heritage [3].

3.3.3. WESTERN BUILDINGS OF CENTRAL YARD - BURNED BUILDING I

On the west side of the central courtyard, there are two burned buildings. The western part of this building has been destroyed. Nevertheless, many details have been identified such as some different-sized rooms with several buried human skeletons [7].

3.3.4. SOUTHERN BUILDINGS OF CENTRAL YARD - BURNT BUILDING I

This building is the most important part in the south of the central courtyard, with dimensions of 43.75×38.75 m^2, and extended in the north-south direction. The building includes an entrance hall, stairs, several storage rooms, and a central stove. In the middle of this building, there is a large hall of 19.25×25 m^2, with wooden columns. It seems the burned hall II has been a temple [8].

Figure 5. The perspective of Hassanlu architectural adobe remains

3.3.5. EASTERN BUILDINGS OF CENTRAL YARD - BURNED BUILDING III

This building has a columned hall with dimensions of 4×16 m^2, accessible through a portico-shaped entrance. This hall is the first and oldest large columned hall resembling burned hall II [7].

3.3.6. NORTH BUILDINGS OF THE CENTRAL COURTYARD- BURNT BUILDING IV

This section is located north of the central courtyard, which includes a columned hall similar to the columned hall of the western part. The complex also had 15 rooms built for enslaved people and maids according to the skeleton of 40 women which have been discovered. These three large columned halls are not constructed in the same period. First, columned hall II was built, and then columned hall III. Finally, the columned hall (I) has been constructed [8]. Hasanlu burned columned halls are the oldest known of these types of halls in Iran [7].

4. STRUCTURE AND MATERIALS

The adobe blocks, which have been used in the upper parts of the wall are in the size of 40×23× 14 cm3 [9]. As mentioned, the platforms identified in the halls were also made of adobe. In all of these buildings, the columns are made of wood, usually placed on the bases of irregular boulders, which were also covered with mud [7].

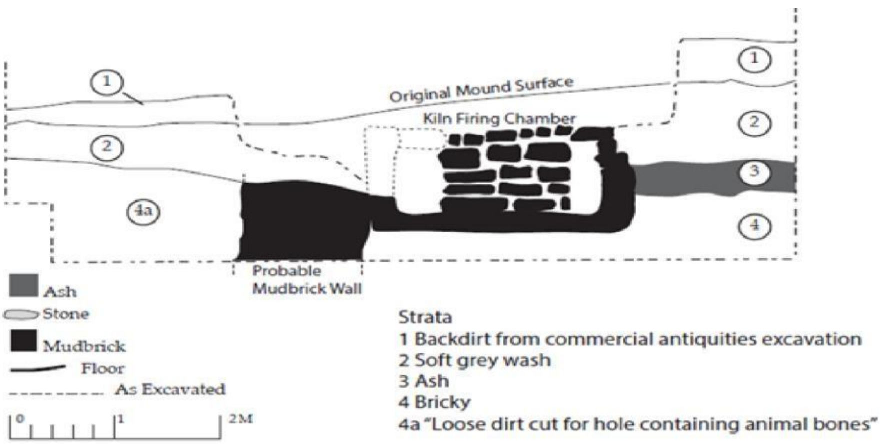

Figure 6. Section of a wall from Hasanlu historical buildings and layers of materials separately [10].

CONCLUSION

According to what has been reviewed, earthen materials for instance: clay, adobe, and mud with a long history in human life, which instances have left their traces from about 8000 years. The results of the study and introduction of the Hasanlu historical site can be summarized in two areas:

- Hasanlu historical site, known mostly as an earthen architecture indicates the existence of a civilization dating back to 8000 years ago and indicates the use of clay in a mountainous climate. The study of the structure and materials of this complex shows that the use of earth/ clay has been more in the form of bulky and large-scale modules.

- Finally, the Hasanlu historical site and everything that has remained from it and archaeological excavations indicate the possible diverse climatic contexts of earthen architecture.

- As a result, this material/ substance can rely on its historical background and can simply function as a new construction material in harmony with green and sustainable architecture in constructing new structures, based on modern and innovative earthen techniques.

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47- The Relationship Between the Architectural Features and theEnvironment of Traditional Adobe Buildings in Elazıg Hussenig District

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ABSTRACT

Adobe is one of the most used building materials in the history of the world, sustainable and developed by the civilizations that came to life in Anatolia for more than 9000 years, transferring their experiences and cultures. It is a material that carries traces of the past and present, like an organism living with its user, and makes one feel a sense of belonging socially, culturally and emotionally.

Due to the changing and increasing population structure and developing technologies today, it is seen that the mudbrick structures, which are the evidence of the lives lived in the past in Anatolia, cannot fully protect their existence today and are lost among the reinforced concrete structures. However, examples of adobe structures that still do not surrender to reinforced concrete and try to maintain their originality are seen in different parts of Anatolia. One of them is seen the adobe buildings in the Harput region of Elazığ, with its current name Ulukent and its old name Hussenig neighborhood. These adobe structures have survived to the present day by preserving their settlement patterns to a large extent.

The distance of Hussenig district from the center of Elazig prevented the buildings from becoming reinforced concrete but it also caused the city to fall behind the city economically and desolate the region. As a result, it is seen that some buildings are not used and are in danger of collapse. For this reason, structural preservation and functional studies should be carried out in order to preserve and maintain the adobe structures in Hussenig district, which is a part of traditional Anatolian architecture.

In this study, the relationship of the adobe buildings of Hussenig (Ulukent) neighborhood, which is trying to maintain its existence today will be examined with its surroundings, its historical development, geographical location, physical and social factors and the traditional texture, plan types and other natural building materials used together with adobe. The environmental and architectural features of the adobe buildings of this neighborhood will be evaluated, and the necessary protection and structural function proposals will be evaluated in order to maintain their existence from the past to the present and to continue in the future.

Keywords: Adobe building, Elazığ-Hussenig (Ulukent), traditional architecture, environmental texture teatures

1. INTRODUCTION

Harput, which has been used as a residential area for about 4000 years ago, has preserved its existence as a defence center for many years. Over time, because of the political, cultural, and social changes in the region. The Harput region has lost its feature of being a center. Because of the construction of the railway to the Elazig Plain, the separation of the administrative and military units from Harput so the settlement areas were moved to the Mezra. Mezra, located in the southof Harput, is today's Elazig city center [1].

Hussenig (Ulukent), one of the important settlements of the Harput region, has been affected both culturally and economically by these changes. Elazig Province, central Ulukent (Hussenig) Neighborhood is located in the south of the historical city of Harput and Harput Castle. While Hussenig District was a village settlement until 1978, it became a neighborhood after this date. It is seen that Hussenig, known as the Armenian quarter in the past. Hussenig had an extremely cultural, commercial and social consciousness, and later on, when the Turks only lived in this settlement that trade and production became passive, as well as it became a ghost settlement where it entered the process of extinction within the urban fabric with demolition and neglect [2].

The traditional houses and historical settlement patterns of the Hussenig region are decreasing day by day and are in danger of extinction in a few graduate studies. In the earthquake of 6.8 Mw that occurred on 24.01.2020 around Elazig and a great deal of life and property were lost. The buildings trying to survive in this region have started to pose a danger to the people living in the buildings due to the lack of maintenance and reinforcement works. In the examination carried out in the region, after the earthquake, 5 buildings were examined and it was determined that the structural damages detected, as well as the relations with the plan facade and the environment, pose a danger to the life safety of the users in the registered buildings and they are helpless.

2. HISTORICAL BACKGROUND ABOUT HUSSENIG

Hussenig is in the northern part of Ulukent District in Elazig. There is the historical Harput District in the northwest of Hussenig, which is approximately 5 km away from the city center (Figure 1). Hussenig, which is located on a sloping area rising from south to north between Elazığ Plain and Harput Plateau. There is a reclaimed stream with an average slope of 10% in Hussenig. The western branch of Hussenig Stream, which consists of two main branches, takes its source from Kırkkuyu and Akçakı Hills [3].

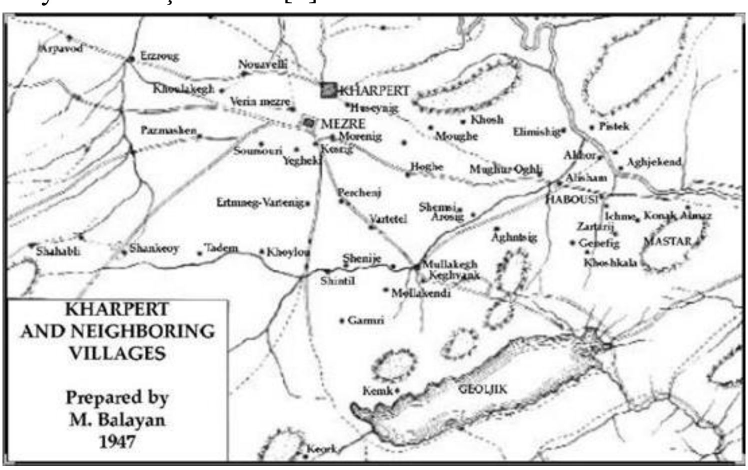

Figure 1. Hussenig is in the northern part of Ulukent District in Elazığ

According to the data of the 16th century 1518-1566, it was seen that the population of the village increased and the rate of non-Muslims was higher in this increase[4].

In the 19th century, the Hussenig population consisted of a total of 2910 people, 800 Muslims and 2110 non-Muslims. It is seen that Harput has become a dead city with mass migrations. It has been observed that there are changes in the cultural structure as a result of the changes in its population [3].

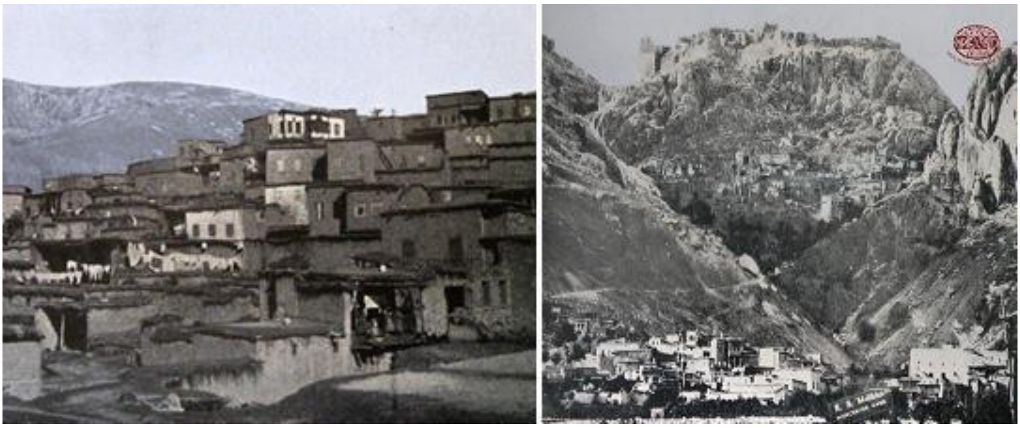

Figure 2. General view with Hussenig adobe houses with Harput Castle [1]

The Hussenic culture was equivalent and higher than the Harput Culture. Hussenig had very well-kept and fertile gardens and houses with beautiful architecture in these gardens. The people residing in these houses were people of high culture who understood music, literature and fine arts. There were educated people with a high literacy rate. Hussenig was an important shopping center in the early 1900s. The fact that the municipality, the police station organization, some military units and the warehouses of these units were present in this town increased the importance of the town [5].

Hussenig is one of the famous centers in the shoemaking craft. In addition, silkworm breeding was also carried out in the region. In the village square in Hussenig, there were bakeries, blacksmiths, tailors, jewelers, barbers, grocers, food processors, saddlers, saddlebags and butchers. The police station was located at the end of Çarşı Street, which is connected to the village square. Hussenig is one of the lucky towns in terms of drinking and utility water. This abundance of water enabled the construction of many fountains in the village and pools in the houses (Bican 2007). General view with Hussenig adobe houses with harput castle in Figure 2 [6].

Most of the population was engaged in handicrafts and trade, as well as agriculture and animal husbandry. This has contributed to the increase in the welfare level of the region. Hussenig, where the trade routes from the southern provinces to Harput ended, became a production center with many business lines such as carpentry, leather, jewelry, sugar-halva production, copper smithing, saddle-making, sericulture, and weaving. The fact that the commercial venues are in the center of the region has provided users with easy access to these places [6].

The general picture of Armenian education in the Harput plain is very impressive. The whole region, at the beginning of the 20th century, has a superb and vast network of boys' and girls' schools. Almost all the Armenian villages have their own schools that are no longer old-fashioned centres of elementary education, but are generally two-storey modern buildings constructed in the newest style. In the towns, each Armenian quarter has more than one school. The town of Harput itself, whose Armenian population is approximately 15,000, has one college, three high schools and at least ten middle and primary schools. The town of Mezire (Mamuretül-aziz), with a population of about 12,000 Armenians, has a college, three high schools and more than ten first and intermediate schools. A little town like Hussenig, made up of 700 families, has seven educational establishments. Although it faced problems in the process of preserving the cultural heritage and transferring it to future generations, Hussenig tries to keep the historical and cultural accumulation from the past alive today[6].

3. ARCHITECTURAL FEATURES AND ENVIRONMENT OF TRADITIONAL ADOBE BUILDINGS IN ELAZIĞ- HUSSENIG (ULUKENT) DISTRICT

There were famous stonemasons and masons in the village of Architectural Features and Environment of Traditional Adobe Buildings in Elazığ- Hussenig (Ulukent) District, and some of them had taken their techniques so far that they had become real architects. Architect Kevork Koncoyan from Architectural Features and Environment of Traditional Adobe Buildings in Elazığ- Hussenig (Ulukent) District built the Mezire hospital and barracks, the warehouse in Architectural Features and Environment of Traditional Adobe Buildings in Elazığ- Hussenig (Ulukent) District and the Kızıl Mansion [6].

The creek and roads in Architectural Features and Environment of Traditional Adobe Buildings in Elazığ- Hussenig (Ulukent) District have an effect on the formation of the traditional texture of the Architectural Features and Environment of Traditional Adobe Buildings in Elazığ- Hussenig (Ulukent) District region. Topography plays an important role in the formation of the texture of the region[2].

In Hussenig, which is divided into two by the stream, the slope of the land on the east side is higher than on the west side. In the eastern region, where the slope is high, water resources are also high. This situation has led to an increase in the distance between the structures on the sloping land. In addition, the slope of the land in this region also enabled some buildings to receive entrances from different floors. The majority of the houses on this side face the Elazığ plain and do not obstruct each other's viewpoints and views. The buildings on the west side of the stream are more adjacent[2].

3.1. HUSSENIG ADOBE HOUSE FEATURES

In general, the houses face the road and have a direct entrance from the road. The buildings are located close to each other on the roads outside the road where Hussenig Stream passes. In some buildings with double fronts to the street, it has been observed that there are overhangs in both the sofa and the room. Houses in Hussenig are not only places of residence, but also the working and production spaces of the people living in them. The ground floors therefore contain service and service spaces to provide for the family's livelihood. These are barns in some houses, shops in some houses, and pools for processing industrial products in others.

There are single-storey, two-storey and three-storey buildings in the Hussenig region. The proportions of the single and two-storey buildings are close to each other and they cover the majority of the buildings in the area. In general, a basement or a mezzanine floor was built by making use of the slope of the land in three-storey buildings made of adobe and stone materials. There are usually two separate entrances to such buildings. Solutions at different levels in Hussenig houses; original plan gave rise to the schematics. Downstairs due to rocky ground one side of the places ends with a rock. This surface is shaved and in its natural state has been abandoned [7].

The plan elements of Hussenig houses, built in traditional style, consist of rooms, sofas, service areas, courtyards, iwans and roofs. Apart from these, there are bathrooms, kitchens and toilets that are not in a traditional style but have changed or added their function in order to adapt to today's living conditions. In the past, it is seen that the roofs of the buildings have flat roofs. The houses have three different plan types: sofa free plan, plan with inner sofa and plan with outer sofa. The central sofa plan type is not seen in the Hussenig house scheme. Turkish house plan types are shown in the Figure 3 [8].

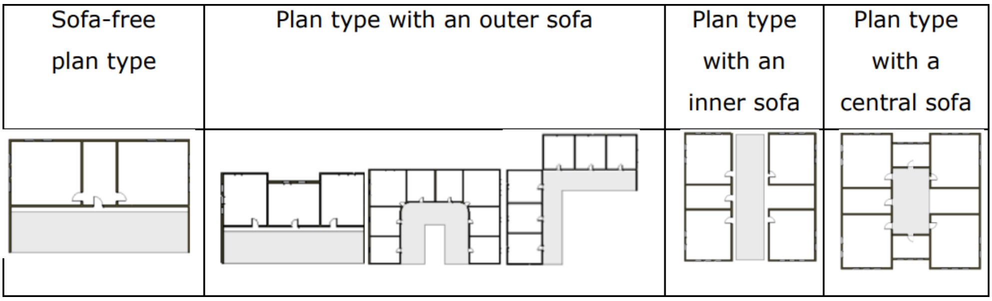

Figure 3. In A Turkish house, plan typologies with respect to Sofa Organization [8]

Plan with outer and inner sofa in houses with a scheme; if the sofa is long, this section can be illuminated. There are small windows that provide light through the door. The windows are inwardly tapered and also allowing more light to enter the space. The upper parts of the houses are on the wooden beams on the cisir, bush, clay soil. The roof was created by logging. In the second half of the 19.century, roofs were built in traditional houses. Most of old buildings were brought to the present by adding a roof. While the rooms in the houses are generally private spaces, the exit rooms also show the feature of the place used by the family members collectively. Sofas are generally a circulation center where transitions between spaces are provided. It determines the shape of the building on the upper floors of the buildings. The upper floors in the region are called şahnişin, they are the gathering unit where the household can see the street. Iwan is a plan element at the entrance of the building in traditional Hussenig houses. Courtyard; It is a rare plan element in Hussenig houses. Şahnişin is a feature of the houses in the middle part of the second floor facing the Street. Şahnişin have five or seven windows. There are three windows in front of it andone window on each side of the exit, as well as two on the sides. They are wood-framed and glazed, mostly latticed on the outside [9].

In houses; sawing out, coming out straight from the side and being disappeared. There are three types of exits. The overhangs are at most 80-90 cm [10].

The şahnişin, which is usually located between two rooms, has been found several times in large mansions. One of the elements used to create a semi-open space is the portico. It is an architectural element used in other settlements in the region. The porticoes, which have two spans and formed by arches, It is a widely used space. The fact that the arch is a decorative element makes the inner courtyard aesthetically pleasing. The weather has won a cottage architecture. Since they are elements, the direction of view is north. Porticos and iwans are opposite to the direction of the sun so that they do not see the sun at all times of the day [9].

3.2. HUSSENIG HOUSE MATERIALS FEATURES

From the courtyard, the upper floor or rooftop was accessed by climbing wooden or stone stairs.

The upper floor housed four to six rooms, and one to three porches (ayva, chardakh), while the remaining space was open air. The house's second floor served as a bedroom for the household.

The foundation of the houses were made of stone, and joined together by mud-cement. In the Harput region, the most commonly used stones were the chechkar (pumice stone), the white pukh, and limestone. Masons dug holes around 60-150-cm. (2-5-feet) deep, and of comparable width, and filled them up to the surface with foundation stones. They then lined the bricks on the foundation.

The external walls of the house were usually 60 cm. (24 inches) thick, while in the interior, the walls were 45 cm. (24 inches) thick. Two units were used to measure the density and thickness of the walls, the anadj and khuzi, which were in fact different sizes of brick. One anadj corresponded to 60 cm. (24 inches), and a khuzi was half the size of an anadj. To keep the walls firm and solid, crossbeams (locals called them khatel) were used from the wood of poplar trees. The two ends of the beams were smoothed and placed in parallel on both sides of the wall, 90 cm. (3 feet) apart. These parallel support beams were attached to one another with wooden nails [6].

The stone rising from the foundation to the flood level in houses. The thickness of the foundation walls varies between 70-100 cm. Wooden framed parts have usually 20-30 cm thick. Surfaces of external walls, chaff-tempered mud plastered with mortar[11].

The middle halls of some houses are decorated with natural stones in the form of raft (slate) stone. On the upper floors, the sofa and the floors of the rooms are mostly coated with wooden. While it was covered, it was sometimes left plastered with soil mortar plaster. Upstairs of the some of the spaces are paved with stones (slate). On the steps resting on an inclined wooden beam, the height of the riser is up to 25 cm [10].

The sink, which is found in the sofas and sometimes in the rooms of the houses, is used for both washing and It was used as a place to wash things. It has been designed slightly elevated from the place. There are sinks with different sizes depending on the purpose of use. As a result of the differentiation of wet spaces to their homes in the last hundred years, the sinks have been largely has lost its function [10].

Cedars and cloisters in interior spaces create a different style. The place called bathroom is used when requested, and other than this purpose, items such as beds and quilts are used. It is also used as an indoor space where it is stacked [12].

The sundried brick was prepared with clay-like soil and mud made from fine crumbs of chaff and water. The brick was also prepared by mixing clay, adobe (soil with clay), and water. The villagers covered the roof of the house with wooden beams and djisirs (small beams). The beams were usually 25-30 cm. (10-12 inches) thick, and were placed approximately 3 meters (10 feet) apart from each other. The space in between was filled with 20 cm. (8 inch) thick djisirs, at a 45- 60 cm. (18-24 inch) distance from each other. To support the beams of the roof, wooden pillars were fixed on the floor of the house. Each pillar stood at a distance of 3 meters from the other. After the djisirs, the joints were put in place, again at a distance of 10-12 cm. (4-5 inches) from one another. On top of the joist, the laths—short, thin pieces of wood—were placed tightly next to one another. The laths were then covered with green tree branches (in Pazmashen, these branches were called keveshe), and covered with slightly wetted soil, called peteruk or petrig (in the local dialect, this meant dough or cement). In this soil was a mixture of chaff and mud. The peteruk on the root had to be 7.5-10 cm. (3-4 inches) thick. This was further condensed and often flattened with a stone-roller. On top of all this, a 5 cm. (2 inch) layer of kerpidj was added. This mixture was also used to plaster the walls of the house, both from the inside and outside [6].

The building of the roof continued with the placement of eaves. The lower layer was made up of branches of durable wood, while the upper layer was a mix of soil and chaff. The eaves had a width of 25 cm. (10 inches). They were placed next to one another on the four corners of the roof,pointing outward. The eaves prevented the walls of the house from getting wet. Hence, they lookedmore like wooden umbrellas attached on top of the walls of the house. At the eaves, they placed the gutter (in Harput, they called it djrton, as well as gurchivan, gurchrvan, chortan, or chrortan). The gutters were semicircular wooden tubes that carried off rainwater to the ground. In Tadem, during a draught, tradition dictated that villagers steal the gutter from the house of a woman who had been widowed three times, and hide it for a few days, in hopes that it would bring rain [6].

On the roof, there was also the dormer, a square opening right over the cooking room. The smoke came out from here, and fresh air entered the house. The villagers used a wooden cover to close it shut when needed. This collective labor of building a house in the village could last 2-3 months. [6]

There are three types of windows in the study area: arched, non-arched and inward-expanding windows. These windows are specialized depending on the plan element, floor and facade. Regarding the number of windows of items such as cupboards and cabinets in the interior, It should not be ignored that it determines the front [13].

In the Hussenig region, there are few original gates that have survived to the present day. Wooden doors have often been replaced by iron doors. When the original doors are examined, there are varieties with stone jambs or wooden sills. There are two types of doorknobs. Their shapes are different from each other, but their functions are the same. There are two doorknobs, a deep voice and a low voice. The low voice is used by the female guests and the low voice is used by the male guests.

Architectural elements such as fountains, pools, jambs and arches seen in houses are generally made of stone material. Wooden decorations are the most common type of decoration in architectural elements in the Hussenig. There are examples of woodworking in auxiliary elements such as moldings, shelves, tins, and sills. The wooden works found in the bay windows are rarely seen today.

It has been determined that the ratios of structures made of mud brick and mixed structures made of adobe and stone materials are close to each other. Stone material was used extensively in the foundation and ground floors. Since adobe is a material that requires maintenance, the abandoned buildings either collapsed or faced the danger of collapse. As a result, it was observed that the upper floor mudbrick walls of some buildings were destroyed, but the ground floor stone walls were still standing.

4. CONSTRUCTION PROBLEMS AFTER ELAZIĞ EARTHQUAKE IN ADOBE HUSSENIG HOUSES

When the masonry houses in the region during the last earthquake in 2020 were examined, it was not possible to talk about a construction technique that could be clearly defined. The residences examined are single or two storeys. Stone and mudbrick materials were used on the walls, but it was observed that in most of them, different types of bricks (hollow briquette, solid briquette, ytong, fire brick, etc.) were added to the structure later, as a mix. The tensile strength of the wall has decreased since the weights of such materials used in the masonry wall are different and it consists of multi-piece elements. At the same time, with the reinforced concrete additions, it has been observed that such structures do not work together and show different behaviors to the loads on the structure. Since different building materials cannot show homogeneous behavior when used together, the behavior of the walls such as stiffness and ductility also differed [14].

After the Elazığ earthquake on January 24, 2020, after the Elazığ earthquake on January 24, 2020, the drawings of the historical adobe houses, which are registered in Hussenig District, were carried out as of December 18, 2020. The first stage of the projects were discussed in the Diyarbakır Cultural Heritage Preservation Regional Board, and the survey projects were decided by the Board in June 2021 has been approved.

There are 22 registered immovable cultural assets in the region. 16 of these structures are examples of civil architecture and are located on Hussenig District, Sefer Street and Çarşı Street. As a result of the socio-economic change of the people living in the Hussenig settlement over time, most of the historical buildings have become idle as a result of the lack of maintenance and repair. A comprehensive conservation study is needed to transfer the buildings in the Hussenig Region, which has the cultural and historical value of Elazig, to future generations[2].

The traditional houses in this neighborhood are in disrepair. Those who live in the buildings registered by the Ministry of Culture and decided not to be demolished indicate that they have no safety of life due to the cracks formed after the Elazig earthquake. Since the resident population is low-income citizens, it has been determined that they are in a rather helpless situation.

Some houses have been exposed to fire due to indefinite demolition decisions due to property problems. Many structures, which do not have a very durable material and require constant maintenance, have been destroyed.

Planning in historical cities has two important issues, on the one hand, to control the change, to slow it down, to protect it, and on the other hand, to advance the change further; they are seen as opposing alternatives to each other, in reality they are nothing but two different sides of the same coin. It is stated that successful results can be achieved with works that creatively reconcile them [15].

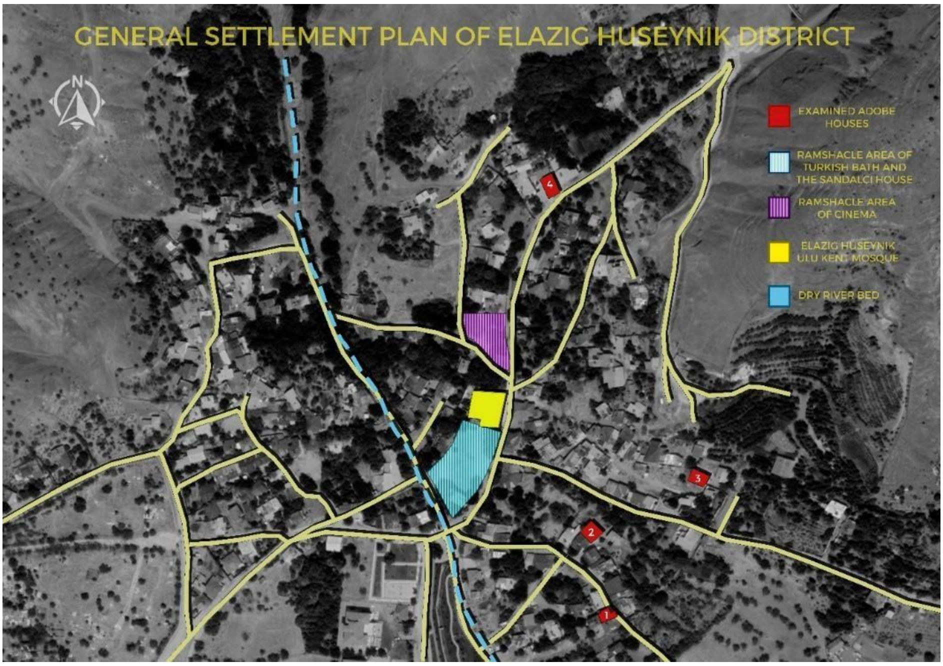

Figure 4. Examined 4 Adobe house with their physical environment on the map Earthquake (Prepared by Demir, 2022)

In the examinations made in the region, it has been determined that protection measures have not been taken yet. 4 houses were examined on site and the damages in the interior and exterior structures were determined (Figure 4).

People living in the houses are very worried about the damages in the house after the earthquake.

Damages detected in House no:1 and House no:4 are shown on the analysis sheet. Accordingly, consist of damages in order (Figure 5, Figure 8);

- Spilling on plasters
- Loss of materials and structural elements in walls
- Partial or complete wall collapse
- Plugin build
- Horizontal and vertical deep crack
- Deflection of the roof covering
- Stairs damage

Damages detected in House no:2 is shown on the analysis sheet. Accordingly, consist of damages in order; (Figure 6).

- Spilling on plasters
- Loss of materials and structural elements in walls
- Partial or complete wall collapse
- Plugin build
- Horizontal and vertical deep crack
- Deflection of the roof covering
- Stairs damage
- Collapse in floor
- Cannot be used

Damages detected in House no:3 is shown on the analysis sheet. It is different from other examined houses because of fired. Accordingly, consist of damages in order (Figure 7);

- Spilling on plasters
- Loss of materials and structural elements in walls
- Partial or complete wall collapse
- Plugin build
- Horizontal and vertical deep crack
- Deflection of the roof covering
- Stairs damage
- Windows and doors jackets damaged
- Fired
- Cannot be used

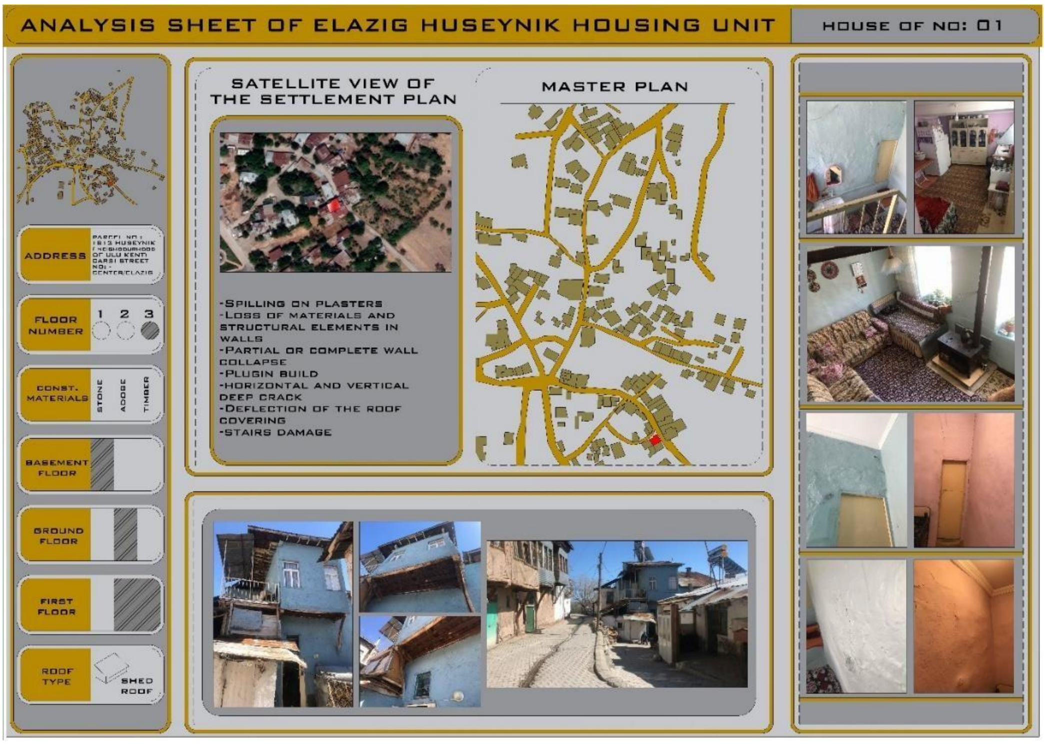

Figure 5. House No 1 Analysis Sheet After 2020 Elazığ Earthquake Earthquake (Prepared by Demir and writers,2022)

Figure 6. House No 2 Analysis Sheet After 2020 Elazığ Earthquake Earthquake (Prepared by Demir and writers,2022)

Figure 7. House No 3 Analysis Sheet After 2020 Elazığ Earthquake Earthquake (Prepared by Demir and writers,2022)

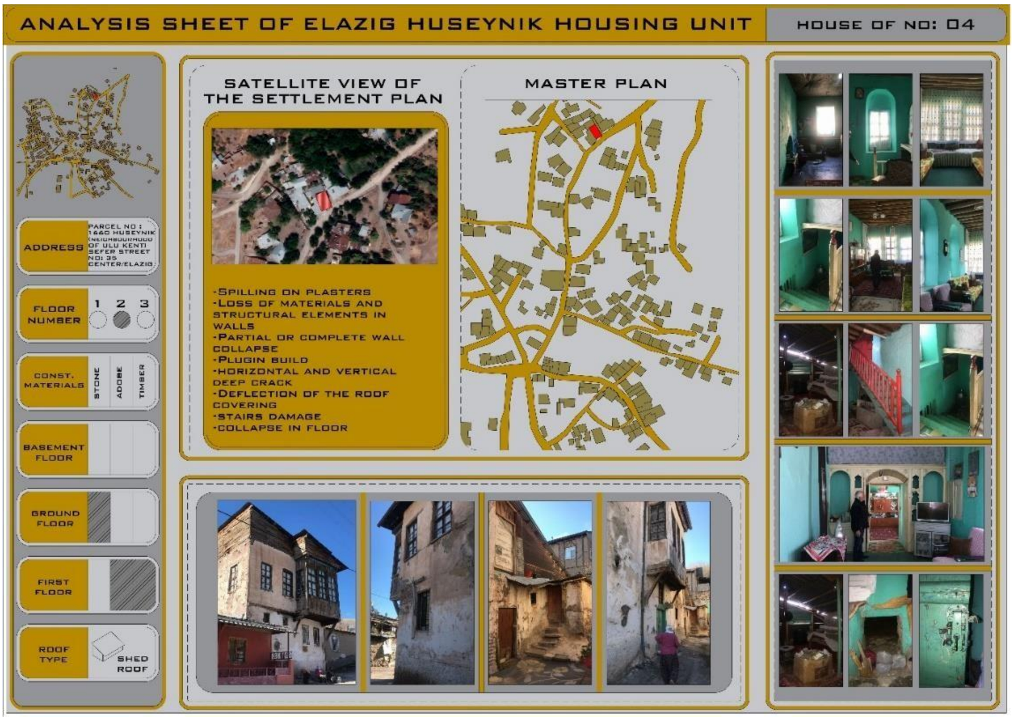

Figure 8. House No 4 Analysis Sheet After 2020 Elazığ Earthquake (Prepared by Demir and writers ,2022)

According to researchers, "a sense of belonging" is important in order to look into the past. This feeling manifests itself in the urban environment in the form of protecting historical sites.Historical places represent stability and permanence. On the other hand, they are also accepted asa "heritage" by the people [15].

Today we can't see the house entrance of the Hussenig (Figure 9). This house was a sense of belonging and cultural self. As material; It was demolished in 2021 by the house owners who used stone adobe and wood, and it was stated by the professors of Fırat University that it was a building that gave the Hussenig urban identity.

A lively facade with a stone-arched entrance door and wooden buttressed bay windows has order. All of the oval windows were of the type in the rooms on the upper floor. Due to the spaces located at different levels in the plan diagram, windows were at different elevations. The original doors, the entrance door built with cut stones, showed the decoration details of the building forms. Doors and ceilings at the bottom of the falcons and on the ceilings of the rooms were wooden material was used as decoration element in the windows [7].

But their owners wanted to build new house. Now, unfortunately as a green area waits to be built a new reinforced concrete building like near by the area (Picture 4).

Figure 9. Before destroyed house at the entrance of the Hussenig [7]

Figure 10. The house was destroyed and now it's place is a green area (by writers,2022)

CONCLUSION

Today, Hussenig has very few traditional houses in its neighborhood has remained. With the effect of the urbanization process in the existing ones; in the city lost its importance and became inactive. Preserving our historical heritage is also a moral duty. It also has a pedagogical aspect. The silhouette of a place in historical settlements, people's past.

It enables them to form the teaching of "cultural memory" by observing the evaluation of This memory will disappear unless conservation and re-functioning actions take place in Hussenig.

Preserving our cultural heritage and transferring to the future. If the studies to be done in this region are recommended that

- to provide the region with the level of development it deserves before the people of the region have hopes that the city will swallow the neighborhood in order to eliminate their economic weakness, and to enable the renovation works to revitalize the region,

- Converting the desolate Hussenig from a place frequented by those who live here and those who

need to go, to an open-air museum that also attracts those who want to see and visit,
- Transforming derelict buildings from mysterious and dangerous places into places that live and serve on the street,

It is important in terms of creating data that will enable restoration and conservation studies should be carried out in order to somehow pass through the evaluation process and reintegrate into the society. It can be with its preservation and revitalization of the region, re-functioning, and some activities in the form of Culture house, museum, accommodation and social.

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48- The Sustainability Effects of Choosing Adobe inContemporary Buildings

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ABSTRACT

Many reasons such as the increasing need for buildings in the face of the increasing population after the industrial revolution, various global problems, decreasing resources and cost increases in production are taking away the choice of people to have their own buildings or living spaces. In addition, unconscious construction, intense resource, and energy consumption; it poses a threat to biodiversity by causing waste generation.

As a solution proposal to all these problems, sustainable building formation and sustainable building material production, which considers the protection of the environment and the continuation of vitality, gain importance.

With the right material selection in the projects to be created, it may be possible to build a more sustainable world by minimizing the carbon footprint. The choice of material that does not lose its properties for many years plays a major role in reaching the goal of sustainable construction by extending the life of the building. In this regard, adobe can be preferred as one of the materials with zero carbon emission in its production, life and disposal.

In this study, it has been evaluated that, with the successful combination of adobe, which is a natural building material, with contemporary techniques in a modern building, environmentally friendly and energy efficient structures can be created. Through the examples of contemporary mudbrick structures selected by the literature review method; The suitability of adobe for sustainable architecture has been interpreted in terms of economic, social and ecological aspects.

Keywords: **S**ustainability, sustainable architecture, adobe, ecology, local

1. INTRODUCTION

Ensuring the continuity of the ecosystem without damage and not being affected by the negativities of future generations can only be possible by ensuring social, economic and ecological sustainability. For a sustainable architecture; Minimizing the carbon footprint and going for energy efficient solutions will lead to the most accurate results in the design and material selection of buildings. In this regard, the buildings built with the choice of natural materials take their place as examples of sustainable architecture, that are environmentally friendly by their origin. As it is known, more than 30% of the world's population lives in adobe structures produced with local soil. Adobe structures have a breathable, hygroscopic property that provides thermal comfort with an intense thermal mass property that has a minimum environmental impact. When built with the right techniques, adobe structures that have survived for many years; It ranks first in the sustainable building category with its energy conservation, comfort, non-flammability and ability to mix with nature again due to its origin.

As a result of the need for sustainable and environmentally friendly buildings, interest in adobe structures as an alternative to expensive construction techniques has started to increase. Especially soil structures built in arid regions where natural resources such as wood and stone are limited, have been updated and integrated with modern techniques and have started to be preferred again.

2. USE OF ADOBE IN ARCHITECTURE AND ITS EFFECT ON SUSTAINABILITY

In areas where stone and wood resources are limited, human beings have produced adobe blocks by mixing various binders such as clay-containing soil, water and straw in suitable proportions, pouring them into molds and drying them in the sun. We encounter adobe blocks, which are the first building materials produced and shaped by human beings in history, and examples of adobe structures that have survived from the early ages to the present day. Today, mud-brick structures, which are simple, primitive, poor people's choice and are not resistant to earthquakes, are challenging time and these discourses with examples reaching today from thousands of years ago [1].

Adobe is a natural material that is produced from local soil with local labor without the need for any facility and used in building construction. Thanks to the natural and environmentally compatible materials it contains, adobe; It does not cause waste for production, use and after its service life and can be recycled back to its source. It is a healthy and sustainable material with its climatic, thermal, acoustic and natural comfort properties that it offers to its user. It has the feature of protecting its service life and all its sustainable properties without losing its service life when precautions are taken for its sensitivity to water and humidity and when it is maintained during use. As with all other building materials, it is also resistant to earthquakes when built with the right construction techniques [1].

Today, the correct management of ”resources, energy and waste" constitutes the main decisions in terms of ensuring sustainability. For these reasons, the interest in natural building materials and especially adobe is increasing as an alternative to today's unhealthy construction problem. It is in question that the production and construction of adobe material is updated, harmonized with contemporary materials and techniques and brought to the construction sector. While faster and mass production is required in the face of increasing construction demands, alternative solutions can be produced for increasing maintenance and durability. Considering that the energy used for heating and cooling in our country is more than one third of all consumed energy, the preference of natural materials such as adobe, which can breathe and have thermal and climatic comfort properties, is of great importance.

When the physical and mechanical properties of adobe are examined, it is concluded that in the direction of the findings obtained, there is no need to use any vehicle to provide cooling in soil structures in hot periods and that appropriate comfort conditions can be provided in soil structures with a fuel consumption of 1/4 of the fuel consumption used in concrete structures in cold periods [2].

Thanks to the correct integration of adobe with technology; Contemporary and sustainable structures that are subject to nature, life and culture emerge. With the inclusion of renewable energy solutions (such as photovoltaic panels, wind turbines, heat pumps), passive energy solutions (design according to the sun), water conservation and recycling in designs, it provides great economic, ecological and social contributions to the societies in which it is made.

3. THE SUSTAINABILITY EFFECTS OF CHOOSING ADOBE IN CONTEMPORARY BUILDING EXAMPLES

Adobe structures provide a physical environment in which a person can live comfortably that other materials cannot provide. Since it uses less energy: it does not pollute the natural environment, protects the family budget and the country budget. Although the building housing the largest number of people in the world is made of earth, it is not included in engineering and architecture education since there has been no industrial production in this area in the last hundred years [3].

Adobe has begun to be forgotten due to the fact that experts do not know adobe material well enough, that they do not receive support at the point of application, and that today's other building systems are preferred. Today, when looking for healthy and comfortable natural materials that can meet the needs of societies in terms of ecological, economic and cultural; adobe emerges as a material that attracts attention again and is updated in contemporary buildings and brought to the sector.

In the contemporary building samples examined within the scope of the study, the preference of adobe; communities, ecological and economic effects were evaluated and tried to be interpreted in terms of sustainability.

3.1. AKNAIBICH PRESCHOOL

In 2014, a low-cost preschool was built using adobe and rattan in Aknaibich, Morocco, under the direction of Architect Frank Stabel, with the participation of a group of architecture students from the University of KU Leuven (Belgium) and local workers 'Fig. 1' (Url 1).

Figure 1. Aknaibich Preschool, Plan and Section (Url 1).

It is inspired by the traditional earthen architecture of the old city in the area where the city has a dense concrete structure. The preschool building was built with local materials and typology, with a contemporary look. Concrete beams supported by vertical bars were used in the building, which was built with mudbrick blocks on a local stone foundation and plastered with straw-mixed earth mortar, considering the earthquake risk. In the design of the building, small and deep window openings were left on the thick walls in the south façade direction in order to use the sun effect indirectly in the interior lighting, and also benefited from the thermal comfort feature of the thick mudbrick wall. At the school, an outdoor area with a pergola has been created, which can be described as an external classroom that can be used for storytelling and other activities, where children aged 3-6 can play outside the classroom 'Figs 2, 3 and 4' (Url 1).



Figure 2, Figure 3 & Figure 4. Aknaibich Preschool Garden and Rattan Details (Url-2)

The adobe structure consisting of a single classroom; It is concluded that it is a sustainable structure in terms of using community dynamics with local workers, observing the bioclimate, incorporating and protecting the three existing argan trees in the treeless area in the city, and beingan architectural design that combines today's modern school infrastructure standards with local style (Url-2).

3.2. BURKINA INSTITUTE OF TECHNOLOGY

Local materials clay and eucalyptus wood were used in the construction of the Burkina Institute of Technology, designed by Francis Kéré in Burkina Faso, Africa 'Figs 5 and 6'.

Figure 5. Burkina Institute of Technology (Url- 3)

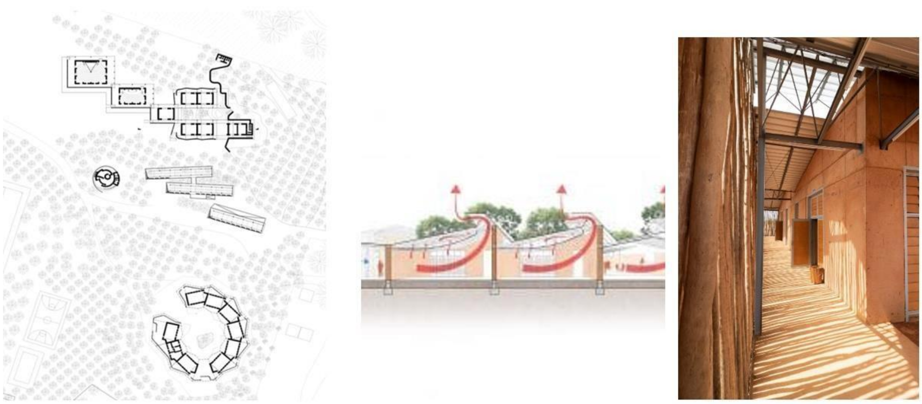

Figure 6. Burkina Institute of Technology Plan, Section and Roof Ventilation (Url- 3)

The 2100-square-meter structure, consisting of classrooms, a conference room and other complementary areas, consists of a decoupling of repeating modules. Classroom modules, with a rectangular courtyard at their centre, were constructed by pouring a concrete-clay mixture into classroom-sized demounted molds.

Considering the abundance of clay in the environment and the thermal comfort effect, the use of soil was preferred in the building to help cool the classrooms. The walls, which are formed by pouring in-situ molds with a mixture of cement, aggregate and clay, provide more flexibility and a faster construction process compared to the use of traditional clay bricks. An entire class-size formwork was used to build each module in situ. This method is cheaper and more sustainable than concrete. Wooden curtain facades made of eucalyptus trees protect the clay walls of the building from rain, while shaded corridors help cool the classrooms 'Fig.7'. The roof openings provide ventilation by allowing the rising hot air to be expelled.

With a special landscape design in the building area, which is located on the flood plain, it is planned to store the water in an underground tank and use it to irrigate the trees on the campus. At the same time, the building is protected against water in rainy seasons (Url- 3).

Figure 7. Interior of Burkina Institute of Technology (Url- 3)

3.3. PUNTUKURNU ABORIGINAL HEALTH SERVICE

The use of compacted soil was preferred in the 970m2 Puntukurnu Aboriginal Health Service structure, the construction of which was completed in 2020 in the driest Newman region of Western Australia 'Fig. 8'. Kaunitz Yeung Architecture, who realized the design, aimed to solve the difficulties that local Aboriginal communities have in terms of transportation and financial expenses to the city of Perth, 1400 km away, in order to receive health care, with the use of local materials and the support of the local people. With the realization of the building, access to health services has ceased to be a privilege for local communities who are experiencing impossibilities (Url-4, Url-5).

Figure 8. Puntukurnu Aboriginal Health Service (Url-6)

Economy has been provided in terms of materials and transportation expenses to be brought from Perth with the choice of local materials. The building consists of two parts, the health center and the administrative 'Fig. 9'.

Figure 9. Puntukurnu Aboriginal Health Service Plan and Section (Url-4)

The courtyard in the middle provides visual communication between the departments and creates an area to shelter in the harsh wind and sun of the desert climate. The courtyard with the landscape created with endemic plants is an outdoor waiting room. In addition to all these features, the photovoltaic panels placed on the roof make the building sustainable by meeting more than 85% of the electricity need of the building, which is located in a sunny area, during the day 'Fig.10'(Url-6).

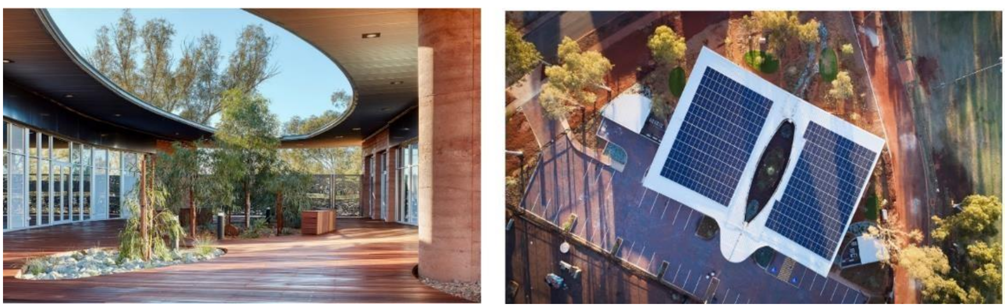

Figure 10. Puntukurnu Aboriginal Health Service Courtyard and Roof (Url-6)

The intended success of the project was achieved, and the need for local residents to leave their families in Newman at great costs, go to another city and undergo a negative psychological process was left behind. Cultural ties between local Aboriginal communities and other communities living in the region have been strengthened and a work of art has been put forward in which cultural beliefs and a sense of community ownership representative of dreams have developed with the use of decamped land (Url-6).

3.4. MUYINGA LIBRARY

The 1,500-square-foot Library of Muyinga was established on the campus of a boarding school for deaf children in northeastern Burundi, with the aim of providing social interaction and educational support to children in this group without exclusion 'Figs.11 and 12' (Url-7).

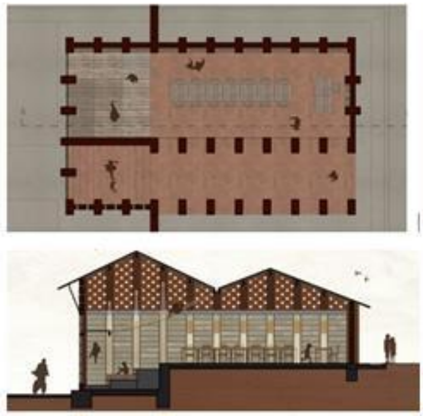

Figure 11 & Figure 12. Muyinga Library's façade, plan, section (Url-6)

Reintegrating deaf and blind communities, who are excluded from education and often isolated in Burundi culture, as intended in this project (community integration) is a very important social movement. The project was implemented with a participatory team including local workforce, young architects and architecture students. The team had a learning and production period by experiencing the processes of the building in the workshops created 'Fig. 13' (Url-8).

Figure 13. Muyinga Library Construction Process (Url-8).

According to the climate, special material selection, volume and facade designs were made in the building. Using compressed earth brick blocks and baked roof tiles; A library structure with high body walls and a porch roof was built. By leaving rhythmic spaces on the façade, a bright image is obtained in the evenings, while cross ventilation is provided against humidity and heat in the interior. The porch corridor, which is included in the local housing typology, is also used in the library structure, playing an important role in providing protection from heavy rain and harsh sun. By keeping the corridor porch larger, it has been tried to obtain a social area where community relations are strengthened. It is tried to provide interaction with transparent doors on the surface facing the porch from the interior. The mezzanine floor created with a large hammock on the street side and the sitting areas made of wood offer the opportunity to dream while reading 'Fig. 13' (Url-9).

Figure 13. Muyinga Library Construction Process (Url-10)

The existing slope is transformed into playgrounds and courtyards with landscaping. The combination of the local materials and techniques used with contemporary sustainable design principles, and the socially unifying feature it provides in the society, is of great importance for Burundi in terms of a sustainable future.

CONCLUSION

Although it is part of different communities, one of the things that has not changed for people is the need for a sheltered shell in which they can take refuge. This need, together with the increasing population, has turned into materials and designs that have been processed and used without considering the effects on human health that have arisen after the unconscious consumption of natural resources. This situation appears as a problem today. Sustainable use of materials in building formation will be the right choice in solving the problem.

In today's conditions when resources are scarce, soil use in contemporary architecture is seen as a good alternative to other natural materials when its sustainable properties are compared. When the examples examined in this context are evaluated in this study, the use of soil as a building material provides many benefits in terms of economic, ecological, social and cultural aspects. Many of the buildings selected as examples are located in areas where communities live below a certain level economically. The choice of land use in the design, by building local materials with local craftsmen and participating individuals; Economy has been achieved in terms of transportation, out-of-town master and qualified team expenses. During the construction process, local people were both educated and part of a unifying community movement as they experienced and learned how to build. While buildings with primary priority such as education and hospitals are brought to the regions; In addition to the comfort features offered by the earthen material, these earthen structures were equipped with contemporary sustainable techniques, resulting in sustainable buildings that are self-sufficient in terms of energy. When evaluated for the whole of the buildings; The sensitivities shown in the designs in terms of adapting to the geography and climate they are in draw attention. Especially in these regions where the sun and wind have harsh effects, solutions with courtyards and landscaping, conservation of water and other resources have led to the emergence of structures intertwined with nature. The strengthening of cultural ties and the development of a peaceful life are witnessed in the communities using these structures.

As a result, in today's conditions, there is a need for comfortable and environmentally compatible structure formations where resource consumption can be kept at a minimum level. In this regard, adobe meets the sustainability criteria with its features of production with contemporary techniques and integration with contemporary materials, while enabling communities to build their own structures in harmony with their own culture and ecology.

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49- Challenges of the Modern Earth Architecture Practices:Indian Scenario

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ABSTRACT

The benefits of earth architecture in terms of environmental sustainability, climate responsiveness and cost-effectiveness have been proven in the literature. Locally available mud has been used as the vernacular construction material for centuries. However, in the modern-day, they are classified as temporary structures and are increasingly discouraged in India, considering their vulnerability to natural hazards like cyclones. Instead, a few modern earth architecture techniques have evolved that harnessed the benefits of using earth and structurally perform similar to brick and concrete structures. One such technique is Cement Stabilized Earth Blocks, where the blocks are made out of the earth with a mix of a small proportion of cement. In contemporary construction practices in India, project performances are frequently measured in terms of time, cost, and structural performance. Compared to the prevalence of conventional materials, earth architecture practices in India are still limited to small scale sporadic projects. There is less research on project management of earthen structures, and this paper intends to fill this gap. This paper aims to critically appraise the challenges faced in using Cement Stabilized Earth Blocks at all stages of the project life cycle. The methodology involved dialogue with engineers, contractors, architects, and occupants of modern earth structures and trace the challenges faced in five projects. The research found that the structures which finished in exposed blocks needed to take extra measures for weather protection. The use of modern earthen material does not have cultural popularity and is accepted only by self-motivated, environmentally conscious individuals. Scepticism related to its structural performance prevails. Availability of skilled workers and equipment locally is minimal, and assembling a team often results in time and cost escalation. Earth blocks do not match commercial and real estate projects' rapid and massive construction or cost expectations. Further innovation and policy governance are needed for earth architecture to compete with conventional techniques.

Keywords: Stabilized mud earth blocks, conventional techniques, local availability, implementation challenges

1. INTRODUCTION

The construction sector is responsible for 39% of CO2 related energy use resulting in emissions of which building material is responsible for 11% [1]. In the era of climate change, the challenge to the construction sector is two-fold – one, to adopt environmentally sustainable practices in its techniques, designs and materials to reduce emissions; and two, to cope with the increasing demand for cooling buildings in light of increasing temperatures and events of heat waves [2]. Mud is a natural material which has been used extensively in vernacular architecture. It has proven through the test of time that it is climate-responsive in terms of mitigating the adverse impacts as well as an apt option of sustainable material [3]. Innovations in mud technology like cob, adobe and compressed stabilized earth blocks (CSEB) can fulfil modern architecture requirements as well as the objectives of sustainability of the construction sector [4]. Past literature has listed many advantages of mud architecture: eco-friendliness and recyclability, reusability, cost-effectiveness, local availability, self-construction, promotion of local culture and handicrafts, durability, pleasing aesthetics, etc [5, 6]. Structures made of mud have a very low carbon footprint. CSEB is considered a green product and earns credits in green building ratings. Reddy, et al. [7] have demonstrated that the strength of modern or engineered earth materials like CSEB can be made comparable to other conventional materials.

There have been several efforts to promote mud architecture by the government, NGOs and research institutes. The United Nations Industrial Development Organization has published a technical manual on the production and use of mud stabilized blocks that give the know-how of what is involved in the block making process [8]. Several state governments, housing boards, and housing financers in India have endorsed the technology and promoted it in various forums. However, it is not one of the conventional materials, nor is it popularly known. Mud architecture has always had a people-centric approach traditionally and in modern times. It is difficult for large agencies and corporates to adopt it or even disseminate the knowledge. The requirement of the involvement of the local community and the residents and the user-friendliness in the construction process makes it more appropriate for rural construction. And yet it has not been adequately incorporated into national housing policies due to the feasibility of making earthen blocks depending on the soil type, which massively varies throughout the country [9]. Several other reasons ail the adoption and use of CSEB. Through the case of five projects that have used CSEB, this paper traces the challenges faced in using CSEB throughout the project lifecycle and discusses the probable reasons for CSEB not being used extensively in urban India.

2. LIFE CYCLE PROJECTS USING CSEB

The lifecycle approach gives a holistic view of the challenges and enables dealing with them in a phased manner. Like any other project, construction projects have a distinct start and finish. Based on the lifecycle of a construction project, the phases of projects using CSEB are formulated as shown in **Error! Reference source not found.**. As CSEB is adopted chiefly in self-motivated construction projects of individuals, the phases of the project reflect the lifecycle of a small scale independent construction project suitable to the case projects selected. It is modified from established construction project lifecycles available in the literature [10, 11]. The first phase of planning includes project initiation and land assembly, architectural and structural design including CSEB and other climate-responsive sustainable features consideration, the feasibility of CSEB, project costing with CSEB and conventional materials, resource availability and consulting. Project planning is rooted in the interests and abilities of the property owner, socio-cultural challenges, procurement ease etc. The second, i.e. execution phase, is more concerning with the contractor who deals with the workers, site, material, equipment and construction. Manufacturing and use of CSEB are at this phase. Phase three of occupancy is the concern of the occupants where they experience the benefits of CSEB and deal with maintenance. Phase four of closure concerns the owner and is monitory, where he deals with the procedure of sale transactions or value of demolition and reuse.

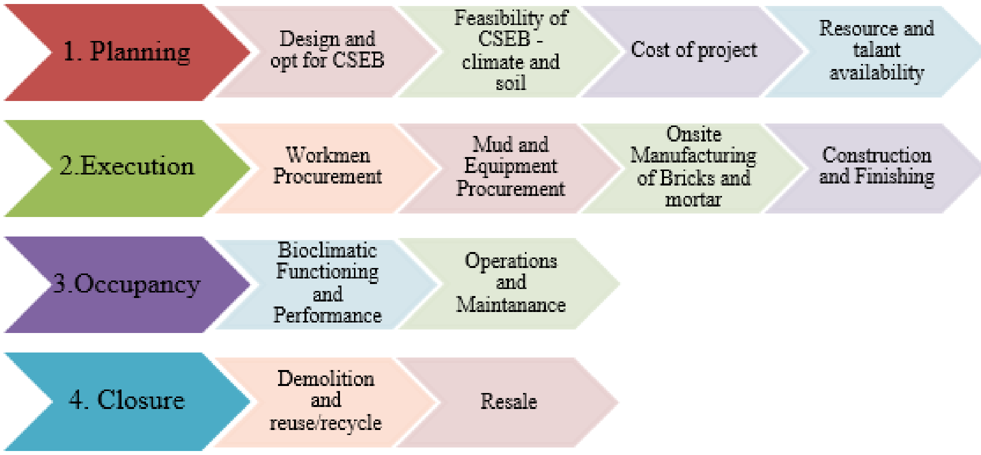

Figure 1. Lifecycle of a Project using CSEB

The phases in the lifecycle of the projects are used in later sections of this paper to elaborate upon the challenges faced in CSEB use in each phase.

3. METHODOLOGY

3.1. METHODOLOGY FOLLOWED

This research mainly dwells on the implementation challenges of projects using CSEB. Therefore, five such projects were identified. Semistructured interviews were conducted with the occupants of those projects to understand their motivation for adopting CSEB, their socio-cultural difficulties, and post-occupancy challenges. Semistructured interviews were also conducted with other architects using CSEB to understand the challenges in designing buildings, idea pitching to clients, workers, material procurement, and aesthetics. Interviews with the contractors and engineers were vital to understanding the challenges of working with mud, skillset availability and training of the workers, space, time and techniques required and challenges related to them. Informal discussions with professional realtors were also carried out to understand why CSEB is not seen as an option for corporates. Through the conversation, certain challenges seemed imminent, and they were compiled and documented.

3.2. COMPRESSED STABILIZED EARTH BLOCKS (CSEB)

CSEB is made from damp soil which is mixed with 5 to 10 per cent of a chemical binding agent such as Portland cement for stabilization, then compressed at high pressure to form blocks. The soil composition for cement stabilized blocks is recommended to be 15% gravel, 15% silt, 50% sand and 20% clay. The soil should not have organic content, salt, or other chemicals. There are mechanical and hydraulic machines available for pressing the blocks. However, manual machines are more prevalent for onsite processes due to ease of use and affordability. The blocks used in the case studies in this research were manually made. The pressing is required to achieve higher density, reduce water absorption and attain compressive strength. The blocks need 28 days to gain strength. For the same, freshly made bricks are placed on a flat surface and cured with water twice or thrice a day for 14 days and then sun-dried for 14 days. Sun-drying reduces CO_2 emissions but requires space and time. These blocks then can be used to construct walls using standard bricklaying and masonry techniques. Mud mortar (with a small proportion of cement) can be used for homogeneous bonding of the blocks [8].

3.3. BIOCLIMATIC PERFORMANCE OF CSEB

The production of CSEB has much lesser embodied energy than other contemporary materials as the mud is locally sourced mainly from the site itself. No form of energy is used in manually made blocks. Mud being a natural material, the healthy living in earthen homes is primarily extended to living spaces made of CSEB. Bioclimatic performance in terms of thermal comfort rendered by CSEB is significantly better than other bricks or cement blocks [12]. The blocks absorb the heat from the sun during the day, making interiors cool and radiate back during the night, making them warm. Due to the higher thermal lag offered by mud, the walls have natural insulation and remain cool on summer days and warm in winter, which is very suitable for the climate in most parts of India [13]. The thermal mass of the walls is directly linked to the thickness of the wall (the more the thickness, the more the thermal mass). The need for artificial cooling can be further reduced if CSEB is coupled with other passive climatic response techniques of ventilation, positioning and size of openings for stack and venturi effects. The sand in the blocks gives the porosity to the walls, which acts as a humidity performer, controls indoor humidity and prevents cracking. This advantage may be negligible in areas receiving heavy rainfall and colder climatic regions receiving snow and not receiving ample sunlight (in cooler climatic regions of India, which do not receive snow and temperatures don't drop below zero degrees, the CSEB houses remain warm). The bioclimatic performance is best with exposed CSEB or with mud plaster. Cement plaster and painting have reverse properties, and the performance of CSEB is then nullified.

3.4. PROFILE OF CASE STUDIES

As shown in Figure 2, the selected five case studies are from the inland districts of the southern state of Tamil Nadu, India, which has a warm and humid climate. All the projects are load-bearing structures with a stone foundation for residential purposes. Project A is under construction and is expected to be completed in 2022. Project B was completed in 2010. Project F, completed in 2011, is in the vicinity of B, where the owner took inspiration and self-built with the village masons without the involvement of an architect. A, B and F are located in rural areas, and CSEB were made onsite. The mud from the site was used, and additionally, mud was procured from the vicinity (own farmland) as excavated soil was insufficient. Project C and E are in urban areas. Project E was first completed in 2006 but was partly demolished due to road widening and then again expanded and renovated in 2016. Project C was designed to be constructed with CSEB, but the soil at the site is clay and is not suitable for CSEB. Procuring mud is posing a challenge due to sand mining regulations in the state. Hence the plan now is to procure the CSEB from a neighbouring state 350 kilometers away. The burnt brick structure seen in the image is the pit for rainwater harvesting (compulsory in the state). Images shown in D are of onsite block preparation of project B.

Figure 2. Images of the case studies

4. ANALYSIS AND DISCUSSION

4.1. CHALLENGE OF MARKETING CSEB IN THE CORPORATE WORLD

Given that India is urbanizing and mega construction activities are happening in the cities, techniques like CSEB, to have an apparent environmental benefit, need to be extensively used in the cities. Until recently, apart from infrastructure, the major construction activities were self-led, meant for their own use. Therefore, individuals or families were deeply involved in the entire project's lifecycle. But now, particularly in Indian cities, real estate is in boom as demand for investment in properties rose [14, 15]. They are looked upon as one of the primary long term investment options that also have short term utility. Houses, shops, industrial units, and offices are now becoming products delivered by corporate houses that have adopted the retail cycle of production, marketing, sale and service. The projects are evaluated more in terms of cost, time and efficiency, and the choice of material is subjected to profit margins. Due to exorbitant land prices, the residential segment is tilting towards group housing, the commercial segment is getting organized into complexes, manufacturing into industrial hubs and so on. Conventional building materials are now manufactured in masses and provide the economy of scale to become cheaper. The corporate retail segment does not choose to use CSEB for several reasons. Firstly, easy procurement CSEB is not possible as they are not manufactured in bulk in factories. There are stringent rules against sand/mud mining in almost all parts of India to protect water bodies and fertile soil. This prevents mainstreaming CSEB through the principles of demand, production and supply. In highrise construction, the structural requirements are fulfilled by reinforced concrete columns, beams and slabs, and bricks can be used for walls. The option is that for mega construction sites like townships with high rise buildings, the CSEB can be produced onsite like the cement batching plants. However, they compete with manufactured bricks or autoclaved aerated concrete blocks. In highrise, as the bricks don't have any structural function, they are preferred to be lightweight, and CSEB loses on that front to other materials. Also, it is simply economic to procure materials for mass construction rather than manufacture them onsite. Thus, CSEB is a lifestyle choice that only the very affluent who can afford the land price can make in cities. Institutional buildings and small scale construction in small towns and villages are the only clientele right now for CSEB. The challenges for this segment are discussed in the next part of this paper. Even though using mud was prevalent in vernacular houses, choosing to use CSEB now has become a conscious individual endeavour. Government policies that promote earth architecture have a 'do-it-yourself' outlook. The policies need to be more aggressive if CSEB is tobe adopted as a mainstream construction material in the future.

4.2. CHALLENGES OF USING CSEB IN SMALL SCALE CONSTRUCTION PROJECTS

The socio-cultural and technical challenges encountered during each project phase using CSEB are discussed here. It is based on the interactions with the owners, architects, contractors and consultants of the selected projects.

4.2.1. PLANNING PHASE

Building a home is an owner's deep financial and emotional investment. Choosing to adopt CSEB in his personal dream project is a distinct endeavour where the owners have to struggle with the lack of general awareness that creates scepticism among family and friends influencing his decision. Lack of awareness is one of the critical hindrances in popularizing CSEB. The use of mud for homes is not perceived as modern by the general populace, which then is linked with the family's socioeconomic status. Mud houses are also deemed as a 'kutcha' (temporary) for official purposes based on their vulnerability to floods and cyclones [16]. Even though the use of CSEB, as it has cement mix, would be a 'pucca' (permanent) structure (it is an officially recognized material for construction), apprehension prevails among the local populace. The fear of the masses that the blocks may dissolve during the rains is hard to overcome. Hence, even if one is willing to adopt CSEB, he will only go for it if he has a solid and experienced recommendation or his close family or neighbours have used it. The aesthetics of exposed CSEB or mud plaster is not appealing to some compared to sleek finishing materials. The mud colour varies in every site, making it difficult to simulate the aesthetics of the final form, and the expectations of colour may not be fulfilled. The consciousness of the outsider's (visitor's) opinion of their home runs gravely deep in Indian society, and they feel that earthy finishing or exposed finish (unfortunately perceived as unfinished) would not be as impressive.

Even if these socio-cultural issues are overcome, there are other challenges. As the soil from the site may be used to make the blocks, soil testing and suitability are essential. The soil may not have a suitable composition or strength or may have salt content making it unusable. Procuring mud or mud blocks is expensive and difficult in the absence of industrial manufacturing. Government officials and locals may have objections if the soil is mined from nearby areas like ponds, which may be illegal.

Extra care needs to be taken in designing for the use of CSEB in cold climates or areas of heavy rainfall. Sun-drying may be a challenge in areas receiving rainfall for a large part of the year, and additional steps are required to weatherproof and protect the blocks. Good workmanship is required to carry out electrical and plumbing works if the structure is exposed. There are limited options for selecting the team of architects - contractors, and workmen. A team from outside the local area may not be conversant with the texture and composition of locally found mud.

Construction cost with CSEB is only marginally less than conventional materials (as they have the cost-effectiveness of the economy of scale). An additional cost is incurred if mud has to be procured, the team has is from outside the region, or local workers have to be trained, and extra time is required to achieve a uniform and precise exposed finish. The lifecycle cost may be low as the need for painting and repainting etc., is not incurred. However, that is not a consideration at the beginning of the project. It is often expected that the cost of an exposed finish structure should be the same or lesser than a conventional unfinished structure, which is not the reality.

4.2.2. EXECUTION PHASE

Traditionally mud construction has been an artisan's work carried out by families with knowledge building and transfer for generations. However, in India, the construction workers are from common families of marginal income, and most learn the skills on the job. The workers are hired and managed by contractors who have commissioned the work. Te contractors may or may not be trained professionals. There is no concept of professionally trained workmen. Even though there are training institutes, it is not feasible for the actual workmen to train themselves or the contractor to get them trained professionally. The skills required to make the CSEB onsite and using them are atypical, and it is a challenge to find an experienced team or train new workers.

If the soil from the site is unsuitable for CSEB or insufficient (as excavated earth may not be sufficient if the built-up area is more), it is challenging to procure the mud. In light of increasing laws against the exploitation of fertile soil and river beds, sourcing mud is increasingly impossible. This is a real threat in executing projects using CSEB (even if it stands true for cement-based blocks of burnt bricks).

There must be sufficient space for stacking and drying the bricks during onsite manufacturing. It is challenging to get that kind of space in small plots, especially in urban areas. Achieving the consistency in the composition of the mud mixture is critical to achieving the required strength, as failing to do so could have a long term structural threat. Regular maintenance of block making machines and their proper setup is essential in producing uniform sized blocks. The weight, composition, and density should be the same for every block, which must be closely monitored. If the pressing of the blocks is improper, then the compressive strength may be reduced. The brick-making process is time-consuming, and it is necessary to plan the process considering site conditions, weather, workers' availability etc. If site conditions do not permit, the blocks must be made parallelly with construction in batches.

Construction and finishing using CSEB is the same as the conventional process but needs meticulous efforts if finished in exposed masonry, which is preferential for aesthetics of mud colour and cost-effectiveness. The quality in alignment, uniformity, accuracy, etc., required in masonry is absolute, along with preciseness in the use of mortar. 'Pointing' job in the masonry is essential. This level of quality requires patience and attention to detail, resulting in extra time for the job. The trend in construction contracting of houses in India is to charge as per square unit of area to be constructed (eg., 1200 rupees per square foot charged by some contractors who quote low and do so by compromising the quality). In conventional techniques, the finishing in terms of joinery and mortar thickness is compromised to achieve speed, as ultimately, the masonry will be plastered and painted. Because of this, contracting with the CSEB team is turning out to be expensive as time is spent perfecting the finishes during masonry work, deterring the cost benefits. It is very difficult to convince people to opt for CSEB blocks in such a scenario.

4.2.3. OCCUPANCY PHASE

If the occupants prefer the aesthetics and indoor ambience of exposed finish, living in such a space would be healthy and pleasurable. Suppose the structure has also adopted other climate-responsive features such as curated opening for air pressure control, filler slab or traditional roof or white painted roof (to increase reflectance), skylights, clay/ mud flooring etc. In that case, the thermal comfort and indoor air quality can be felt in hot and dry, composite and warm and humid climatic conditions. Occupants particularly seem to love the aroma of wet soil during occasional rains. However, the bioclimatic performance of CSEB is only comparatively better. With the increase in the overall temperatures worldwide and occurrences of heatwaves, the need for active cooling is apparent even in earthen dwellings.

Structured finished in exposed CSEB requires minimal maintenance as there is no requirement for painting. However, in case of damages, like cracks, it is very difficult to repair without affecting the aesthetics. Occupants have to be careful with permanent stains on walls, hammering nails, etc. They cannot be removed easily as opposed to conventional structures. It may be difficult to find workers for such a job during occupancy. Many houses, particularly in rural India, are incrementally built depending on the household finances and changing family size. In the case of future extension, it may not be possible to have the same quality due to changes in the team or restrictions on mud availability (no excavation may be possible or required). The exposed finish is also prone to external damages due to weather or human activities, and special treatment is needed to prevent weeds.

4.2.4. CLOSURE PHASE

At the end of one owner's occupancy, in case of demolition, it is much easier to recycle the CSEB.

However, the same socio-cultural challenges are faced in the case of resale as the prospective buyers will have the same scepticism. Mud structures, moreover, may be valued lesser than similar conventional structures due to the criteria followed for valuations. However, most of the structures using CSEB in contemporary structures are designed by prominent architects and patronized by netizens and the media, which may result in commercial value addition to the property.

Many of the challenges mentioned in the lifecycle phases will be addressed if the use of CSEB becomes more prevalent with the support of the community and government, and commercial manufacturing is permitted even if it is regulated. This will result in the experience of more workers making and using CSEB, and they will be available locally. There are certain aspects such as resilience to whether and repairs where more research is required. Project management for CSEB is necessary to improvise the time and cost management and ease of maintenance.

CONCLUSION

It is concluded that CSEB, a modern mud architecture technique, can be used for construction suiting contemporary structural and space standard requirements and have comparatively better bioclimatic performance. CSEB is well researched and is accepted and endorsed by several national and international agencies. However, their use is not popular among the masses, nor are they a conventional technique and are opted for only by self-determined individuals. Due to the non-commercial handicraft nature of CSEB, the struggles in using them are many. Most of the challenges can be linked to the unavailability of commercially manufactured CSEB due to sand mining regulations (to protect water bodies and fertile soil for exploitation). If the soil from the site is not suitable or sufficient, then the mud or blocks cannot be procured easily in urban areas. There is a shortage of workers team as there is no formal training, and regular masons simply did not have the opportunity to learn CSEB techniques on the job. Making blocks and using them is a meticulous job that requires patience and time. Also, the quality of finishing required for an exposed finish is high, requiring additional time. As a result, the use of CSEB is more time consuming than the prevailing construction speed. For the contractor, constructing in CSEB may not be profitable if there are issues in procurement. The general scarcity of the required resources leads to cost escalation and difficulty in further repair and expansion. Maintenance of exposed finish requires separate measures for weather protection. There are heightened socio-cultural impediments to using CSEB. Mud is considered vernacular and not accepted as modern, rustic aesthetics of mud plaster or exposed finish is not appealing, fear of structural stability concerns the masses etc. This not only discourages the owners but also may affect the resale value. Thereforeto promote mud architecture for its environmental sustainability values, it is necessary to generate awareness, promote extensive usage supported by industrial manufacturing and strengthen project management through research.

DECLARATION

Project reference: Author Noel Jerald Victor and Biome Environmental Solutions, Bangalore
Due permission was taken from the project owners to document the contents relating to their project, including photographs. The authors declare no conflict of interest.

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50- Building with Salt (the components, affect and technique)

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ABSTRACT

Salt is an element of the natural environment, which is used in construction in some regions and countries, such as in Siwa Oasis, Egypt. It's a natural element that may form around salty lakes over the years or in the form of masses closer to rocks, it has a significant positive effect on human health and psychological calm, it is using in some buildings for the purpose of making separate rooms for meditation or relaxation or making entire walls within a space. Therefore, it is important to recognize this environmental material as an element that can be used and making it a part of the environmental healthy house, Siwa Oasis in Egypt is known for this type of buildings, as a whole building and not just a part of the building. But the material used in the buildings of Siwa Oasis in Egypt is called Karshef, and it is a material in which the salt formed around the salt lakes and was mixed with atmospheric factors like dust and other elements formed over the years to form that solid material suitable for construction which called Karshef. In this paper we will present salt as an individually substance, and its health advantages to humans, not just to the environment, the technique and presenting some suggestions that may add a positive addition when using this material in any building.

Keywords: Salt building, back to earth, Karshif, Siwa Oasis, earth architecture, meditation spaces, Himalayan walls

1. INTRODUCTION

In the past salt was mostly used in cooking and for food conservation, with a growing world population, the amount of salt (sodium chloride) produced as waste through seawater desalination processes is increasing, most of it is disposed of into nature where it causes environmental pollution. On the other hand, salt can be used therapeutically in various respiratory treatments. So, using salt as a building material may increase resource efficiency while reducing the pollution. And it was necessary to determine salt materials already in use in building construction. As salt can deactivate the growth of microorganisms and is used not only therapeutically in various respiratory treatments but also for skin diseases. It has already been used as a building material thousands of years ago in Siwa Oasis - Egypt, and other ancient cities in the world. It is an environmentally friendly and renewable material that we seek to exploit in architecture in an appropriate manner for each environment. And work to develop it, either by adding other supporting and strengthening materials to it or by using it as a raw material. Therefore, in this paper, we will learn about the types of salt, methods, and places of extraction, and how it can be used in architecture.

2. THE SALT COMPONENTS

Salts are defined as components of positively charged ions, and negatively charged ions. And mainly consists of Sodium chloride (NaCl), or common salt, is the most known of all salts and consists of Na (Sodium) and Cl (Chloride) ions. It can be found underground as salt rocks or in mine and salty lakes.

Sodium chloride has an international standard that is created by ASTM International. The standard is named ASTM E534-13 and is the standard test methods for chemical analysis of sodium chloride. These methods listed provide procedures for analyzing sodium chloride to determine whether it is suitable for its intended use and application (URL2).

Frequently, salt in the field of building construction is related to damage of buildings. With the increasing water content in brick masonry, salt dissolves and moves together with water through the capillary pores. In drier and hotter climate conditions, the water evaporates, and salt crystalizes. Salt crystallization in the capillary pores produces an interior pressure and can cause deteriorationand efflorescence of the brick (URL1).

Despite the problems that salt can cause in buildings, this is if it is treated as a dissolved compound within building materials, but it can optimize indoor air quality if uses for building houses if it used as a separate building material. In construction, salt also is added to secure the soil and to provide firmness to the foundation on which highways are built.

Figure 1. The salt crystal, separated and on the wall

3. THE SALT TYPES ARE USING IN CONSTRUCTION

There are three types of salt, raw salt "RS", processed salt materials (PS) and composite salt materials (CS). We will find most historical examples of (RS) have a common harsh climate that very hot and dry, and specific location like near salt lakes and salt mines, and frequently unavailability of other local building materials.

Other RS materials are rock salts from salt mines with bulk density from 1,920 kg/m3 to 2,160 kg/m3, low porosity (0.6–7.2%), specific heat capacity around 865 J/kgK, thermal conductivity from 2.65 to 6.65 W/(mK), widely varied hygroscopic properties due to different additive contents, and compressive strength ranging from 3.3 to 20.7 MPa. Pink salt blocks are the most conventionalrock salts and are used in the interiors of spas, restaurants, and residences (URL1).

Composite salt (CS) materials are combinations occurred between salt and local materials such as clay or volcanic ash or dust, that called Karshif, Karshif is a salt block (NaCl) clay mixed with sand naturally, which is dried under direct sun exposure and then used as a "brick" in the Karshif building technique found in Siwa Oasis in Egypt, Tafla is using as a mortar between Karshif blocks.

4. EXTRACTION OF SALT MASSES PROCESS & BRICK MAKING

We may find many sources of salt, including those resulting from desalination of sea and ocean water, as well as salt lakes in which salt masses were formed over time around it and in the bottom, such as the city Taghaza in Mali, from lakes in Siwa Oasis – Egypt, where they were using the blocks of raw salt in building, or Himalaya salt blocks from mines.

At more than 75.3% relative humidity, the pores in salt are filled with water, the crystals start to dissolve, and brine is formed. If relative humidity decreases, the brine evaporates, and re-crystallization takes place. This repeating process within salt generates strong connections between crystals and throughout history, therefore, has been used to create strong materials (URL1).



Figure 2. The salt blocks after extracting, Taghaza-Mali (URL4); Figure 3. Extracting salt rocks from lakes, Siwa Oasis-Egypt; Figure 4. The salt crystals, Dallol-Ethiopia (URL6)

Due to the climatic conditions in Siwa Oasis, which are characterized by drought and high temperatures, the movement of water in the salty lakes between salt and mud leads to the formation of new salt crystals, characterized by high resistance in construction, and it was found that the oldest rock blocks consist of approximately 95% salt.

Salt rocks are formed at a depth of approximately 50-70 cm. As we mentioned earlier, they are salt crystals that were formed over the years due to the movement of salt water with mud, it takes about 11-15 years until the mass is formed. As one of the specialists in extracting salt rock from the bottom of the lakes in Siwa mentioned and he said, how to know the completion of the growth of the rock mass to be extracted, this appears in the form of salt interactions with a thickness of approximately 5-6 cm on the surface of the water. When the mass is not yet complete to be extracted, the water surface is completely flat, and when it is complete, the surface of the water begins to appear on it as if there are reactions at the bottom. And to extract the rocks from the lake's bottom, it takes place in several stages.

The first stage: the layer of mud covering the surface of the rock mass, which is about 30-40 cm, is removed until the material under the mud appears.

The second stage: extracting salt rock from the water, cleaning it and left in the air under the sun for 30-40 days and sometimes 60 days until the salt expels the amount of moisture stored in it and acquires the appropriate hardness for the construction process.

The size of the blocks that are extracted from the lakes are 1-1.3 m and the thickness is 15-25 cm. as the higher of the evaporation rate, as it is easier to be extracted. Excavators are used to extract the salt blocks.

The last stage: preparing the rock for cutting into molds after cleaning from the mud impurities because of the mud layer that covered it under the water.

Karshif stone shows the highest thermal conductivity and the lowest specific heat capacity. However, if the humidity exceeds 76%, the sodium chloride in the Karshif stones starts to melt, and if the humidity less than 76% the sodium chloride crystals start to grow.

Figure 5. The Salt rocks after extracting and preparing for cutting and cleaning, Siwa Oasis-Egypt (URL1, video)



Figure 6. The Salt rocks after extracting and preparing for cutting and cleaning, Siwa Oasis-Egypt (author, R. Elborgy); Figure 7 & Figure 8. Cutting and shaping the salt rocks in forming to use, Siwa Oasis-Egypt (URL1, video)


Figure 9 & Figure 10. Preparing the clean blocks for making lamplighter or bricks, Siwa Oasis-Egypt (author, R. Elborgy)

Figure 11 & Figure 12. Extracting the Himalayan salt blocks from the mines, Pakistan (URL2, video)


Figure 13 & Figure 14. Preparing the clean Himalayan salt blocks for making lamplighter and bricks, Pakistan (URL2, video)

5. WALL & SPACES CONSTRUCTION

As for the Himalayan rock salt, it is distinguished by its pink color and is extracted from mines such as in Pakistan. Himalayan salt in the mines can be found in layers of crystals salt formed over centuries of years because of the confinement and evaporation of sea water and the concentration of sea salt in this place. The percentage of sodium chloride in Himalayan salt is about 98%.

Whether the salt blocks extracted from lakes in Siwa or the mines in Pakistan, we find that the blocks of salt after the extraction process go through the same stages of cleaning, cutting, and preparing for use, whether in making lighting lamps or relaxing elements or making salt bricks for use in the construction process.

Regarding the use of salt as a building material, the climatic conditions have to be usually hot and dry, which greatly controlls salt rock use, and the extent of salt availability in the surrounding environment, such as in the Siwa Oasis - Egypt. In ancient building techniques, salt blocks were connected by the mortar available in the surrounding environment, and due to dry weather factors, the adhesion of the mortar with the salt blocks increased with time.

Recently, it has become possible to use salt bricks of specific sizes as interior walls, whether for a room in the house or for a separate interior wall, through wall cladding or plastering. The use of traditional building techniques requires high craftsmanship and a long time, whether in the construction of the external or internal walls of the building, and although they are the best, but modern design must also be considered for the use of salt blocks, and the humidity must be studied and considered that does not exceed 70%, and the temperature in the Location internally and climatic conditions externally must be studied.

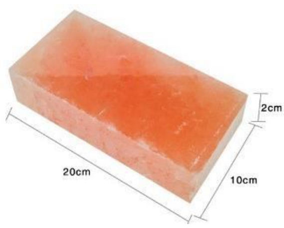

Figure 15. The dimensions of Himalayan salt bricks are using in building walls

As for the process of constructing an external wall, in the traditional and well-known construction methods in Siwa Oasis-Egypt, for example, we find that the construction with irregularly shaped Karshif blocks is connected by clay mortar, and over the years the bond between mortar and salt blocks is strengthened.

The process is simple in the technique in which it is carried out, but it requires time and professional skill to deal with the Karshif.

As for the internal cladding process, it can be explained in points as follows:

1. Preparing the wall that will be covered with Himalayan salt bricks.
2. Installing horizontal and vertical metal beams in the wall, in the back an aluminum cladding is placed, and lighting elements are placed either on the wall or on the metal beams.
3. The bricks are laid on the metal beams in the form of a brick course, the mortar used is a strong adhesive purposed for salt bricks.

In this way, the interior wall is ready, and the lighting that was previously installed behind the bricks can be controlled by a light organizer. Lighting helps stimulate positive energy from the salt bricks, secondly, it keeps the bricks dry due to the heat they emit.

Figure 16. Stabilizing of Himalayan salt bricks on walls (URL5, video); Figure 17. The aluminum sheet and lighting behind the salt brick (URL5, video)

Figure 18 & Figure 19. Using strong glue specified for Himalayan salt bricks.

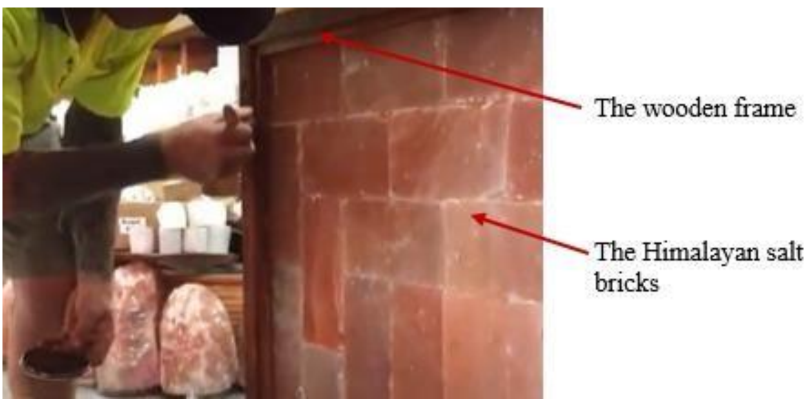

Figure 20. Paint the final outer frame for the Himalayan salt brick cladding

5.1. THE POSITIVE EFFECT OF SALT ON OUR BODIES

Salt uses a natural, basic mineral — pure sodium chloride (salt). Sodium chloride is an essential element for the regulation of mucus in the lungs and upper respiratory system. It cleanses the respiratory tract and strengthens lung function by stimulating the body's internal processes.

Cleanses the respiratory tract, improves lung function, strengthens the immune system, helps people breathe more easily, improves skin health.

Emissions from salt materials could provide healthier working or living conditions. Salt is not toxic, is free of chemical emissions and has no odor. salt has positive affect on human health in building.

5.2. EXAMPLES

5.2.1. PALACIO DE SAL HOTEL, SPAIN

The hotel is built from more than one million compact blocks, extracted directly from the surface of the salt flats, and assembled thanks to a paste made from ground salt and water. Every year, after the rainy season, the hotel loses about 10% of its original structure and a reconstruction process begins. The building was constructed with about 1 million 35-cm (14-inch) salt blocks, which are used for the floor, walls, ceiling, and furniture, including beds, tables, chairs, and sculptures. The rooms are unfussy featuring furniture and detailed domes made of salt.



Figure 21. The bedroom built with a salt bricks dome (URL7); Figure 22. An open area with salt brick columns and floor covered by salt (URL7); Figure 23. Sitting room "reception" all furniture made of salt and floor covered by salt (URL7)

5.2.2. ADRÈRE AMELLAL HOTEL, EGYPT

The structures are made of a integration of kershif, stone structure, and carved out dwellings from the large mountain that hosts the lodge. the thick earthen walls (Karshif stone walls) absorb heat during the day and maintain a cool interior, then radiate heat at night when the temperature is low. oil lamps and candles are the only source for light after the sun sets, any electricity is forbidden, the beds are made of rammed cotton and Palm fronds and the simple furnishings made by hand using ancient techniques.



Figure 24. Exterior courtyards connect the sky with the buildings (URL12); Figure 25. The restaurant and candles only for lighting (URL12); Figure 26. Sauna room and walls made of salt bricks (URL12)

CONCLUSION

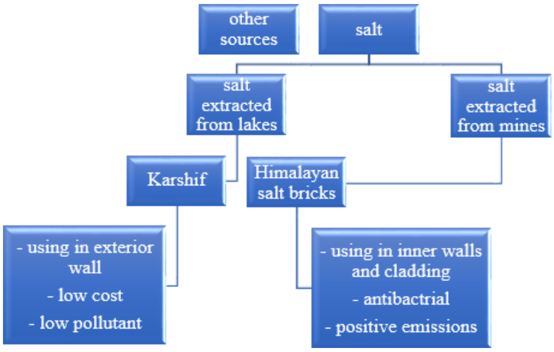

Diagram 1. The salt elements that has been shown in the paper

Salt is an element and a renewable material from nature. It has been known for thousands of years since ancient times. It is famous for its positive impact on human health and the places in which it is located. It has already been used as a building material thousands of years ago in Siwa Oasis - Egypt, and other ancient cities in the world. It is an environmentally friendly and renewable material that we seek to exploit in architecture in an appropriate manner for each environment. And work to develop it, either by adding other supporting and strengthening materials to it or by using it as a raw material.

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51- Designing a Sustainable Workflow for the Fabrication ofBiologically Improved Rammed Earth Blocks

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ABSTRACT

This paper presents the intermediate results of an interdisciplinary research project that aims to improve earth materials with biological additives and develop a design and fabrication system for prefabricated rammed-earth blocks. In the first phase of the research project, a series of laboratory tests are conducted. Earth is stabilized with microorganisms and waste plant additives in order to improve its physical and mechanical properties. Within the context of laboratory tests, three plant waste-incorporated mixes and three bacteria-incorporated mixes are produced. Bacteria and plant wastes are selected considering the goals of the project as being sustainable and harmless to human health while supporting various performances such as lightweight blocks or durability issues. The physical and mechanical properties such as compressive strength, shrinkage and thermal conductivity of the new mixtures are determined. The second phase of the research project covers the methods to integrate the developed earth mixes into the factory production system and manage a sustainable design-fabrication system for biologically improved rammed earth blocks and panels. The production process will be planned in such a way that the least energy is consumed with the least damage to the environment. It is planned to carry out a life cycle assessment (LCA) starting from the obtaining raw material stage including all additives; transportation of the raw materials to the fabrication area, production step of the rammed-earth blocks with the newly proposed material, transportation step of the rammed-earth blocks to the construction site, construction stage, usage, decomposing or recycling stages of blocks at the end of their useful life. With the LCA, the design-production process will be examined in terms of having a sustainable workflow and environmental factors and effects on human health.

Keywords: Rammed-earth, biomaterials, sustainability, prefabrication, life cycle assessment

1. INTRODUCTION

To improve the mechanical and physical properties of earthen building elements, earth has been supported with different stabilization methods and various additives have been applied [1,10,12] throughout the history. The most commonly used stabilization method is a mixture of earth and straw usually used as adobe bricks, in our country. This method is generally used in rural areas and low-rise buildings because it requires intensive labor, long application time and periodic maintenance after application. Işık, complies with the principles of adobe brick and gypsum adobe brick masonry construction materials, which are suitable for sustainability and human health; she has shown its use by applying it in many individual structures and housing settlements with rapid casting in situ or rapid block production on site [7,23]. Various material mixtures, stabilization methods, on-site production, or factory production methods are being explored to increase the use of earthen structures in the city, which have significant potential for sustainable cities and healthy buildings[16]. In the research of additives, cement, fly ash, fibers, vegetable waste, etc., contributions are examples. Cement-added rammed-earth shows high performance in terms of strength, but the use of cement is not suitable in terms of environmental effects [6,7,8,9,13]. ALKER mixture, which was founded by Kafescioglu [8] and the Earth Research Group at ITU, consists of a mixture of earth, gypsum, lime and water, having a similar strength to cement-added rammed-earth mixtures [6,7,8,9,13].

Within the scope of the BIRE-PAN research project (*), the mechanical and physical properties of a typical ALKER mixture were compared with new recipes containing different types of plant additives and microorganisms. Within the scope of the project, the properties of the proposed plant and microorganism-added earth mixtures were determined by several tests . A new mixture (BIRE) to be proposed within the scope of the project will be produced and definite properties will be enhanced with several additives considering the designed building blocks and the design-production system (BIRE-PAN) , blocks, panel and mold prototypes to be made at the factory.

2. BIRE:EARTH MIX DESIGN, TESTING METHODS AND PERFORMANCE

In this study, the production of a sustainable earth mix design with enhanced properties was aimed. Within this context, several waste plant additives and microorganisms are used. Several rammed earth mixes were produced, using locally available earth and waste plants. The plant additives such as ground peanut shell (GPS), ground sunflower stem (GSS) and corn husk (CH) pieces are used to enhance physical and thermal properties. On the other hand, bacteria are used to improve the mechanical properties of the earth mixes through biomineralization [5]. Three types of bacteria, bacillus subtilis, sporosarcina pasteurii, and bacillus subtilis subsp. subtilis, are tested in rammed earth and gypsum+lime stabilized rammed earth mixes and the compressive strength performance was compared.

The earth sample was collected from a depth between 0.5 and 1.5 m from Kemerburgaz, Istanbul. Table 1 shows the properties of the earth used.

Property	Parameters	Details
Atterberg limits	Liquid limit, W_L	36%
	Plastic limit, P_L	18%
	Plasticity index, I_P	18%
Proctor test	Optimum moisture content (OMC)	18%
	Maximum dry density (MDD)	17.3 kN/m^3

Table 1. Properties of the earth

In all mixes, alpha gypsum and CL 80S type air lime were used as physicochemical stabilizers to enhance the mechanical properties. Ground sunflower stem (grains lower than 1 mm), ground peanut shell (grains lower than 0.85 mm) and corn husk having 2-3 cm long and 0.5 cm width were used as plant waste additives (Fig. 1).

Figure 1. (a) Ground peanut shell, (b) ground sunflower stem, (c) corn husk pieces.

A total of five mixes (Table 2) were produced to determine the physical, thermophysical properties, and compressive strength of the mixes. Gypsum and lime were used 10% and 5% by weight of the earth, respectively. The water ratio was kept at 0.25; however, due to high water absorption capacity values of GSS and GPS water ratio increased to 0.28 in those mixes. Plant additives were incorporated by the volume of the mixes. The mixes were coded depending on the plant additives used; *RE* refers to rammed earth, while *SRE* refers to gypsum+lime stabilized mixes.

Mixes	Binders (%)		Plant additives (%)			Water (%)
	Lime	Gypsum	GSS	GPS	CH	
RE	-	-	-	-	-	25
SRE	5	10	-	-	-	25
SRE-GSS	5	10	5	-	-	28
SRE-GPS	5	10	-	5	-	28
SRE-CH	5	10	-	-	1	25

Table 2. Mix proportions of plant additives-incorporated mixes.

Bacteria-incorporated mixes are designated with their commercial numbers, which 6051, 11859 and 23857 define bacillus subtilis, sporosarcina pasteurii, and bacillus subtilis subsp. subtilis, respectively (Table 3). The mixes were coded depending on the bacteria used; RE refers to rammed earth while SRE refers to gypsum+lime-stabilized mixes.

Mixes	Binders (%)		Bacteria (OD_{600})			Water (%)
	Lime	Gypsum	6051	11859	23857	
RE	-	-	-	-	-	25
RE-6051	-	-	3,250	-	-	
RE-11859	-	-	-	4,010	-	
RE-23857	-	-	-	-	1,803	
SRE	5	10	-	-	-	
SRE-6051	5	10	2,475	-	-	
SRE-11859	5	10	-		-	
SRE-23857	5	10	-	3.702	2,262	

6051:Bacillus subtilis, 11859: Bacillus pasteurii, 23857: Bacillus subtilis subsp. subtilis

Table 3. Mix proportions of bacteria-incorporated mixes.

A wooden hammer was used for compacting the samples manually. Rammed earth cube specimens with a size of 50 × 50 ×50 mm were produced for compressive strength measurements on the 7th, 28th, and 90 days. The thermal conductivity of the mixes are determined on rectangular prisms having dimensions of 80 × 40 ×160 mm. Also, drying shrinkage was determined on 40×40×160 mm beam samples.

It was observed that lime and gypsum addition enhanced compressive strength for both early and further ages. Waste plant additives caused a reduction in compressive strength as expected; it was prominent in GSS-added mixes, while CH-added mixes presented only a slight decrement (Fig. 2). On the other hand, plant additives caused lower shrinkage and thermal conductivity values (Figs. 3 and 4). It can be deduced that waste plant additives, GSS, GPS, and CH, can be regarded as a good potential to obtain lower shrinkage and thermal conductivity values in rammed earth materials; however, possible reduction in the compressive strength should be considered.

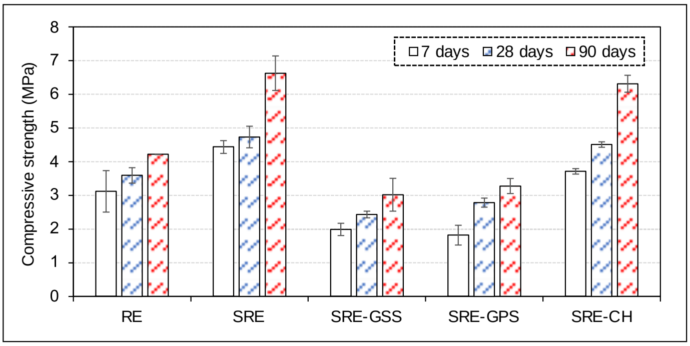

Figure 2. Compressive strength values of rammed earth and plant additives-incorporated mixes.

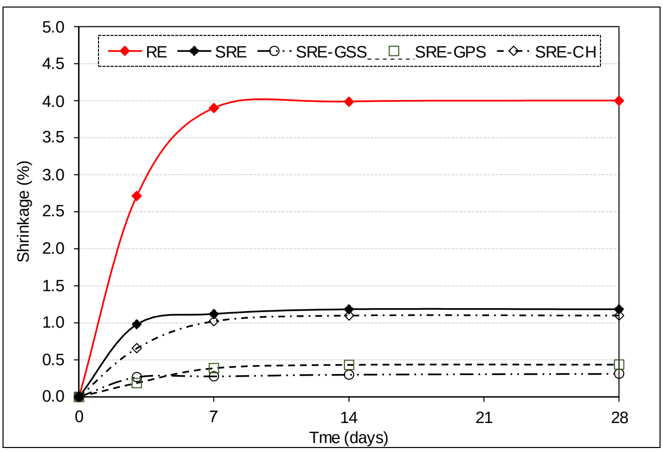

Figure 3. Shrinkage values of rammed earth and plant additives-incorporated mixes.

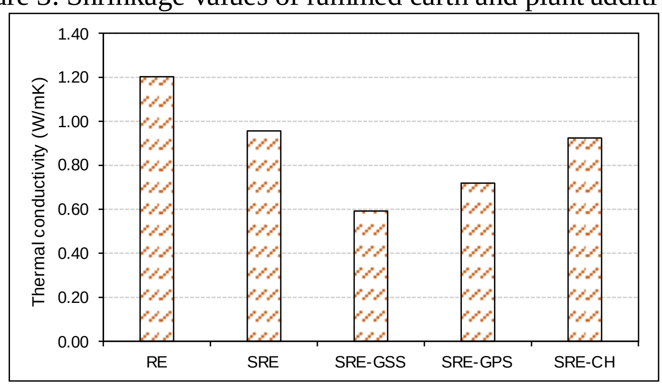

Figure 4. Thermal conductivity values of rammed earth and plant additives-incorporated mixes.

The compressive strength test results of bacteria-incorporated mixes are given in Figs 5 and 6 and it was observed that those mixes presented promising results in terms of compressive strength in the case of gypsum and lime stabilization was applied (Fig. 6). The maximum strength values obtained in the bacillus subtilis incorporated mixes reached higher than 8 MPa at 28 days, representing two times higher values than the reference mix (Fig. 6). 28 days strength values increased significantly compared to the reference stabilized mixes and 7 days results, representing the possible calcite formation which occurs over time [11,15,16]

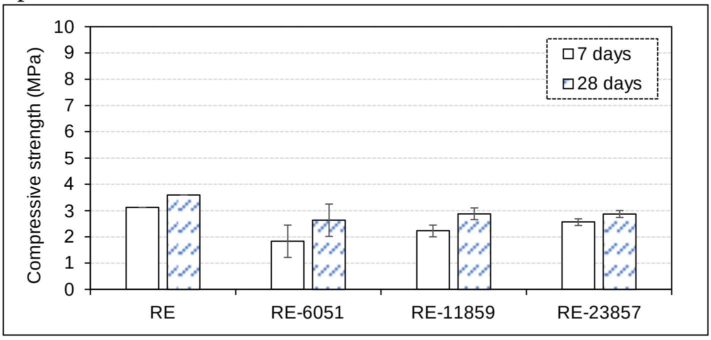

Figure 5. Compressive strength values of bacteria-incorporated mixes.

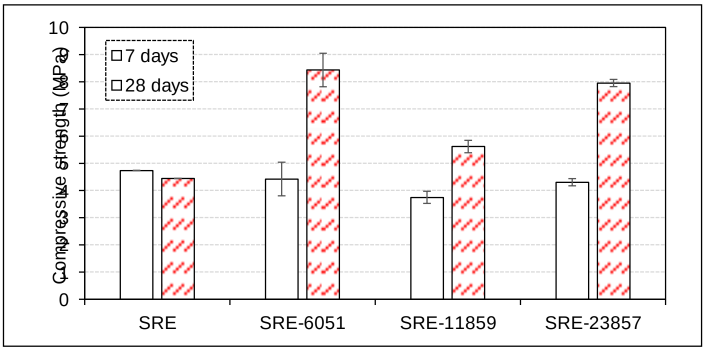

Figure 6. Compressive strength values of stabilized bacteria-incorporated mixes.

3. BIRE-PAN DESIGN AN FABRICATION SYSTEM: DESIGN GUIDE FOR PREFABRICATED RAMMED-EARTH BLOCKS

From the architectural point of view, it is observed that computational techniques enable explorations in earthen block forms and molding techniques. However, these explorations require material research and standardization issues for factory production. As a result of this research project, a context-sensitive design system will be defined as a design guide. This design system will be composed of BIRE blocks that create various types of walls. With the help of material studies and geometric explorations, the performances of these wall types will be evaluated via prototypes[3].

The design system, will be developed using parametric modeling languages included in CAD software. This technology will enable the exploration of design alternatives. The design process of BIRE-PAN's block and panels exhibit major parameters such as lightness, structural strength, and permeability. In general, masonry systems are based on a component-based design logic, which incorporates the combination of basic units into more complex and specialized building components. The design system, which is still under development, will configure these parameters to create a system of solid-void combinations for various functional needs (e.g. wet areas, living spaces, public spaces). It is expected to include not only solid but also semi-permeable wall instances (Fig. 7).

An important issue that should be taken into account in design is that the proposed block/panel systems should have similar deformation characteristics to the load resisting frames of the structure. As an initial phase, the blocks are designed as partition or separation wall systems. Although partition walls are not expected to resist the forces acting on the structure directly, they should have sufficient flexibility to be able to deform together with the beam/column frame they are constructed in.

In general, conventional wall systems are known to have high rigidity but low strength. Shear failure, which is usually observed in the form of X-shaped cracks, is a typical damage pattern caused by insufficient strength. Similarly, if not designed appropriately, due to their high rigidity, walls may also limit the deformation of the columns resulting in a very severe structural problem known as "short column."

Therefore, in order to provide the required flexibility, the blocks are designed in several horizontal layers that can slide over each other in case of an earthquake. The unique shape of the blocks generates a geometric interlocking mechanism for the blocks within the same layer, whereas sliding planes between different layers allow relative deformation and prevent excessive shear stresses due to the increased rigidity.

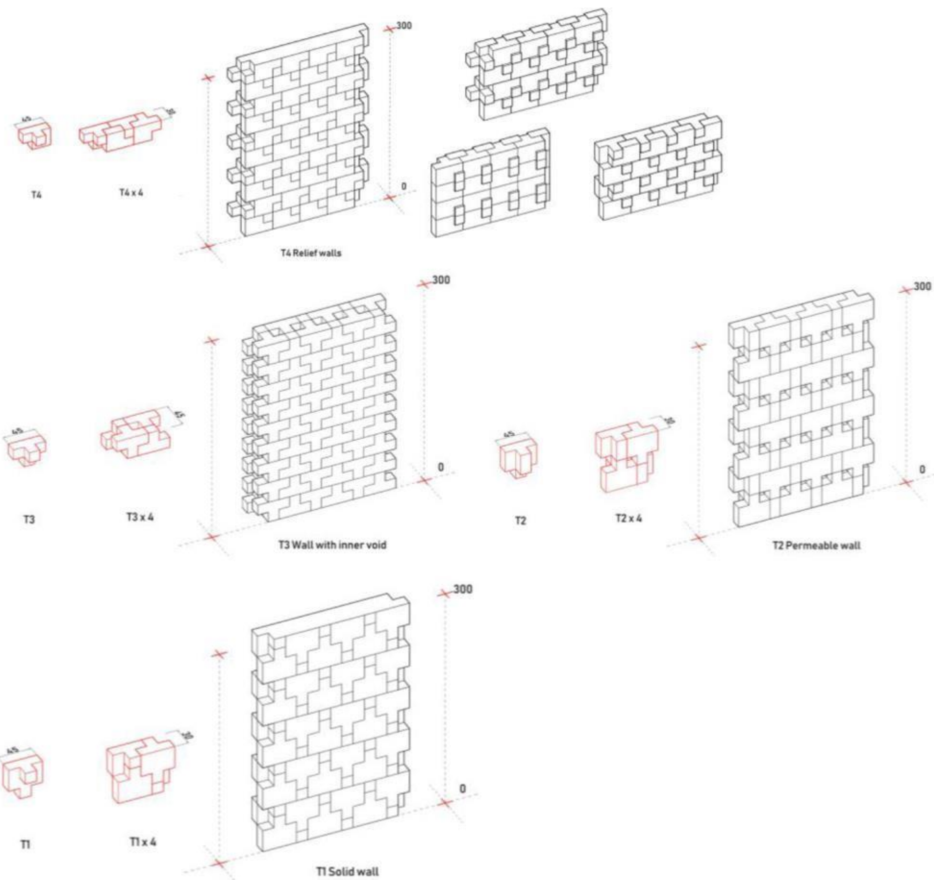

Figure 7. Initial sketches for the design system of BIRE-PAN based on various types of walls composed of prefabricated rammed-earth blocks

4. LIFE CYCLE ASSESSMENT

Life cycle assessment (LCA) is a system developed for examining and calculating the environmental impacts of products in their processes from production to disposal. LCA is developing and using assessment tools and databases on a local and global scale in different countries. [2,14,19,20] LCA analyses the phases of raw material obtaining, transportation, production of the product, transportation-distribution, application of the product to the structure, use-maintenance-repair, completion of the life of the product and recycling or decomposed processes. It covers the processes of making an inventory of the energy, water, other raw materials and natural resources used in these processes, as well as the environmental impacts that arise with it, and the systematic and comparative evaluation of the results. The life cycle for structures; material-product production, building production, use and destruction and recycling are examined in 4 basic phases[19,20]. Especially LCA studies for building materials, some phases of the life cycle are taken into consideration instead of the whole. System limits are expressed as; cradle-to-grave (processes from raw material extraction to product destruction); cradle-to-cradle (processes from raw material extraction to raw materials recycling), cradle-to-gate (processes from raw material extraction to factory exit), gate-to-gate (processes between factory entry and exit)[14]

There are few studies within the scope of LCA research for earth material. The reason for this is that different results are obtained for the earth of each region, and a standard is hard to be established, as issues such as local land use, climate and geography differentiations. The lack of standards prevents definitive results in this area. However, certain parameters can be determined, and a conclusion can be reached through mandatory tests for each earth in line with these parameters. [2,14]Martin Rauch set up Erden Factory for the production of the earthen building components in the factory. They built various components such as rammed-earth blocks or walls produced at the factory [9,21,22]. When the cradle-to-grave life cycle of the building material is examined for the earth material, it completes its life cycle when it is left to the nature after its decomposed, as long as no additives are made to the earth material [Fig.8], [21,22].

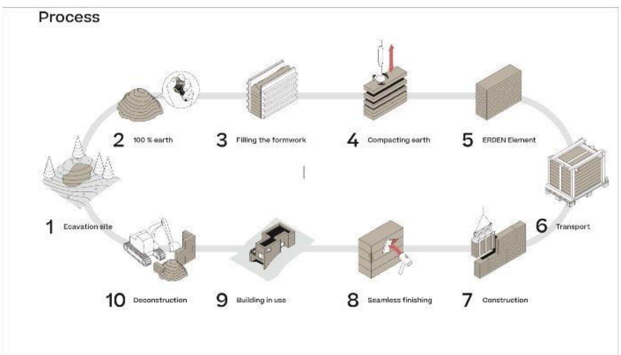

Figure 8. Martin Rauch-Erden Factory Rammed-Earth Fabrication Process.

CONCLUSION

Within the scope of the BIRE-PAN research project, it is aimed to produce rammed-earth blocks and panels in the factory and to build a prototype space with the recipe obtained as a result of earth construction material research and design processes. It is planned to make an evaluation of the design-production processes in terms of LCA as the guide for design-fabrication process. It is aimed to create a life-cycle evaluation in which raw material obtaining, samples prepared in the laboratory environment, tests, block/panel design processes, production in the factory, prototype structure construction processes generate data. Although cradle-to-grave and cradle-to-cradle inspections will not be possible during the project period, it is expected that there will be an opportunity to examine building materials in terms of 3 of the 4 main phases of LCA assessment.

Witihin the context of the BIRE-PAN research project; Investigation of earth building material in terms of LCA will be realised via an ongoing graduate thesis; within the scope of cradle-to-gate; raw material procurement, laboratory tests, design processes and evaluation of the stages of starting production at the factory.

While making LCA investigations for the production of building materials, it is seen that the most energy consumption and carbon emissions occur during the production phase of the material in the process called cradle to grave. In the whole life cycle of a material; it is similar from the production of the simplest pure material to the production of composite materials that contain many different elements. For composite materials, it consumes a lot of energy not only in the production phase but also in the recycling phases. As well as producing composite material, separating the material into its smallest component, raw material, also causes energy consumption.Since the mixture of alker is created with the additive of gypsum and lime, it can be thought that it is actually a composite material. For this reason, it is necessary to separate all the additives in the material when it is aimed to reuse or decompose the raw materials by recycling when the material ends its useful life. The energy spent in this process; it is much more than additive-free or earth materials containing natural additives. Natural additive materials; can be directly mixed with nature in the processes of destruction after its destruction.

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52- Ecological Architecture Approach in Permaculture Design

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ABSTRACT

The understanding of consumer society that emerged with modernism has led to unconscious and excessive consumption of natural resources. This consumption has begun to reveal damages on a local and global scale. On the basis of the consequences of moving away from the natural in any area of life practices, the extent of the damage to ecosystems has become visible and the process at which it has come can be determined.

The use of unnatural materials and techniques that are not suitable for local conditions in the design of urban or rural spaces have moved the architectural practice areas beyond being sustainable. With the realization of the emerging problems, the ecological understanding towards protecting the environment and natural resources has spread, and the concepts of "ecological design", "green design", "sustainable design" have started to gain functionality. Parallel to this concept, "permaculture", which came to the fore in Australia in the 1970s, can be defined as a holistic system organization by combining traditional agricultural methods, local knowledge and skills, and technological solutions against the problems of existing ecosystems. The design philosophy is to design human settlements by observing natural systems. It has principles that work as an ecological design method that aims to work in harmony and coordinated rather than going against nature. These principles also determine ethical principles and approaches.

After a detailed literature review, the study will continue with the search for ecology-based permaculture farms with efficient, sustainable systems in the design of new rural settlements. Research will be carried out on the design of the existing structures and building types within the operational organization of such farms within the framework of ecological architecture principles. In this study, in which the common aspects and equivalent approaches of both concepts will be detailed, the building materials and construction techniques used will be determined.

Keywords: Architectural design, permaculture, sustainability

1. INTRODUCTION

Approaches in the design of living spaces are important in order to sustain the natural areas and existing ecosystems in which we exist. It is valuable in this respect that the materials used are natural and that they are long-term materials that allow reuse. The construction techniques developed with the use of wood, clay, soil, paper, wool, brick, bamboo and straw bales have the feature of being environmentally sensitive. Ecological cities, where the structures planned within this design approach are together, also play an important role in regional planning. In this context, the issue of energy efficiency and less consumption and benefiting from natural resources is directly related to sustainable design.

In the history of humanity, the state of being disconnected from nature has increased with the industrial revolution. In response to the increasing consumption need, the increase in production reflected on the material quality and increased the consumption need. This situation was reflected in the speed of the construction process and brought the use of reinforced concrete construction systems. The increasing population has brought cities that grow rapidly and uncontrollably. With the emergence of cities and structures built with these construction systems, which are not recyclable and have no integrity with nature, the difficulty of accessing open and green spaces has increased. With the difficulty of this transportation, obstacles between people and natural habitats have started to become visible.

When this separation and consumption issues come together, the desire to destroy and control natural areas has revealed many environmental problems. As of 1968, when the consumption of natural resources, reduction of water resources, environmental pollution, and deterioration in soil quality began to be discussed, solution suggestions and restorative ideas began to emerge. The concept of permaculture, which started to develop in Australia in 1972, began to be applied as a method of protection and improvement regarding environmental problems. The relationship of permaculture with nature, which is based on the design of rich and sustainable human settlements by observing natural systems, is a whole. In this way, when approaches that understand and are sensitive to the local ecosystem and the ability to observe and imitate nature come together, the relationship between plant and animal systems and structure can be constructed. At the beginning of the ecological design principles, the knowledge of the local lies in the construction of the building systems. Permaculture also overlaps with ecological design principles on the use of environmentally friendly natural materials, the correct management and utilization of natural energy resources, water management and rainwater harvesting.

In this study, which aims to examine the harmony of spatial setups with nature in Sihirli Tohumlar Permaculture Farm, where ecological design and permaculture design principles can be seen together, a theoretical framework will be created by referring to the scope and method. Then, visual and verbal transfers about the area will be made and the evaluation will be concluded.

The scope of the study consists of researching the concept of permaculture and its evaluation within ecological design criteria. The main sources on the subject will be searched and the findings obtained in this framework will be examined within the scope of on-site field analysis. In this study, which examines the relationship between the structures in the area and nature, the design stages of the living and production spaces, the materials used and the construction techniques will be examined.

2. LITERATURE DATA

2.1. PERMACULTURE ETHICS AND PRINCIPLES

Permaculture first came to the fore in the 1970s in Australia with the work of Mollison and Holmgren. Permaculture; It has emerged as an earth science that designs human settlements where holistic solutions are developed by blending traditional agricultural methods, scientific knowledge, technology and skills against the problems of the ecosystem. The methods included in the field of permaculture science, which have entered the literature in the process of increasing awareness in the society against the damage caused by human activities to the environment and human beings, have been developed based on previous approaches such as permanent agriculture, soil fertility, natural agriculture philosophy, and experiments on different tree and plant systems. Rothe (2014), explaining that permaculture consists of the terms permanent agriculture and permanent culture, expresses its meaning as "continuity of human life and culture". According to Mollison (2017), permaculture; It is a design method in which rich and sustainable human settlements are created by observing natural systems. According to Holmgren (2001), permaculture; It is a landscape design where sustainable settlements and food production systems are applied to meet local needs and to consume resources in a healthy way.

Permaculture design; It contains three basic ethical rules in terms of being beneficial for nature, humans and other living things on earth. These ethical rules not only shape the design, but also serve as a source and guide on which values the field will be handled (Mollison, 1979, Althouse, 2016). The most important part of these rules, which consists of three ethics, is human (Figure 1), because everything that is done is built on the betterment of human life. In this improvement, the biggest task falls to human beings. Permaculture ethics, which is in the triangle of earth, human and consumption relations, aims to establish balanced relations with nature and to meet their needs with appropriate methods. According to this;

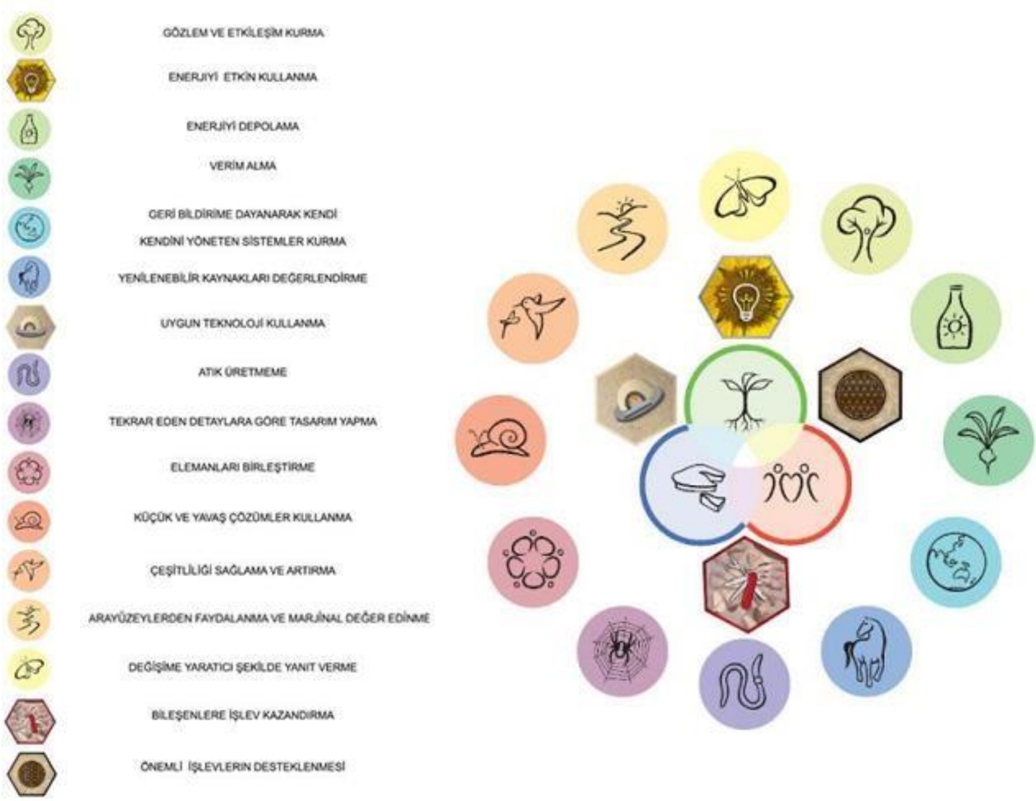

Figure 1. Permaculture ethics and principles of Holmgren and Mollison (prepared by bringing together by Najafidashtape.

Taking care of the earth: The earth, which expresses the area in which people continue their lives, is one of the principles that should be protected. In order to ensure a natural and long-lasting life, people must meet their needs in a sustainable way, in harmony with the ecosystem, and always in a remedial way. All of these mean taking care of the earth.

Taking care of human beings: Humans, who are the rulers of nature, have a decisive role on earth with the decisions they make and the activities they do. One of his most important duties in this role is to provide energy, food, shelter, etc. It is meeting the needs of people and their access to resources without disturbing the order of nature, valuing themselves and without risking their future.

Determining consumption limits: This code of ethics, which aims to share many needs such as food and energy provided by using natural resources, under control and in a fair manner among all living things, aims to prevent waste. In other words, it is the determination of the decisions forthe necessary environment and order for the realization of the previous two ethics.

2.2. THE CONCEPT OF ECOLOGY AND THE CONCEPT OF ECOLOGICAL DESIGN

Ecology is a field of study that has emerged as one of the sub-research areas of biology. Ecology, which focuses on examining the relationship of all natural beings with each other and their environment, sees nature as a system consisting of parts that cannot be thought independently of each other and that work in harmony with each other. At the beginning of the agenda items of the age we live in; phenomena such as global warming, climate change, rapid urbanization and the gradual alienation of nature from our environment. The understanding of design, on the other hand, renews itself with these agenda items and the changing ecosystem and develops with the differentiating human needs. Sustainable design, on the other hand, is based on meeting our human needs without harming the ecosystem, and is implemented as a design in harmony with nature.

Sihirli Tohumlar Permaculture Farm has been designed as sustainable living spaces, together with production spaces of necessary structures in harmony with nature. In the next section, an evaluation will be made specific to the study area.

3. WORKING AREA: SİHİRLİ TOHUMLAR PERMAKÜLTÜR ÇİFTLİĞİ

Sihirli Tohumlar Permaculture Farm, which is an example of a rural campus, was established within the framework of permaculture design and principles, in accordance with the locality and adaptability. In the Küçük Yoncalı Village of Saray District of Tekirdağ, there is 1 private residence, 1 guesthouse, 3 Indian tents, a common kitchen, agricultural areas, chicken coop areas and a common shower/toilet structure on an area of approximately 40 decares. Natural construction techniques were applied for these structures, whose location and architecture were planned by considering passive solar understanding or maximum solar energy gain.

Regarding the management of water resources, drinking water needs are met from a natural source 10 kilometers away, while the irrigation need for land planning is provided through rainwater harvesting and ponds, and the flow of water is adjusted by evaluating the elevation differences in the land. In line with the existing contour data of the land, suitable areas for the pond have been planned. In this direction, the need for irrigation and clean water is met, and at the same time, a living space is provided for the plant and animal systems living in the water and its surroundings.

Heating and electricity needs of the farm owner's residence structure and guesthouses in the area related to the management of energy resources are provided by solar panels. It is seen that food, plant and animal products, which are defined as all kinds of waste, and substances formed as a result of human nature are planned to contribute to a new cycle with the compost method. Thanks to the reuse of food wastes with compost, the soil is nourished and it is possible to obtain products with high nutritional value in agriculture. In addition, attention is paid to the consumption of unpackaged products, since the basis of a life in a natural area is the reuse of all materials with minimum waste. The housing structure used by the farm owner has a symmetrical plan typology in a 120 square meter session. 1 living area, kitchen, heating room, composting toilet and shower, 3 bedrooms are available. Steel ground screw, gravel sacks, natural materials such as perlite, boron cellulose, sheep's wool, goat hair were preferred in the insulation of the structure based on wooden construction, which was built using earthen sacks and syrupy straw. Soil-based straw and mixed plasters were used on the exterior and interior. The use of colored bottles seen from the kitchen space is reflected both as a reuse of glass material and as a decorative element as a source of colored light. (Figure 2, Figure 3, Figure 4) Insulation is provided by covering the northern facade of the building with material obtained from local wood. Apart from natural building materials, no product with different content was used for construction, wall filling material and plaster, or insulation purposes.

Figure 2. Farmer's house; Figure 3. Farm owner home living area; Figure 4. Farmhouse kitchen

While the production of black water with the compost toilets in the house has been stopped, the toilet and bathroom water outlets pass through the treatment system as gray water and are used for irrigation purposes. (Figure 4).

Figure 5. Compost toilet

The fact that the building produces its own energy with solar panels and that this production is managed according to needs is an example of benefiting from the sun. There are two systems used by the building for heating purposes. The first of these is the solar panels located on the roof in the middle of the building. Similar panels are positioned vertically on the front facade. (Figure 6) It meets the electricity needs of all four seasons of the year. For heating, a system is used to distribute the water in the water barrels, which are also heated by solar panels, to the entire structure. (Figure 7).

Figure 6. Solar panels; Figure 7. Water drums for heating

Another building on the land is the guest house. The building, which includes single, double and triple rooms, is in an octagonal plan, with rounded corners. In the green roof system, the center is again completed with an octagonal skylight. With the stove located in the center, heating is provided and the possibility of using the middle sofa emerges. The main walls were built with a kind of masonry system using earth-filled sacks. Contrary to the farm owner, it is seen that organic forms are preferred instead of corner forms. There is also a building with showers and compost toilets for common use by guests. In addition, Indian tents, tent areas are reserved for volunteers.

CONCLUSION

The formation of Sihirli Tohumlar Permaculture Farm has made it a way of life to establish a life as a human being in accordance with the functioning of all plant and animal systems in its natural habitat, and to benefit from these systems by supporting them. While the management of spatial organizations, which are established in harmony with the ecosystem, is sustainable in this way, it also extends the life of the building and human life and makes it healthy. In the construction of living spaces, it was ensured that the basic needs of people were met without harming natural resources. In the consumption of these natural resources, attention was paid to keep them in common use by paying attention to some ethical principles. In this context, the ethical principles of permaculture, taking care of the earth, taking care of people and determining consumption limits, constitute the implementation response.

It is possible to evaluate these principles in an ecological formation and to overlap conceptually. It is possible to observe sustainable and ecological design criteria in buildings designed in a natural area and using natural building materials in their application.

The fuel and electricity needs of the buildings, which are completed with the use of wood, straw and soil-based materials, provide the use of clean energy. By applying cold compost and hot compost methods, the foods defined as waste are returned to the soil as foods with high nutrient content. For wet areas, a black water system is not created with the use of compost toilets, it is only possible to purify and reuse kitchen and shower water as a gray water system. It can be said that nature has designed and adapted the requirements of human life in a way that is sensitive to its natural cycles. It is clear that in the area designed in accordance with the principles of permaculture as a spatial integrity, the buildings can be applied in parallel with each other, in parallel with the natural cycle of all living spaces.

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53- The Roof Repair of a Boranhane

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ABSTRACT

Pigeons have had an important place since they have been benefited from many of their features from the past to the present. In addition, pigeon manure was used in agriculture to obtain fertile products as well as gunpowder production. Pigeon manure and eggs are still used today. Throughout history, people who have benefited from these features of pigeons have built shelters in many countries to protect pigeons. In Turkey, different names have been given to these shelters, which were built specifically for the regions. These shelters are named as "burç" in Gesi region of Kayseri province and "güvercinlik" in Cappadocia region. In Diyarbakır province of the South-eastern Anatolia, these structures built for the protection and breeding of pigeons were called "boranhane". These *boranhane*s built in Diyarbakır represent a symbol of the lost cultural heritage and tradition. It is important to protect these structures, which are important both culturally and as a part of the tradition, in order to pass them on to future generations. In addition, it is of great importance to protect these structures, which still exist today, in order not to disturb the ecological balance. As a result of the increase in the use of artificial fertilizers instead of pigeon manure around Diyarbakir, *boranhane*s are no longer used. Over time, these unused structures have suffered many damages due to neglect, such as the damages on the floors above the ground, on the walls, and on the parts that provide the entry and exit of the pigeons. In addition, as a result of insufficient attention and protection, some of these structures have been destroyed and some of them have survived to the present day with great damage.

In this study, the architectural features of the existing *boranhane*s in Diyarbakır as well as the building materials, planning and forms used during the construction were examined. In addition, the repairing applications of the damaged roof of one of these traditional *boranhane*s with the traditional system were examined in detail. Today, these structures are faced with the problem of losing their originality due to the decrease in traditional construction techniques. In order to solve this problem caused by the gradual decrease in traditional construction techniques, it is aimed to observe and document every stage of this traditional construction technique.
In this context, the roof construction phase of a *boranhane* located in Diyarbakir has been observed practically. The surveys and the plans of the examined *boranhane*s, located within the borders of the province were drawn, their architectural features were examined on-site, and their original conditions were photographed and archived.

Keywords: Boranhane, pigeon houses, soil based top cover, traditional structures.

1. INTRODUCTION

Throughout history, humans have valued the birds, benefited from their fertilizer, eggs, and meat, and used their feathers to do pillows, quilts, and beds; and use the birds to communicate. Also, because they can fly they have seen as sacred beings because they get closer to the god (Özçakı, 2020). One kind of bird that humans love and benefit from is the pigeon (Bekleyen,2007). The pigeon is a member of the Columbidae family. The pigeon is middle sized, it has a small head a short neck, and short legs. Also, it is fast, it can fly for a long time and it produces some special voices (Yılmaz et al., 2012). The pigeon is the first bird known as domesticated (Yılmaz et al., 2012). According to the scientists, it is domesticated approximately 6.500 years ago in Iraq (Boz et al., 2012). Pigeon is affected by natural conditions such as temperature, frequency of precipitation, duration of daytime, and speed and strength of the wind. That's why it is known that pigeons in the south live longer than pigeons in the north (URL-1).

In most countries and areas, shelters are built for the protection of pigeons. According to the regions these shelters are named differently. In Cappadocia region shelters named as "güvercinlik", in Gesi region in Kayseri they called as "burç" and in Diyarbakır they called as "boranhane" (Bekleyen, 2007). In Kayseri, shelters generally found in Gesi, Efkere, Gürpınar, Kayabağ (Darsiyak), Güzelköy (Nize) regions (Büyükmıhçı, 2006). In Cappadocia, it is known that there are pigeon shelters in the valleys in Nevşehir, on the high levels of the valley, in rocky places, and the carved Fairy Chimneys (Maraşlı, 2019). The geomorphology of the volcanic tuff and basalt rocks in that area makes it easier to build a shelter.

Pigeon shelters are built to let pigeons survive. They are generally shaped like a tower, a castle, or rectangular and they have holes to let pigeons pass. They are built to protect pigeons from animals such as wild birds, wolves, and foxes; for their nutrition and reproduction and to benefit from their fertilizer (Maraşlı,2019). The fertilizer gathered in those shelters was used to get a better product from the soil and in making gunpowder and shoe leather (Yılmaz et al., 2012). The fertilizer is used in vineyards in the Cappadocia region, vineyards and gardens in Gesi in Kayseri, and in cultivating watermelon, lentil, melon, bean, cotton, and pistachio in Diyarbakır (URL-2). Because the fertilizer of pigeon is consist of 25% organic matter, 2% nitrogen, and 1-1,5 % phosphoric acid, it is more effective than the fertilizers of sheep and goats, and thus it is preferred to be used (URL-2). Plants cultivated in soils that used pigeon fertilizer grow faster, be resistant to bad conditions, and are more fruitful. Chemical fertilizers affect water pollution and air pollution negatively (URL-2). That's why using organic fertilizer is important to maintain the ecological balance and human health.

These pigeon shelters are made by the public and have forms, functions, and materials peculiar to the region. They are ecologically compatible and have an important place in terms of natural and cultural heritage (Büyükmıhçı,2006).

Recently, because there is artificial fertilizer now and it is very cheap, pigeon fertilizer is not preferred in Diyarbakır. That's why "boranhane" is not used. They are not protected well and are neglected, so in time they are destroyed and other constructions are made instead. In some neighborhoods and villages in Diyarbakır region, because false floors and walls of pigeon shelters are broken down, those boranhanes are in danger of collapse. It is important to examine their architectural features and register them in terms of cultural heritage. Examining their features of design and repairing them according to their original systems are necessary to transmit them to the next generation. In this study, the repair of the roof of the boranhanes which have minor damage is observed in place and the construction system is examined and recorded in detail and step by step.

2. ARCHITECTURAL FEATURES OF BORANHANES IN DIYARBAKIR

2.1. FEATURES OF BORANHANE'S PROJECT

In Diyarbakır pigeon fertilizer is used for agriculture. Pigeon fertilizer is preferred to increase the fertility of many products such as watermelon and lentil (URL-2). People build pigeon shelters to obtain the fertilizer. These shelters are called "boranhane". The origin of the name is "boran" which means wild pigeon (Özçakı, 2020). People who work in agriculture in Diyarbakır's rural areas, build pigeon shelters near their houses or on high hills (Bekleyen,2007). Those shelters are generally placed in regions near the shores of Dicle river (URL-3). Boranhanes in Diyarbakır city is in Erimli and Karaçalı neighborhoods (Figure 1). The boranhanes in this region are rectangular and constructed by simple planning.

Figure 1. Karaçalı and Erimli neighborhoods (google earth excerpt)

In the shelters, there are small doors open temporarily, once a year, which let people enter to gather the fertilizer. The height of the entrance door is approximately 99 cm (Figure 2). After people take the fertilizer, the door is closed by using adobe. Boranhane is planned as one part or 2-3 parts connected (Figure 3-4). Local people called these parts "lüle" (Bekleyen,2007).

The plans of the parts are similar, the only difference is the size of the space. The length of the parts is in the range of 775-1200 cm and the width of the parts is in the range of 160-245 cm. The average length is 975 cm and the average width is 188 cm. In the connected parts, transmission is caused by little holes whose heights are 99 cm.

Figure 2. Boranhane Doors

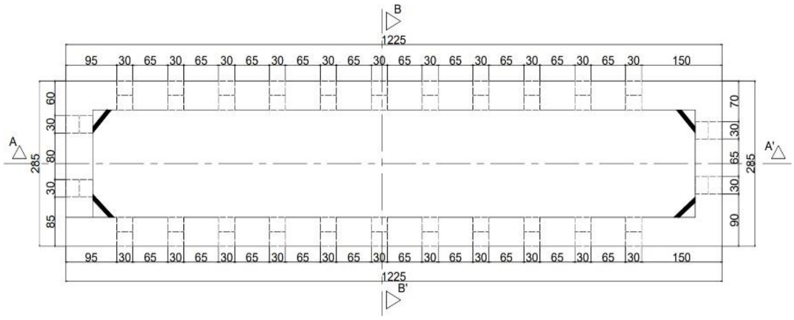

Figure 3. Boranhane plan consisting of a single compartment (Drawer: Rahşan Sala)

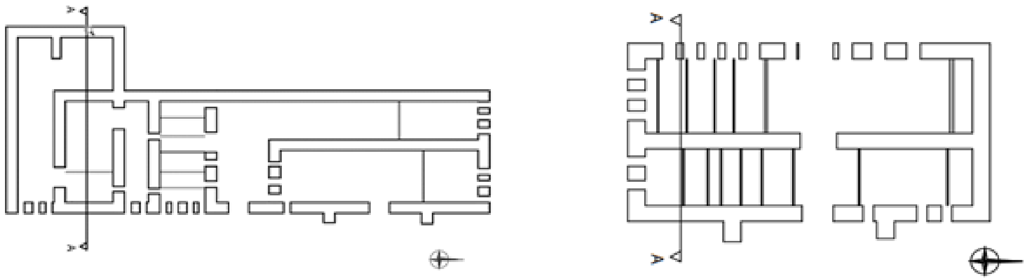

Figure 4. Boranhane plan consisting of more than one compartment (Drawer: Merve Sincar).

In boranhanes in this region has wooden stakes on their long walls inside. The diameter of those stakes is in the range of 10-15 cm. Also, they are placed at two different heights changing between 130-200 cm (Figure 5). The first level of height is in the range of 130-160 cm and the second level of height is in the range of 215-300 cm. Those wooden stakes increase the strength of construction and they are used to hang baskets (Figure 6). Also, to let pigeons enter and exit the shelter, approximately 30 cm under the roof made by soil, holes whose sizes are 25x25 or 25x30 are built (Figure 7). Their façade is plain and there are many holes (Figure 8).

Figure 5. Wooden poles

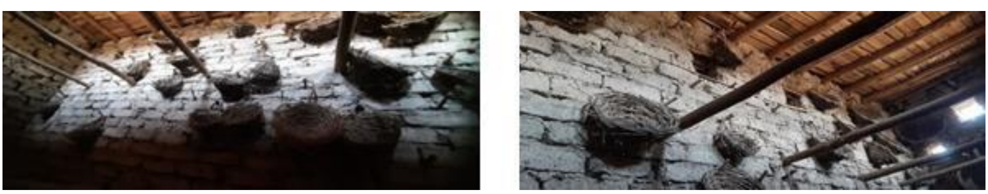

Figure 6. Baskets suspended on wooden poles

Figure 7. Spaces left for the entry and exit of pigeons

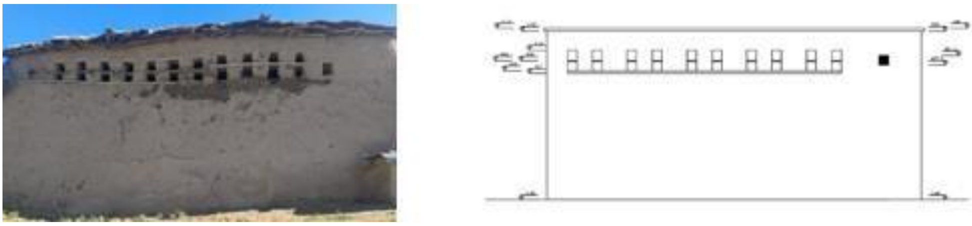

Figure 8. Boranhane facade (Drawer:Melek Geçirgen)

2.2. TECHNIQUES OF BORANHANE'S CONSTRUCTION AND MATERIAL

The walls of boranhanes Erimli and Karaçalı neigbourhoods in Diyarbakır are made of adobe. The thickness of the walls is in the range of 50-55 cm. Adobe is compressed and built with cast adobe 80-100 cm above the ground (Figure 9). 35x15x10 cm adobe blocks were made on the cast adobe.

Figure 9. Wall mesh system

The height of floors generally falls between 3.5 and 5 meters. Also, to increase the durability of the walls, supporters are built from the inside and outside (Figure 10-11). The door which let the transmission between the parts has 10 cm lintel on the top of them (Figure 12). In addition, the roof of these structures are flat and made of soil.

Figure 10 & Figure 11. External and internal support

Figure 12. Lintel use

3. THE PROCESS OF RESTORATION IN A BORANHANE IN DIYARBAKIR

The unused boranhanes in Diyarbakır are damaged greatly because of environmental factors. The boranhane which is examined in this study is in the Karaçalı neighborhood. The plan of the structure consists of two parts. One part of the height is 4 meters and the other part of the height is 3.5 meters. It has 23 windows on the northern front, 34 on the southern front, and 6 on the eastern front. There is no window on the western front (Figure 13). Among these boranhanes, theone whose carrier system is fine but the top cover system is damaged is protected from being destroyed by restoring its roof which is damaged because of neglect and its decayed wooden carrier beams. The stages of restorations are conducted compatible with the original system of the structure. In the restoration process, the removing of the roof and renewing it are observed by examining them in place.

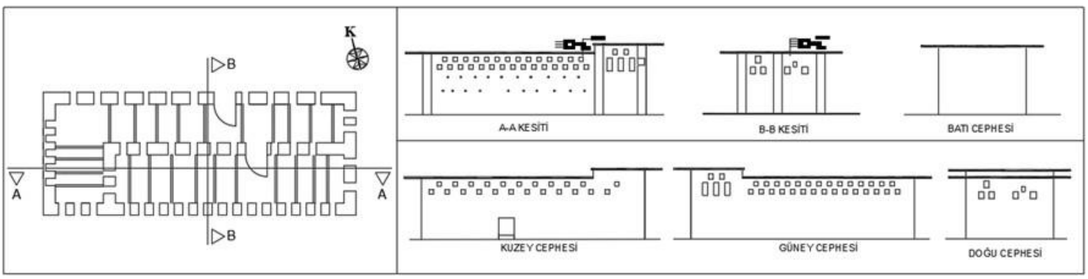

Figure 13. The repaired boranhane (Drawer: Muhammed Özalp)

Before the restoration, the soil layer which constitutes the top layer of the roof is removed. It is observed that the linoleum which is placed under the soil layer and leads to water insulation is damaged partly over time and lost its ability to insulate. Because of these damages, linoleum and bushes under it are removed. Branches of trees that are under these layers are also completely removed (Figure 14). After removing the layers of the roof, the wooden carrier beams showed up. The beams which have corruption and cracks are detected and the highly damaged ones are renewed. To extend the short eaves distance, thick lumbers and main carrier beams are put together with nails. The distance of eaves is extended and more decent eaves are obtained. Also, the corner points of the eaves are strengthened by the woods. On the extended eaves, the lumbers whose length is 20 cm and whose width is 2-3 meters are nailed, and by doing so the top of the carrier is totally covered. The elements of the extended eaves are filled with mortar whose length is the same as the wall's and the top of the eaves is totally covered by the lumbers (Figure 15). By doingso, the flatter and the stronger ground is made. The linoleum that helps insulation and protects thesoil layer from spilling on the place is nailed to lumbers and is immobilized. The reeds obtained from the basins of the region are placed one by one and smoothly in order to get a flat ground. Also, because reeds are harsh and sharp, the chaff is put on them to make them smoother. It is important to put the chaff evenly and completely on the roof to avoid the sharp parts of the reeds harming the linoleum. After the roof is covered completely with the chaff, 2 layers of nylon are put for water insulation. A soil local is brought from a hill that local people called "Tilalo". The soil is mixed with water and chaff thinner than the former and put on the nylon (Figure 16). The soil which is the top layer gets stuck approximately in 1 year. It is recommended that in dry seasons of that one year the surface of the roof should be made smoother by plaster mortar by the roofer.

Figure 14. Dismantling of the roof

Figure 15. Regeneration phase

Figure 16. Completion phase

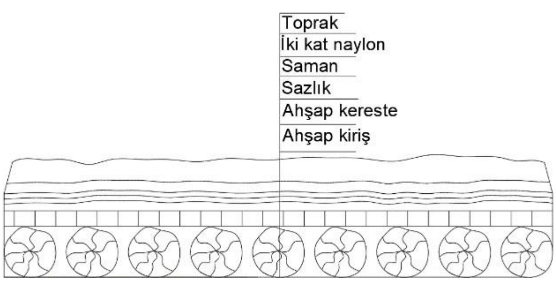

Figure 17. Material detail

Figure 18. Condition before and after repair

CONCLUSION

Recently, because artificial fertilizer is preferred now, the boranhanes are used less and are in danger of extinction. These unused structures are damaged highly in time and some of them are destroyed and other constructions are made instead. The culture of the region is also started to disappear.

For a long time, pigeon fertilizer is used in many ways, and to obtain it the shelters are built in Diyarbakır region. In terms of culture, it is important to transmit these structures, that have endured from past to present, to the next generations.

The boranhane examined in this study is one of the examples of these kind of structures. Also, in this study, it is underlined that, in terms of the cultural heritage, it is important to protect boranhanes that are about to extinct. The restored boranhanes could be the pioneers of the restoration of other damaged ones and it is important to transmit them to the next generations.

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54- Investigation of Façade Arrangements in Rural Architectureof Diyarbakır Province Erimli Neighborhood

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ABSTRACT

As the archaeological remains indicate, adobe is one of the building materials that has been in existence since the earliest known period. Particularly in residential architecture, the inaccessibility of wood and stone materials, according to the characteristics of the region, necessitated the use of earthen materials. The use of earth-based adobe is common in rural architecture, especially in the mid-latitude region of the world, as it is easily available, does not require production facilities, and is economical and sustainable. The adobe architecture, which was used as a building material in the traditional architecture of the ancient Anatolian and Mesopotamian civilizations, still exists present day. Although adobe material differs in terms of its properties depending on the presence of water in the region, the type of earth, molding, and drying techniques, it is generally accepted as a common architectural and cultural heritage for thousands of years. Due to its cultural and architectural heritage, adobe architecture, which needsto be preserved and maintained, is in danger of losing its unique examples by being damaged due to the decrease in adobe mastery and abandonment due to migration from rural to urban areas, andneglect. In this context, the study aimed to draw attention to adobe architecture, adobe structures, which constitute the rural architecture of the Erimli Neighborhood of Diyarbakır province and are mostly composed of dwellings, were selected for examination. 13 unique dwellings selected in theErimli Neighborhood have been examined in terms of façade arrangements. The positions of the dwellings to each other and the streets, the fullness and gap rates on the façade, the size, form, andlocation of the openings that composed the façade architecture were determined by photographs and drawings and grouped within themselves. The findings obtained aimed to draw attention to the place and importance of the rural architecture of the Erimli Neighborhood of Diyarbakır Province, built with adobe, in adobe architecture with its unique qualities. The necessity of preserving and maintaining the adobe architecture of the Erimli Neighborhood which has existed as a result of many years of experience and tradition has been tried to be revealed.

Keywords: Adobe, local dwellings, rural architecture, traditional dwellings

1. INTRODUCTION

The need for shelter is one of the basic needs that humanity has had to meet, and the increase in knowledge about agriculture has increased the necessity for well-designed shelters suitable for the physical environment. Temporary shelters, which are the habits of hunter-gatherer life, have left their place to the settled order with agricultural activities. The earliest examples of earthen shelters were built for use only in inclement weather conditions, often covered with mud for waterproofing, using shrubs and small pieces of wood. The development of adobe brick, which is a modular masonry unit made of sun-dried mud using molds, took place at higher civilization levels. [1]. One of the earth-based materials, adobe building material, has been widely used and developed in vernacular architecture with different forms, in almost every region of the world. The regions that use adobe building materials in the world are as follows: Mesopotamia, Nile Valley, North Africa, Mali, Morocco, Iraq, Iran, Yemen, Afghanistan, India, China, Sweden, Germany, Denmark, France, Spain, Portugal, England, South America, Mexico, and California (Fig. 1) [2].

Figure 1. Global map illustrating the use of the adobe building material

Contrary to modern building technology, traditional applications are developed through trial and error rather than contemporary testing and application. Construction practices in vernacular architecture reflect the building materials, climatic conditions, social life, and skills available in a particular region. Considering all these criteria, it is still one of the most used building materials in vernacular architecture due to its local availability, low cost, waterproofing, thermal insulation, and sustainability [1,3]. Studies show that around 30% of the world's population lives in structures made of earth-based materials [4].

Although the constructions are now developed over reinforced concrete, adobe is still used in the vernacular architecture of Anatolia, especially in dwelling construction, with low cost and easy production methods. In Diyarbakır Erimli Neighborhood, which is located in the Southeast Anatolian Region, there are adobe dwellings that preserve their unique qualities despite the increasing number of reinforced concrete dwellings in the neighborhood. The study aims to draw attention to the unique dwellings by examining the façade arrangements of the adobe dwellings of the Erimli Neighborhood, which should be preserved and maintained.

2. PROPERTY OF ADOBE BUILDING MATERIAL

The adobe building material is obtained by adding fibrous additives such as straw to clay-based soils that can bind the grains together, and turning them into a mortar with water. The resulting mortar is shaped with wooden molds, removed from the mold, and dried in the sun [5]. In its early days, adobe was used with the pouring technique on the stone wall, without the molds prepared beforehand. After this application, which took a long time, it is understood that the pre-shaped sun drying technique has become increasingly widespread [6]. Generally, adobe shows higher strength than rammed earth [7]. Correctly prepared and dried adobe can be used as a load-bearing wall material in buildings because it is homogeneous and compact [8].

Due to its porous structure, adobe quickly replaces the moisture in the air with the in its body. Thus, the microclimate in the environment is balanced in terms of humidity. Thanks to its heavy mass and porous structure, it has a high heat retention feature. It provides good bio-climatic comfort indoors both in summer and winter [9]. However, adobe is vulnerable to water due to the transport of fine clay particles to the surface in the presence of water. Since it is a building material whose heat retention and carrier properties decrease when wet, it requires compatible moisture insulation [7].

In addition to the ingredients of adobe material, molding, and drying techniques, its dimensions also differ from region to region. According to the Turkish Standard 2514, the most commonly used adobe components in Turkey are classified as 30-40 cm in length, 18, 19, 25, 30 cm in width, and 12 cm in height. The large-sized adobe component is called " ana kerpiç", and the small-sized adobe component is called "kuzu kerpiç" (Table 1) [10].

Category	Dimensions(cm)	Volume (dm^3)	Approximate Weight (kg)	Name
I	12x19x40	9,12	10-12	Kuzu
II	12x30x40	14,40	15-25	Ana
III	12x18x30	6,4	7-11	Kuzu
IV	12x25x30	9,00	10-15	Ana

Table 1. Classification table according to the dimensions of the adobe [11].

Adobe material is a material that stands out with criteria such as sustainability, energy efficiency, low emissions, use of natural materials, use of waste materials, and recycling, which are used in the environmental evaluation of building materials and construction methods [12].

3. FAÇADE ARRANGEMENTS OF RURAL ARCHITECTURE OF ERİMLİ NEIGHBORHOOD OF DİYARBAKIR PROVINCE

3.1. ENVIRONMENTAL CHARACTERISTICS OF ERIMLI NEIGHBORHOOD

The study area is in the Sur district of Diyarbakır province, located in the Tigris Section in the eastern half of the Southeastern Anatolia Region. The Erimli Neighborhood, which was selected for study, is located 21 km from Diyarbakır city center, on the edge of the Tigris River (Figure 2a). The neighborhood's area is 438 m², and the residential is 660 meters above sea level [13].

Figure 2. a. The location of Erimli Neighborhood relative to the Tigris River [14]. b. Erimli Neighborhood slope view.

The Southeastern Anatolia Region has a continental climate with hot and dry summers and cold winters. The low relative humidity level causes dryness in the region. This situation has caused the settlements to be designed with passive strategies, especially according to the cooling period. In this context, Erimli Neighborhood benefits from the climatic advantages of the Tigris River, on which it is located. Located on the west-facing slope of a low-lying hill, Erimli Mahallesi provides optimum settlement conditions for hot-dry climate regions with its location and adobe structures (Figure 2b).

3.2. SETTLEMENT CHARACTERISTICS OF ERIMLI NEIGHBORHOOD

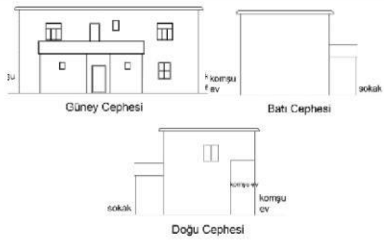
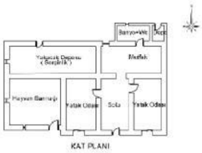
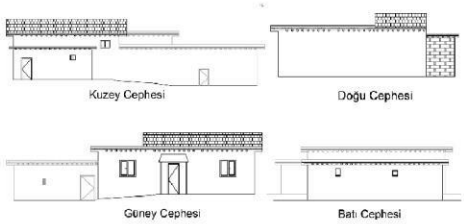
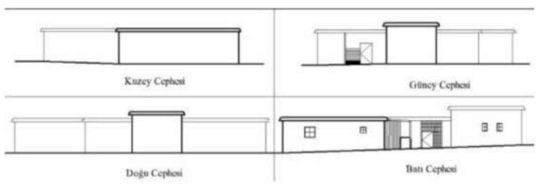
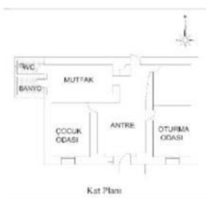
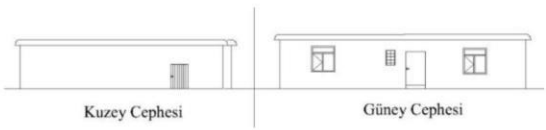
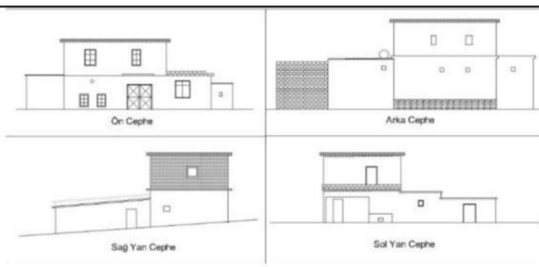
The middle part of the settlement axis forms the center of the neighborhood. There is a coffee house, mosque, and condolence house used as a public area in the center. The buildings are not in a specific order but have an organic order developed in line with the needs. Houses arranged at close distances or adjacent to each other formed streets of various widths. These distances vary between 1 meter and 3 meters.

The traditional buildings made of adobe in the settlement are single storey. There are also two-storey examples of reinforced concrete structures built in recent years. Adobe houses can be classified as planned houses with and without a sofa. Adobe houses usually have a sofa, room, hall, kitchen, bathroom, toilet, and storage. In the garden areas, there are settlement, poultry and food warehouses. The construction technique of these places is the same as the houses and the building material is mud brick. Although adobe houses are mostly built in rectangular and compact forms, there are also houses that cannot be defined as rectangular, depending on the later additions. The houses are generally oriented to the south and east.

The walls that serve as carriers in the houses built with the masonry construction technique are made of adobe. The use of adobe building material on the walls increases the thermal performance of the spaces due to its heat-retaining feature and long time delay. The outer wall thickness of the buildings in the settlement is generally 80-85 cm, and the inner walls are approximately 55-60 cm thick. The upper cover of the buildings is made of an earthen roof with straw added. The roofing system consists of rafters with an average diameter of 5 cm, which are added in a vertical direction to the wooden rafters with an average diameter of 10 cm placed on the walls in the short direction of the spaces.

3.3. FAÇADE ARRANGEMENTS OF ERIMLI NEIGHBORHOOD

In the study, 20 adobe houses in Erimli Neighborhood were examined in terms of their façade arrangements. The examination was made by classifying them according to the elements that constitute the façade. The plan drawings, façade drawings, and images of the examined houses are presented in Figure 3. The entrance arrangements, walls, openings, and roof coverings that constitute the façades of the adobe houses in the settlement are designed simply and without ornaments. There are no moldings, cartridges, or consoles in the façade arrangements where functionality is prominent. The number of floors of the adobe houses, which were mostly designed as one-storey in the settlement, later increased to two with brick material. There are also examples where additions were made with brick material. Despite the existence of houses with balconies on the façades, balconies are not a common element in the settlement. Although the occupancy-space ratio and symmetry concerns are not observed on the façades, sharp lines are often not encountered as a feature of adobe material.

House No.	Plans	Façades	Images
1			
2			
3			
4			
5			

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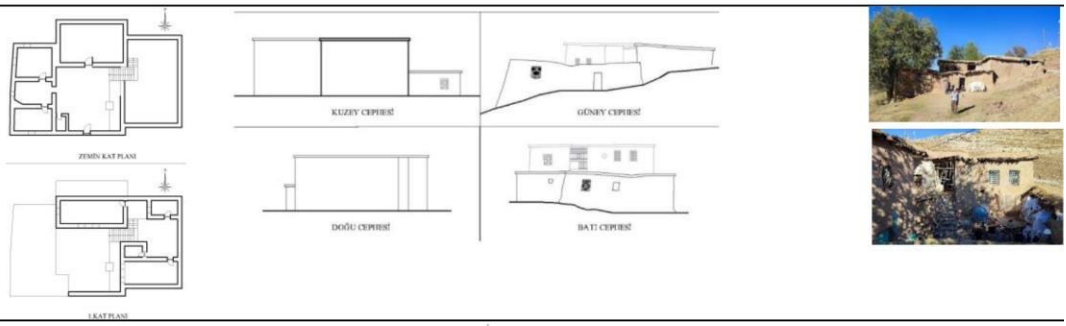
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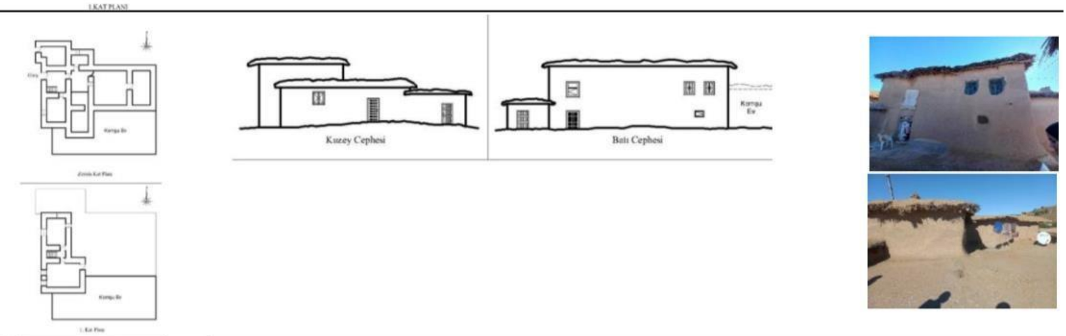
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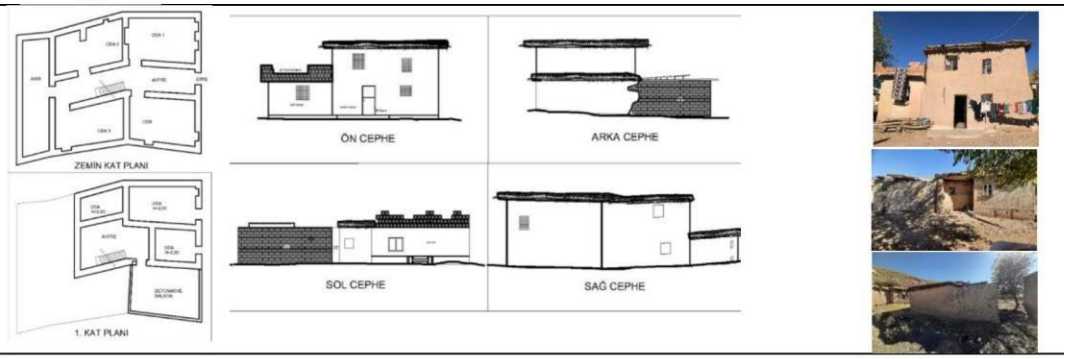
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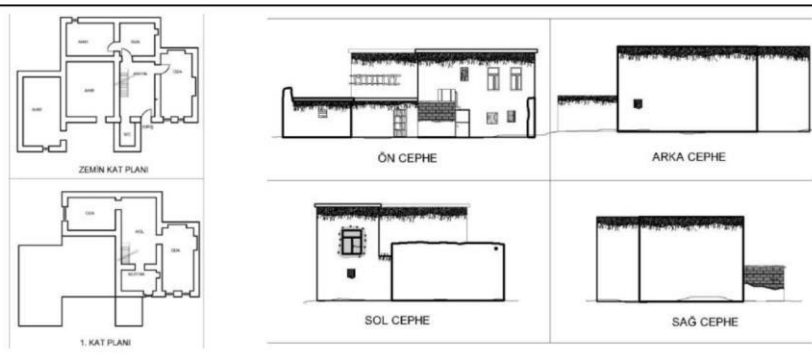
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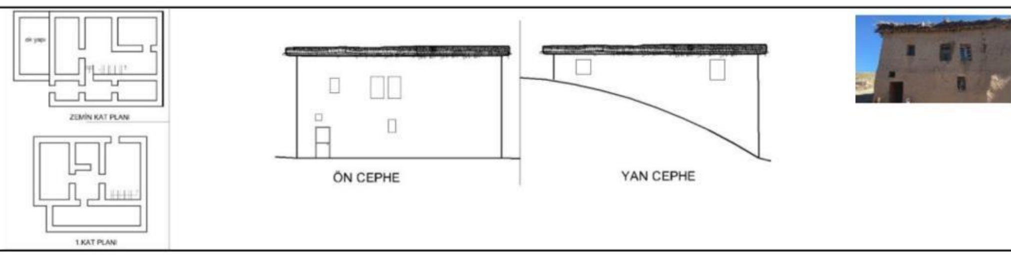
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Figure 3. Plan, façade drawings and images of adobe houses in Erimli Neighborhood

3.3.1. ENTRY ARRANGEMENTS

The locations of the entrances to the adobe houses in the settlement were determined by the parceling features and the garden areas. Houses with a garden can be accessed from the garden area, and houses without a garden can be accessed from the street. Entries are usually opened at ground level or, in some cases, from sills 10-15 cm high. In most garden areas, there are units such as coops, barns, and warehouses which are made of adobe. In the settlement, tandoor sections with separate entrances are also seen, which are planned independently of the houses not to increase the room temperatures. The entrance doors are protected by the 50-centimeter eaves of the top cover, and there is no independent entrance marquise on the façade. Although the dimensions of the entrance doors vary, the doors are 80-100 cm wide and 130-200 cm high on average. The doorsof the barn unit, which are reflected on the façade, vary between 80-100 cm in width and 140-170cm in height. The entrance doors of the units used as food warehouses are approximately 70x140cm in size. While the material of the entrance doors of the houses is metal, the entrance doors of the coop, barn, and warehouse units are made of wood. There are no ornaments on the iron or wooden doors.

3.3.2. WINDOWS

Despite the proximity of the settlement to the Tigris River, the orientation of the buildings did not develop towards the west where the river is located. However, the arrangement of the houses in the settlement in a closely spaced or adjacent order necessitated the orientation of a few in number and small in size windows to the west. While the buildings are generally positioned with their long façades facing south, it is also possible to see examples oriented to the east. Opening a window in the south direction reduces the heat gain by blocking the solar radiation coming from the east-west direction. In this way, indoor temperatures can be balanced during the summer months when the outdoor temperature reaches high degrees. Although there is no standard ratio of the windows of adobe houses, it can be said that the room windows are in the range of 70-110 cm in width and 100-140 cm in height. There are also near-square windows in the range of 60-80 cm. In wet areas, barns and warehouses, there are windows with an average width of 15-50 cm and a height of 35-50 cm. The fact that the window profile made of wood is usually on the inner surfaces of the walls, protects from solar radiation. There are also examples where wooden joinery was later replaced with PVC profile. Metal railings are mostly used on the windows. There are wire mosquito nets and cloth covers on metal railings on the windows of some houses in the settlement. In the wet areas of adobe houses, there are window openings of 30-40 cm width, without profile, in the north or west direction. Cartridges or shutters were not found on the plain and unadorned windows.

3.3.3. TOP COVERS

The upper cover of the adobe houses is an earthen roof with wooden beams. Wooden rafters with an average diameter of 10 cm in the short direction of the space and rafters with a diameter of about 5 cm in the long direction were placed on the wall. After the rafters are covered with materials such as wood and bushes, soil with the addition of straw is laid. Soil is poured into the middle parts of the cover at a higher level than at the edges. With this method, precipitation waters discharge by creating a slope towards the edges. The eaves arrange at an average thickness of 50 cm. The roof systems of adobe barns, poultry houses, and storage units were built with the method used in the houses. The chimneys in adobe houses are generally made of adobe, in a simple form that narrows towards the upper part. There are also brick chimneys added to the houses later. The top cover of the tandoori section has a small skylight that functions as a chimney [15].

CONCLUSION

In this study, the façade arrangements of rural architectural examples made of adobe in the Erimli Neighborhood of Diyarbakır province were examined. The entrance arrangements, windows, and roof coverings that make up the façade elements of 13 adobe houses selected for examination in the settlement are discussed under separate headings. The plan and façade drawings and visuals of 13 houses determined by fieldwork are presented in Figure 3. The façades of the adobe houses, which were examined according to the findings, were designed according to the climatic and topographic characteristics of the settlement, rather than an aesthetic concern, and they have the characteristics of the rural architecture to adapt to the physical environment. The entrance arrangements as an element of the façade elements are oriented according to the parcelling features, and the window openings are oriented according to the thermal performance. The number and dimensions of the openings were also designed by considering the climatic features. There aren't any ornaments on the doors, windows, or walls of the façade elements, and functionality is at the forefront. This simplicity observed in the façades of adobe houses allows them to adapt to the basic conditions of the environment in various climates and topographies. The façades of the adobe houses in the settlement, which were designed without façade movements such as molding, cartridge, cantilever, pillar, and ornament, created unity and added a characteristic feature to the settlement. In this context, adobe houses built with building materials and construction techniques suitable for the region in Erimli Neighborhood, which is facing the danger of concretization, are structures that should be preserved with their original qualities and handed down to future generations.

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55- The Place of Adobe in Turkish, American And New MexicoRegulation, Standards or Building Codes

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ABSTRACT

Adobe is one of the most important building materials that has been used from past to present. Among the factors that make this building material important are that its raw materials can be easily obtained from or near the construction site and that it can be prepared practically on site. Since 1966, various regulations in Turkey have begun to draw attention to adobe and adobe construction systems.

The two Turkish standards, issued in 1977 and 1985 and repealed in 2011, contained definitions, design rules and tests for adobe materials and construction systems.
In the Official Gazette published in 2018, the annexes of the Turkish Building Earthquake Code include Chapter 11 Special Rules for the Design of Masonry Building Support Systems Under the Impact of Earthquake. In this regulation, adobe is only referred to as a "word".
Besides that, many countries such as New Mexico, America, Germany, New Zealand, Peru etc have building codes, standards and guidelines that have taken root in the last few decades and are updated regularly. In these regulations, the concept of sustainability often comes to the fore side by side with adobe and earth construction systems.

In this study, the changes regarding adobe buildings in the regulations in our country are presented chronologically, the TS2514, TS2515 and TS537 standards are examined and attention is drawn to the place of adobe in the American and New Mexico standards.

Keywords: Earth architecture, adobe, building codes

1. INTRODUCTION

In our country, adobe materials are found in Troy, Boğazköy, Hacılar, Çatalhöyük and many ancient settlements. There are two types of adobe structures in our country. The first is the construction system with adobe blocks, in which the walls built with adobe bricks are carriers. The other is the system in which the wooden pillars and beams placed inside the walls at wide intervals assume more load-bearing, while the thick adobe walls are not completely load-bearing [7,8,9].

The development of building codes is one of the most important tools to improve building technologies. For this reason, countries with adobe construction technology in their history have developed building regulations or building codes that take this technology into account [5].

These codes and regulations generally aim to set the minimum standards for earth construction systems and to create a guide for the users and the architects, engineers and craftsmen who will do this work.

2. WHAT IS ADOBE?

Adobe; It is a building material obtained by pouring soil containing clay in appropriate proportions into wet molds, blending with water and additives, kneading and drying in dry and open air[9].

The adobe balances the humidity of the environment and cleans the air and can be mixed with water and reused, or it does not harm the nature when mixed with the soil by recycling. Since the building is produced on site, there is no transportation cost and it is produced with very little energy consumption. The heat storage capability of adobe is much higher than that of brick. As long as the adobe is protected against water, it is long-lasting. But its resistance to water is low [3,10].

3. ADOBE IN REGULATIONS AND STANDARDS IN TURKEY

For the first time, adobe buildings were taken into account in the third part of the Istanbul Province Yalova Municipality Zoning Regulation and the 14th item titled Building Types of the Official Gazette published on 08.09. 1966 in our country. This item is an item that specifies the number of floors and heights. According to this item, a basement and a normal floor cannot exceed 3.5 meters in adobe buildings, and an attic cannot be built on top of adobe buildings [6].

TS 2514 adobe blocks and construction rules standard, dated February 03, 1977, is about the definition, classification and properties, construction rules, inspection and tests of adobe blocks. It covers simple adobe that has been poured into an unstabilized adobe and dried in the sun. The sources used in the creation of the standard are as follows: DIN 18951, DIN 18957, Eyyüp Kömürcüoğlu, Adobe and Adobe Construction Systems as Building Materials, Necmettin Sönmez Researches on the Properties of Adobe Agricultural Construction Material, Ministry of Construction and Settlement Research Mudbrick Seminar Communiqué and Minutes. WhatShould Be Considered in Board Adobe Buildings? [11]

TS 2515, dated 03.04.1985, the construction rules of adobe structures, is about the rules that must be followed in the design and construction of structures made of adobe blocks. Dimensions, heights and design rules are standardized in detail. The sources used in the creation of the standardare as follows: DIN 18951 57 In Revision: (April 3, 1985) TS 2515, Adobe Seminar Communiqués, Regulation on Structures to be Built in Disaster Areas, Earthquake and Earthquake Resistant Structures [12].

These two standards were repealed on 22.11.2011.

In the Official Gazette published on 02.09.1997, the Regulation on the Structures to be Constructed in Disaster Areas, Chapter 11 includes the Earthquake Resistant Design Rules for Adobe Buildings [1].

The number of floors that can be built is given as basement+1 floor in this regulation. The floor height is determined as maximum 2.70 meters from the top of the floor to the top of the floor, and 2.40 meters in the basement floor.Plans should be rectangular and load-bearing walls should be symmetrical or nearly symmetrical. Partial basements are not allowed [1].

The adobe dimensions will be 12x30x40 (main) and 12xl9x40 (lamb), or 12x25x30 (main) and l2x18x30 (lamb) and will be produced according to TS 2514. The main adobe is a large adobe brick. Lamb adobe is about half the size of the main adobe.

The outer load-bearing adobe walls are at least 1.5; load-bearing inner adobe walls will be at least 1 adobe length thick. The stability distance is specified as 4.5 meters. The gaps can be opened after leaving at least 1 meter of solid wall from the corners of the building. There must be at least 1 meter of solid wall between two spaces. The length of the solid wall parts between the window and door spaces, except for the corners of the building, in the plan shall not be less than 1.0 m. Except for the corners of the buildings, the length of the solid wall part to be left between the intersection of the walls and the window or doorway closest to the intersection of the vertically intersecting walls shall not be less than 0.50 m in plan[1].

Door gaps will not be more than 1 m x 2.10 m, window gaps will not be more than 0.90 m x 1.20 m. Lintels will be made with two 10cmx10cm wooden frames on the tops of the doors and the top and bottom of the windows. The length of the parts of the lintels that rest on the wall should be at least 20 cm[1].

Reinforced concrete or wooden beams described below will be built on foundation walls or basement walls in buildings with basements.
(a) Reinforced concrete beams will be wall width and at least 15 cm high.
(b) Wooden beams will be constructed by placing two tared frames of 10 cm x 10 cm cross-section so that their outer faces coincide with the inner and outer wall surfaces. These cadres will be nailed together with 5 cm x 10 cm vertical cadres every 50 cm and their spaces will be filled with stone chips[1].

The rules regarding the beams to be built on the adobe walls at the roof level are defined below.
(a) Where the roof is made in the form of wooden trusses or an earthen roof, the roof beams shall be made of wood in accordance with paragraph (b) above.
(b) In case the roof is made of reinforced concrete slabs, reinforced concrete roof beams with a height of at least 20 cm will be made[1].

Roofs of adobe buildings will be made as light as possible, with eaves that exceed the outer walls by 50 cm at most. Earthen roofs will not be built in first and second degree earthquake zones. In the third and fourth degree earthquake zones, the thickness of the soil roof shall not exceed 15 cm. Roofs of adobe buildings can also be made in the form of wooden truss or reinforced concrete plate terrace roof[1].

In the annexes of the Regulation on Buildings to be Constructed in Earthquake Zones issued by the Ministry of Public Works and Settlement in the Official Gazette published on 06.03.2007, Chapter 5 includes the Earthquake Resistant Design Rules for Masonry Buildings[4].

This section also includes information for adobe buildings. Accordingly, the allowed number of floors, storey height, wall thickness and dimensions of the adobe bricks to be used, stability distance, lengths of solid wall pieces required for opening the gaps, window dimensions, lintel and beam conditions are the same as in the 97 regulation[4].

The door space has been updated to 1mx 1.90m[4].

Natural stone, solid brick, bricks and block bricks, aerated concrete building materials and elements, which have void ratios not exceeding the maximum allowed as load-bearing wall material in TS-2510 and TS EN 771-1 as masonry material in the load-bearing wall, lime sandstone, filled concrete briquettes, adobe or similar masonry units can be used[4].

Vertical beam conditions for all masonry buildings have been added to the regulation[4].

In the Official Gazette published on 18.03.2018, the annexes of the Turkish Building Earthquake Code include Chapter 11 Special Rules for the Design of Masonry Building Support Systems Under the Impact of Earthquake[13].

In this regulation, adobe is only included in the article below:
11.2.4 – Hollow concrete briquettes, other bricks produced for infill walls, adobe, rubble stone, pumice stone and similar shaped blocks shall never be used as load-bearing wall material[13].

It can be said that TS2514 and TS 2515 standards are complementary to each other[Table 1].

DOCUMENT	MATERIAL INFORMATIO N /PRODUCTION		CONSTRUCTIO N SYSTEM RULES		TECHNICAL SPECIFICATION S		TESTS	
TS 2514	+		-		+	For material	+	Material tests
TS 2515	-	Just say refer to 2514	+	Design/ Production/ Maintenance	+	For construction	-	
Earthquake Code	-		-		-		-	

Table 1. Comparison of Turkish standards and regulations

4. ADOBE IN ASTM AND NEW MEXICO STANDARDS AND BUILDING CODES

If we look at ASTM (American Society for Testing and Materials), the ASTM E2392 / E2392M - 10 (2016) Standard guide for Design of Earthen Wall Building Systems is currently available. ASTM is an organization that sets standards for many industries[2].

The guide draws attention to two things: to provide guidance to earth structure systems and to consider technical requirements and considerations for sustainable development. In this context, in addition to explanations on materials, production process, indoor environmental quality, the guide also provides information on design criteria for earthen structures and structural and non-structural systems and components. Sustainable development aims to meet the needs of the present without compromising the ability of future generations to meet their own needs[2].

Under the heading of importance and use, it is pointed out that earth structure systems have been used all over the world for thousands of years and that there are many structures that still function today. It is emphasized that earth construction systems, which fell out of favor with the use of new construction materials in the industrializing world, are experiencing a revival in the industrialized world, driven by a number of factors. Here are some building codes, guidelines and standards that have emerged around the world over the past few decades:
Australian Earth Building Handbook
California Historical Building Code
Chinese Building Standards
Ecuadorian Earthen Building Standards
German Earthen Building Standards
Indian Earthen Building Standards

International Building Code / provisions for adobe construction
New Mexico Earthen Building Materials Code
New Zealand Earthen Building Standards
Peruvian Earthen Building Standards[2].

The target audience determined in this guide is actually parallel to both the traditional side of the earth material and the revival it has experienced. First, where practical and economical access to other building systems is scarce, the guide aims to increase both life safety and building durability. Secondly, it aims to provide the framework for coding and engineering design in developing and regenerating places, where soil classified as 'old' as the main structural material is preferred to other building materials qualified as 'new'[2].

Here, materials, technical requirements and design criteria are detailed, and in addition, simplified provisions are listed for cases where engineering design is not possible in the last section[2].

The manual does not recommend using cement plaster for unstabilized earth walls. This plaster, which is less vapor permeable than earth plaster, can trap moisture[2].

The production of unstabilized earthen building materials is more efficient than the manufacture of terracotta, brick or cement-based building materials. The unstabilized adobe that is destroyed can return to the soil without adversely affecting the ecosystem[2].

The New Mexico Earthen Building Materials code also aims to set minimum standards for earth building materials construction. Includes design criteria for adobe construction, Rammed Earth and CEB[10]. [Table 2].

Accordingly, adobe brick shall not be used in buildings higher than 2 floors. Adobe brick cannot be used on foundations and basement walls. There should be a continuous beam on all load-bearing walls. This beam can be concrete or wood. Unstabilized adobe walls can be protected with plaster of at least 7/8 inch thick if adequate roofing, parapet and sills are provided. It is essential not to create a vapor barrier in the application of other plaster and coating types[10].

Document	Material	Construction System – Main title	Update
TS 2514	+	-	1977-2011(repealed)
TS 2515	-	AdobeC. (Traditional)	1985-2011(repealed)
ASTM	+	General terminology of all of earthen building systems, Adobe C. and reinforcings	2016
New Mexico Building Code	+	Adobe C. Rammed Earth C. CEB	2015

Table 2. Turkish standards, ASTM and New Mexico building code

CONCLUSION

When the standards and regulations for adobe materials and construction systems in Turkey are put forward chronologically, we see that while detailed resources have been created to guide users and all kinds of people who will take part in the design and production stages, adobe has not found a place for itself in the last 10 years.

In earth construction systems, beam support on the top of the wall, number of floor limitation, the need for the roof to be light, the protection of the walls against the effect of water by making the eaves wide, the use of earth construction systems in foundations and basements are among the common points emphasized in the standards of the three countries. In addition, simple experiments that can be done on site are also available in all of them.

The ASTM standard sets an example in that it is designed to be used in the development of standards and building codes for earth structure systems, and that it deals with sustainable development and earth structure systems together.

It draws attention to the use of earthen building material in places where it is preferred over other building materials, revealing the fact that it arouses curiosity again today, especially due to its sustainable properties.

In fact, it is seen that TS2514 and TS2515 standards contain comprehensive information in terms of material and construction system. Standards for the traditional adobe building system can be extended with various material stabilizations, with reference to recent work. In addition, various reinforcement methods can be added to the building system criteria. Since the traditional adobe construction system is the most widely used system in our country, priority should be given. In addition, alternative construction methods such as rammed earth systems and CEBs are other topics that should be included in the standards.

In addition, the importance of the material in terms of sustainability should be emphasized and the content should be developed by determining the target audiences. Maintenance and reinforcement will be required for adobe users in the existing building stock. In addition, both traditional and alternative methods will serve as a guide for users and craftsmen for those who want to build a new building and prefer adobe.

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56- High Rise Adobe Buildings

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ABSTRACT

Adobe material has been used in architecture from past to present. In traditional building materials, it is used in many functions such as carrier element, wall filling, roof cover in the building system. It is widely used especially in rural areas due to many factors such as being easy to produce, low cost, environmentally friendly and healthy. Adobe has been used in both civil and religious buildings all over the World. It has been used as low-rise especially in earthquake zones and in Turkey, but it can also be used as multi-storey in places where there is no earthquake zone.

In the study, the earthquake zones in the World are shown on the world map, and the effects of adobe buildings in earthquake zones are mentioned. Then, especially from Africa, which is not an earthquake zone, to the Djenne Mosque, which was included in the World Cultural Heritage list by UNESCO, to the Bobo Dioulasso Grand Mosque and Shibam settlement in Yemen, which is on the UNESCO World Cultural Heritage list, defined as high (5 to 11 floors) in the Arabian Peninsula. In the evaluation section, it has been tried to compare these examples with the ancient settlements that took place in the history of adobe building in Turkey and the structures that are commonly seen today. In the evaluation, the seismicity conditions, the construction years of the buildings and their current usage situations are included. The study was completed by concluding that the adobe structure is long-lasting, and the height of the building depends on the earthquake zone.

Keywords: Adobe building, high adobe building, earthquake effect on adobe building, civil-religious adobe building

1. INTRODUCTION

Earth is a building material that has been used for thousands of years with the human need for shelter. Today, it is used in many parts of the world with different techniques and applications. The reason for this is that it is an economical and ecological building material. Adobe buildings are suitable and comfortable for human health and do not harm the environment. With these features, they are extremely sustainable structures and have been used for ages [URL 1].

The mudbrick was built in many civil, religious and official building types and at different heights. Stone is an accessible building material in Turkey, especially in religious and official buildings, stone or stone-brick mixture was preferred in general, and wood was used from time to time. Adobe was mostly used in civil architecture. In the World and in Turkey, adobe is widely used inbuildings that are not high. The fact that these geographies are earthquake zones has made it necessary for the buildings to be low-rise. However, high adobe structures can be encountered, especially in countries such as Yemen and Mali, which are not in earthquake zones. The use of high adobe buildings in these regions has developed due to certain environmental conditions, and this development has created very good solutions in terms of meeting the requirements. For example, the reason why the buildings are high in Shibam was developed to create a safe environment against attacks in the region.

The aim of the study is to draw attention to the relationship between the low-rise use of the adobe building, which is generally used in rural areas and is remembered as a low-rise building type, with the earthquake zone. It is to give examples that it is used as multi-storey or high in geographiesthat do not have earthquake zones.

The method of the study generally includes a literature review. The data obtained by scanning has been transferred with tables and photographs and the relationship between the use of high rise buildings in the earthquake zone and the characteristics such as construction year and height has been tried to be analyzed. Since it is desired to draw attention to the use of high rise adobe structures within the scope of the study, two regions where these structures are used were selected. Within the scope of the study, the architectural, structural and material features of the sample buildings were tried to be included, the castle structures were excluded from the scope of this study. The study was limited to the samples of Africa – Arabian peninsula, which is not an earthquake zone, and other samples from the world were not included in the scope of the study.

2. EARTHQUAKE REGIONS IN THE WORLD AND ADOBE BUILDING

It is seen that the earthquake zones marked in red on the world map are quite high 'Fig. 1'. In particular, it is stated that 90% of the surface area of Turkey is an earthquake zone [1]. Apart from this general feature, geography and the ground feature of the land are of course important and show differences. Depending on this situation, there may be limited areas with solid ground that are in the earthquake zone. Therefore, in this study, general approaches are mentioned and specialregions are not taken into account.

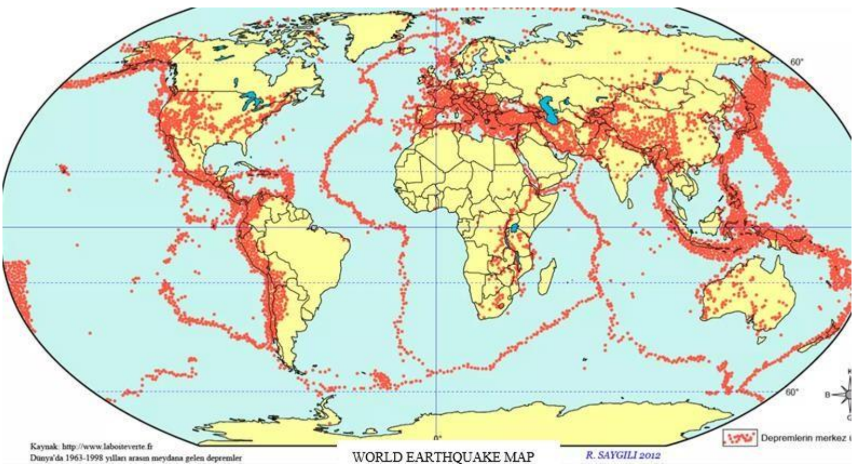
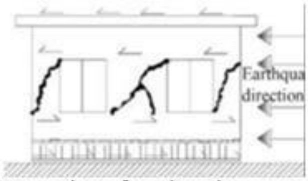


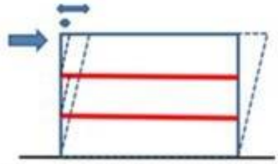
Figure 1. Earthquake epicenters on world map [URL 2]

In Turkey, some measures have been tried to be taken in the construction system in order to reduce the earthquake effect on the buildings. For example, in order to reduce the earthquake load effect that affects the structure laterally, horizontal beams (hatıl) are used in masonry structures [Table 1] [2].



Formation of earthquake damage in a masonry wall [5]

The use of beams in masonry buildings [2]



The amount of earthquake load absorption with beams [2]

Table 1. Earthquake behavior in masonry structure walls

Prof. Dr. Bilge Işık is trying to create horizontal fracture planes to reduce the earthquake effect on the wall. For this, a full-size structure was tested on the shaking table with a horizontal friction layer on the load-bearing wall every 40 cm from the ground upwards. And this building had a Shake Table Test performed by the General Directorate of Disaster and Emergency Affairs (2009) 'Fig. 2 a' [3].

There are two approaches in her experimental work on the adobe wall. 1. Creating a horizontal layer on the wall to extinguishing the energy. 2. Extinguishing earthquake forces by forming lines at 50 cm intervals on the existing building walls with the "Surface Shear" method 'Fig.2 b' [4].

Figure 2 a. Condition of Masonry Building After Earthquake Applied 8 Times [3]; Figure b. Creating a fracture plane [4]

According to this study, in order to prevent diagonal cracks due to earthquakes, horizontal fracture planes are created on the wall and the diagonal fractures are controlled and the earthquake effect is absorbed. In this regard, an experiment was carried out by applying biaxial pressure on a horizontally reinforced and unreinforced mud-brick sample at ITU 'Fig 3 a'. As a result of the experiment, cracks did not occur on the wall with horizontal reinforcement. Cross-fracture occurred in the unreinforced specimen 'Fig 3 b'. This experiment showed that the systems applied in the horizontal direction and created a fracture plane absorb the earthquake load [6].

Figure 3 a, Example of unbroken Wall   b. Diagonal crack formation [6]

Measures to be taken against earthquakes in masonry walls have been tested and solutions have been developed and this is very important. Because in Turkey, single or two-storey adobe structures are also demolished in earthquake zones and loss of life occurs. In the masonry system, the building walls are load-bearing and the load-bearing walls are generally extended by 10 cm towards the lower floors on each floor 'Fig. 4'. For this reason, earthquakes may pose a problem in terms of vertical load transfer in multi-storey high buildings.

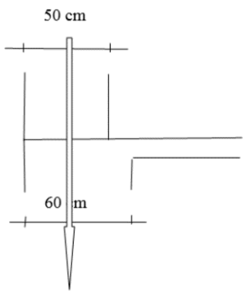


Figure 4. Load transfer on the wall in the masonry system

Despite the precautions taken on the walls, it is recommended to build low-rise adobe structures in traditional applications in Turkey and in earthquake zones, and all applications are in this direction. Therefore, it is accepted that the adobe construction system is suitable for low-rise buildings in earthquake zones.

3. HIGH RISE ADOBE BUILDINGS THROUGH THE EXAMPLE OF AFRICA AND THE ARAB PENINSULA AND THE SITUATION IN TURKEY

In this section, examples of high adobe buildings are given and the applications in Turkey from history to the present are briefly mentioned.

3.1. HIGH ADOBE BUILDING IN AFRICA AND ARABIAN PENINSULA

In cases where there is no earthquake zone in the world, adobe structures can be applied as multi-storey. In this study, three examples, which can be defined as multi-storey or high, are included. The first of these is the high-rise adobe buildings in Shibam, Yemen. The second is the Djenne mosque, which is a religious building in Mali, and the third is the Bobo Dioulasso Grand Mosque also is a religious building in Burkino Faso, West Africa.

3.1.1. SHIBAM

Shibam is a town of 7,000 inhabitants in Yemen. Shibam was dissolved as a multi-storey building to protect it from bedouin thieves, making it the first high-rise apartment block city in the world [7], [URL 3]. Although the town is located in the River floodplain, it survives with its strong environmental walls and maintenance. [URL 4]. All buildings built here are made of mud brick. The number of floors of approximately 500 of these buildings varies between 5 to 11. Some buildings here exceed 30 meters in height 'Fig. 5'. In the years it was built, there was generally only one family living in each building. The lower floors of these residences are used as cellars and warehouses, while the upper floors contain living areas and bedrooms. It is stated that most of these buildings have one or two rooms on each floor. 'Fig. 6' shows that since the ground floors of the buildings are warehouses, there are no windows on these floors. The streets were built one or two meters wide to protect them from climatic conditions and attacks from the environment 'Fig. 7'. In this dense urban texture, houses were built adjacent to each other 'Fig. 8'. Constructing these high buildings adjacent to each other provides an increase in their strength as a result of the structures leaning against each other [8; URL-5]. Buildings in Shibam date back to 1500 BC. During the period of use, all these buildings have survived to the present day by undergoing repairs almost every year 'Fig. 9'.


Figure 5. General view of Shibam town with multi-storey buildings [URL-5]



Figure 6. Facade views of ground floors without windows [URL-6, 7]; Figure 7 a, b. Narrow streets for protection [URL-5, 6]


Figure 8. Adjacent housing in Shibam [URL-6; 7] Figure 9. Building repair [URL 8]

3.1.2. MALI DJENNE MOSQUE

The Djenne mosque is located in the capital of Mali. The construction of the Djenne mosque began in 1280. In the following period, it underwent many repairs and reached its current state in 1907 as a result of the renovation works. This mosque was included in the UNESCO cultural heritage list in 1988 'Fig. 10' [URL 8].

Figure 10. General view of Djenne Mosque [URL 8; 8]

The mosque was built with local construction techniques. In the construction of the mosque, oil added soil (Faray), which can be reached from the immediate surroundings, and wood material is used. In the Djenne mosque, Sudano-Sahelian architecture (Sudan-French) style was used, as is generally the case in West African countries. In this style, there are towering, rhythmic columns and similar supports. The Djenne mosque plan is rectangular, its roof is supported by 90 wooden columns [URL 9]. There are 114 earthen-baked chimneys called 'ladis' for ventilation in the mosque and ceramic covers that can be closed in the rainy season are used for these chimneys 'Fig. 11'.

Figure 11. Ventilation chimneys on the roof [URL 10]

There are three minarets in the mosque and a spiral staircase in each minaret. 3000 people can fit in the Kingdom Hall [URL 11; 12]. There are hundreds of decorative woods on the adobe walls. While these woods provide a decorative appearance, they are used both during repair and provide rigidity in interior flooring connections and wall structures [URL- 13; 14]. The interior of the building has a dim light. Figures 12 a, b, c. shows both the amount of light and the structural wooden beams. The building is located in the delta of the Niger River and in the rainy season the area is flooded. It was built on a platform with a height of three meters to protect it from this effect 'Fig. 13'. Also during the annual plaster festival of the Grand Mosquée, the residents of Djenné contribute to the re-plastering of the mosque against the water effect of the structure 'Fig.14'. Since the necessary repairs were made to the Djenne mosque, the building can still be used today.

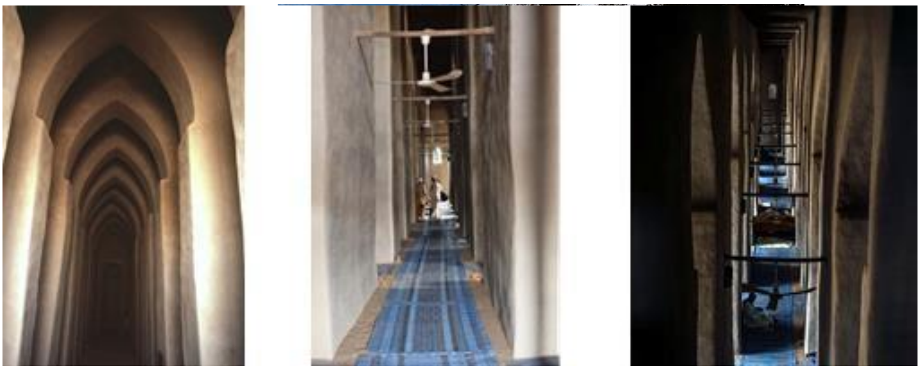


Figure 12 a, b, c Inside view of the mosque [URL 15; URL 16; URL 17]

Figure 13. The platform on which the mosque is placed [URL 18]; Figure 14. Wooden overhangs on the facade [URL-19]

3.1.3. BOBO DIOULASSO GRAND MOSQUE

The Great Mosque of Bobo-Dioulasso was built between 1812 and 1832 and has been repaired since then. The building has an area of 1100 m^2 and rectangular in plan. It is an impressive example of the Sudanese-Sahelian architecture prevalent in this region and is the largest building of this style in Burkina Faso. Soil called laterie, sheabutter and wood were used as materials. Laterite is a rock and soil mixture containing iron and aluminum found in rainy and hot tropical regions [URL 20]. The feature of Sudano-Sahelian architecture is that it has round and soft forms and wooden bars protruding from the walls. In the construction of this Mosque, wooden beams (yiri) were used horizontally and these beams were taken out. These beams are important both as carriers and have an aesthetic effect. There is a tower showing the mihrab and the qibla on the east façade, and a second tower on the north façade that functions as a minaret 'Fig. 15'. The mosque has an open courtyard and a masjid. An additional building was built in 1952, it was renovated in 1982, and the courtyard was covered with a tin roof in 1983. When the mosque is damaged during the rainy seasons, it needs to be repaired. Cement has been used instead of mud in the repair of the mosque, and its original structure has been damaged [URL 21; URL 22].

Figure 15. Bobo Dioulasso Grand Mosque [URL 22]

The interior of the mosque is plain and dim, with mahogany wood used for the ceiling 'Fig. 16 a, b' [URL 23]. Heigh rise information of the building could not be accessed. In the photograph in Figure 17, when the door height is accepted as approximately two meters, it can be accepted that the height of the minaret is approximately 15 meters. The mosque is still used today with regular maintenance.

Figure 16 a. View from inside the mosque [URL 24]; Figure 16 b. Ceiling view [URL 25]; Figure 17. Mosque door view [URL 26]

3.2. ADOBE BUILDING IN TURKEY

Since the Neolithic age, mud has been used in many parts of the world such as Africa, Asia, Europe and South America. It is known that the use of adobe bricks started 9000 years ago in Çatalhöyük in Turkey, and it was used in many historical settlements such as Çayönü, Aşıklıhöyük, Beycesultan, Boğazköy and Troya [9]. Soil has been used by people from every socio-economic level of the society for different purposes such as houses, religions and tombs throughout history in Ancient Egypt [10], [11]. It was observed that different adobe production techniques were used in the excavations made in the first settlements in Aşıklıhöyük, where adobe building material was used. In one technique, the mud was applied wet on the wall by hand shaping. Another technique applied here is the pouring into mold technique. Here, previously dried or used adobe blocks were thrown into the mud placed in the mold and masonry was made. In practice in the lower layers of Aşıklıhöyük (earlier periods), tuff stone fragments were put into the wall molds instead of mudbrick [12]. Societies living in the B.C. 7400s applied the mud in a rectangular shape for shelter needs. By creating a wall with this material, they called this technique the 'pise technique'. The earliest example made with this technique was found in the cities of Temrik and Tell M'lefaat in Mosul, Iraq. Chaldeans and Sumerians also used adobe in that region [13]. Curtain walls, partition walls and beams were built with mudbrick blocks in Jordan at the same time as Çatalhöyük. In this process, it was difficult to make adobe in large sizes due to shrinkage. In order to prevent this, the process of mixing straw was encountered in Egypt. Again in Babylon, asphalt was added to the soil to increase water resistance [14]. The mudbrick, which has been used for thousands of years in Turkey and its surroundings, has been used in single or two-storey buildings since those ages. In this usage process, depending on environmental factors, sometimes it was made only with soil, and in some regions it was applied as a mixture according to the geographical features. For example, there are different uses such as mud bricks on both floors, but sometimes with wooden supports, and in some cases the use of stone on the ground floor and soil on the upper floors. However, as a result, they were applied as one and two storeys, except for the general use, slope and different features. These general application conditions were accepted in the comparison of Turkey's adobe buildings and high adobe buildings in the evaluation part of the study.

4. EVALUATION

In this section, it has been tried to compare high rise adobe buildings and low-rise adobe buildings that are widely used in Turkey. The most important of these comparisons is that the structures are affected by earthquakes. Traditional adobe buildings in earthquake zones are generally built as one or two floors. In Table 2, the locations of multi-storey or high adobe buildings on the world earthquake map in Africa and the Arabian Peninsula are determined and the heights of these buildings and whether they are in earthquake zones and the situation in Turkey are shown.

Thus, it is possible to see that the limitations of being in an earthquake zone have continued since that period. The location of the examined buildings on the world map was marked and copied on Google maps, and the point belonging to the same settlement was shown on the earthquake map with a blue ring. The position of Turkey is shown in the table with an additional line to compare with the buildings examined.

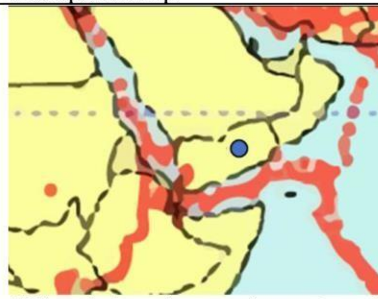
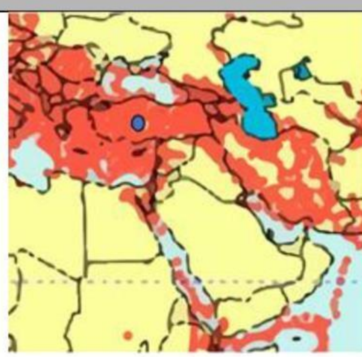
Line No.	Building name	The location of the building on the map	The location of the building on the earthquake map
1	**Shibam**	 Location of Shibam on the map URL 27	 Shibam's location on the earthquake map
2	**Djenne Mosque**	 Location of Djenne Mosque on the map [URL 28]	 The location of the Djenne Mosque on the earthquake map
3	**Bobo Dioulasso Grand Mosque**	 Location of Bobo Dioulasso Grand Mosque on the map [URL 29]	 Location of Bobo Dioulasso Grand Mosque on earthquake map
4	**Turkey**	 Location of Turkey (Çatalhöyük) on the map [URL 30]	 Turkey's place on the earthquake map

Table 2. The place of Turkey and the examined buildings in the world earthquake map

Table 2 shows us that none of the buildings in lines 1, 2 and 3 are in the earthquake zone, whereas almost all of Turkey in Line 4 is in the earthquake zone. This result proves that multi-storey or high adobe buildings are not in the earthquake zone.

The heights of the buildings examined in the third section are given in Table 3.

Building	*Height*
Shibam	5-11 floors building height of **30 meters and above**
Djenne mosque	**16 m**
Bobo Dioulasso Grand Mosque	~ **15 m**
Çatalhöyük	Generally **3 m**
Adobe building in Turkey	Single or double storey around **3/7-8 m**

Table 3. Building heights of examined adobe structures

When Table 3 is correlated with Table 2, it shows that the building heights in non-seismic areas are more than twice that in areas with earthquake zones.

Table 4 has been arranged in order to see the lifetime of the buildings discussed in the study and whether they are still used today.

Building	*Year of construction*	*Current status*
Shibam	1500's and later	in use
Djenne mosque	1280-various repairs-1907	in use
Bobo Dioulasso Grand Mosque	1812-1832	in use
Çatalhöyük	B.C. 7400	Historic area - Tourist area
…………- Nowadays	Adobe building in Turkey	in use

Table 4. The dates and current conditions of the adobe buildings examined

In Table 4, lines 1, 2 and 3 are all still in use. Of course, the use of Çatalhöyük in Turkey is not an expected feature, since it is a 9000-year-old settlement.

Civil architectural examples, besides those that have been used for many years depending on the maintenance conditions, many of them have been abandoned and have begun to collapse.

Table 4 shows that adobe buildings can be used for many years if necessary maintenance conditions are met. Of course, most of the examples selected here were repaired over time as they were private buildings. This proves to us that adobe buildings can be quite long-lasting if the necessary conditions are met.

CONCLUSION

Soil has been used as a building material in many different ways from past to present. The reason why it is used so widely is that it is economical, easy to apply and easily accessible.

It is thought that adobe buildings in societies are mostly located in rural areas and low-rise applications. It is seen that the reasons for low-rise use of adobe structures are mostly related to their location in the earthquake zone.

When the positions of the multi-storey or high adobe building samples on the earthquake map are examined, it is seen that they are not in the earthquake zone.

In addition, the study shows that the life of the buildings is extended with routine maintenance in areas exposed to water, and that the examples that are maintained other than ancient buildings can be used for many years. It is known that all three samples discussed in the study were exposed to water and were affected. But it is seen that these buildings are still in use today.

In addition, many studies have been carried out on the weakness of the soil, especially against water, and developments have been achieved in this regard.

The fact that multi-storey and high adobe buildings built many years ago are still standing shows us the strength of this building material.

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57- Application of Gis Technologies in the Field of Collection andPresentation of Historical Heritage Databases on Sample of Syunik Region Brickwork Structure

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ABSTRACT

The article studied the location of Syunik region, particularly brick-built, historical-architectural monuments, the availability of accurate information about them in electronic maps, the use of geographic information GIS systems with the collected data. There were many mistakes, omissions, both in terms of location and information.

During the research, a number of historical and architectural monuments were studied, the completeness of information about them and the fact that they are unified in one place. An initial database was created with the example of brick structures. Comparing the monuments with information based on the monuments about which there are no databases, it was found that there is a direct connection between the complete accessible storage of information about the monument and their current state.

It was proposed to create a new electronic map (ELMA), which is based on repeatedly verified data. Attached to the map will be intelligence data. This database will allow have reliable information about historical and architectural monuments. Create a complete database for the monument, including current information, and make that database accessible to professional and public circles. Also, by updating this information at least twice a year, we will always have clear information about the monuments. Each intervention must be registered and archived. At present, there is some work done in this direction in connection with the brick structures of the Republic of Armenia.

Keywords: GIS technologies, historical and cultural monuments, smart database, database of monuments, brick structures, electronic map, geodesy, cartography

1. INTRODUCTION

The article studied the location of Syunik region, particularly brick-structure, historical-architectural monuments, the availability of accurate information about them in electronic maps, the use of geographic information GIS systems with the collected data. There were many mistakes, omissions, both in terms of location and information.

During the research, a number of historical and architectural monuments were studied, the completeness of information about them and the fact that they are united in one place. An initial database was create with the example of brick structures. Comparing the monuments with information based on the monuments about which there are no databases, it was found that there is a direct connection between the complete "accessible storage of information about the monument and their current state".

2. MAIN PART

It was proposed to create a new electronic map (ELMA), which is based on repeatedly verified data. An intelligent database will be attached to the map. This database will allow to have reliable information about historical and architectural monuments. Create a common complete database for the monument, including current information, and make that database accessible to professional and public circles. Also, by updating this information at least twice a year, we will always have clear information about the monuments. Each intervention must be registered and archived. At present, there is some work done in this direction in connection with the brick structures of the Republic of Armenia.

The Armenian Highlands are known to everyone as a country of stone monuments, but there are many brick structures (mud bricks) that have reached us thousands of years before our era. Syunik region is rich in both stone and brick historical-architectural monuments, but very few people are familiar with the age, as there is little information about them and their location is unknown.

In the Armenian Highlands, clay and mud bricks made from it have been used in construction since the 7th millennium. The rich heritage of mud brick architecture has been valid throughout the highlands, especially in hot climates such as Syunik. This material, along with the stone that was consider traditional in the region, is still use in construction today. It is use in different parts of the structure: floors, walls, roofs. The quality properties of the ship's construction material were different for each case. There are also different types of brick structures: residential, publicbuildings, churches, industrial and economic structures [1].

During the reign of the Van Kingdom, clay was the most common building material, from which the upper rows of the walls of residential houses, secular and religious monumental buildings, the floors of the same structures were made of raw bricks. The walls and roofs were plastered with clay [1].

Houses made of mud brick and brick were built mainly in the Ararat valley, Sisian region, and in Western Armenia, in the villages of Alishkert, Shatakh, Mush region, and in the villages of the valleys in general, where the main building material was clay. The walls were cover with a flat horizontal roof or a double roof, sometimes vaulted. In case of covering a double slope, one or more columns dividing the room into two parts were stand from inside the room. In case of covering the dome, several wooden pillars were stand from the inside adjacent to these weak walls, which were connect to each other from above, forming a constructive frame, which the roof was carrying [2].

Most of the houses here were built of mud brick, relatively wealthy people built of hewn brick, even hewn stone. Sometimes some of the exterior facades of houses made of raw brick or stone and mud, with intermediate wall strips, window and door frames, fenders, and cornices, were lined with baked brick or hewn stone [2].

The combination of brick and stone was used in the religious structures, the three domed churches of Meghri occupy a special place in the late medieval architecture. One of them is St. John's Church, built in the 17th century. It is located in the northern highlands of Meghri. It is a four-aisled, domed, basilica structure. The church was built of local basalt stone, and the dome is made of brick. The rectangular hall stretches from west to east with two pairs of piers divided into three vessels. The ball dome is located in the center of the prayer hall. The drum is cylindrical on the inside, polygonal on the outside with 12 seats. The only entrance is from the west. The interior of the church is decorated with decorative brick frescoes. Niches and arches have a pronounced needlework.

Adjacent to the church on the west side is a rectangular, semicircular, three-arched open hall(now a ruin) [3]. The excavations and restoration of the church of the monastery were carried out by the "Yerkir and Culture" national charity organization. On July 27, the church was re-consecrated"Figure 1".

Figure 1. The process of restoration of St. Hovhannes Church, built in the 17th century

St. Astvatsatsin Church in the Great District of Meghri is one of the domed churches of the 17th century. It is located in the high northern district of Meghri city, surrounded by residential houses on all sides. It is a four-domed basilica. It is built of basalt, the drum and the dome are made of brick, it has two entrances, from the west to the south. The bell tower is built on the south side of the monument, on the double roof of Jakton (front). It is a square brick rotunda, crowned with a quadrangular veil. The church has a restrained exterior decoration. The only decorative element is the ram's head near the west window of the south façade. The interior of the church is decorated with 19th century frescoes "Figure 2".

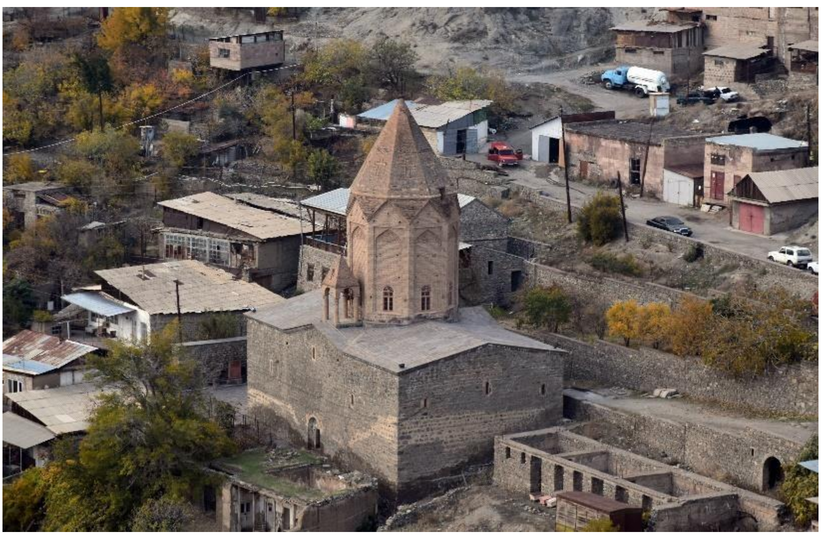

Figure 2. Surb Astvatsatsin Church of Mets Tagh

The church (dimensions: 14.73 m × 8.70 m) is fenced. The only entrance is from the south. The rectangular chapel of the church is divided into two pairs of T-pillars, ending in three naves and ending with a tabernacle. In the plan, on the right and left sides of the semicircular tabernacle, there are rectangular, vaulted, two-storey apses, the second floor of which can be climbed with entrances and stairs opening from the stage. The arches and quarters of the church are semicircular. On the roof, in the center of the church, rises a small brick rotunda consisting of 6 columns of the bell tower "Figure 3".

Figure 3. St. Sargis (also known as St. Hovhannes) 17th century church of "Pokr Tagh" of Meghri city

The above-mentioned group of monuments can be supplemented with a few, but there are structures about which you know only a small part of the locals, and none of the literature mentions their existence. One of the monuments of this type is the basilica church of Merghu factory district, about which no line is mentioned in the literature, and it is not possible to find its place on the map. This church today looks like a ruin and in the course of time it is destroyed and destroyed "Figure 4".

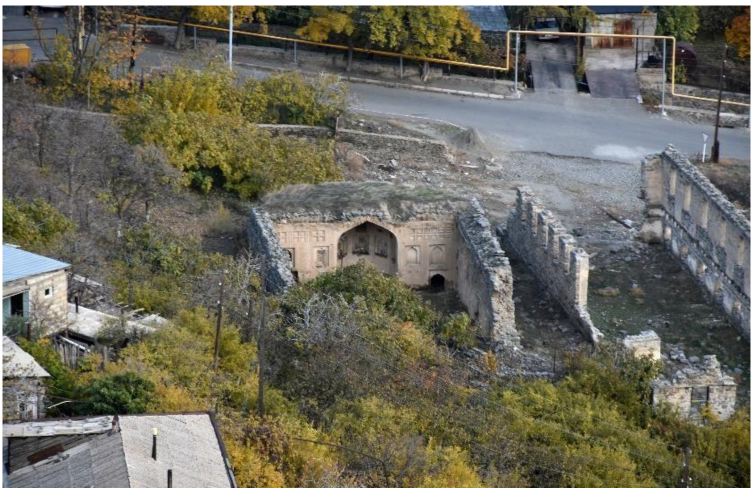

Figure 4. Basil church of Merghu factory district

By pointing out a few monuments in Meghri, we can get a general picture that the monuments that are better known to the public and have information about them are better preserved than the monuments about which the information is vague. Because of this great omission, we are losing a great legacy a large part of history.Currently, there is only a bilingual (Armenian, English) map-guide presenting the historical and natural monuments of Syunik region of the Republic of Armenia, which was created on the initiative of the "Debt of the Soul" patriotic non-governmental organization and with the support of the WFD Foundation "Figure 5". However, it is not possible to have information about monuments here or to classify those monuments in any category. This isa map printed only on paper where there is a little information about the density of the monuments in Syunik region.

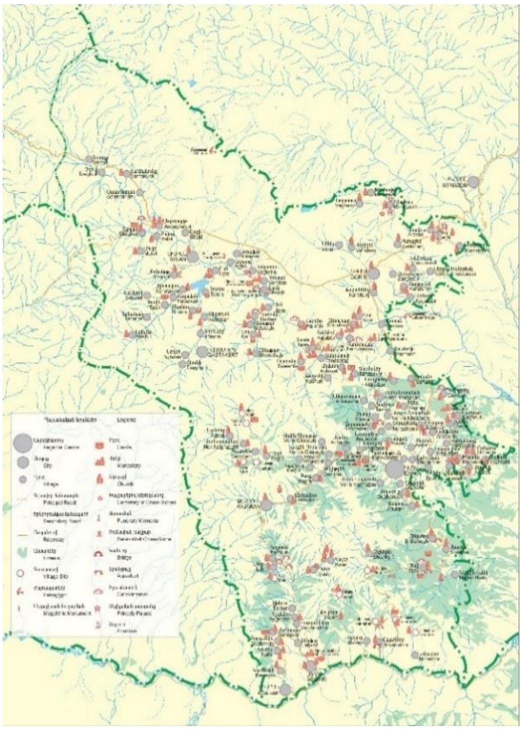

Figure 5. Bilingual (Armenian, English) map-guide presenting the historical and natural monuments of Syunik region of RA

By pointing out a few monuments in Meghri, we can get a general picture that the monuments that are better known to the public and have information about them are better preserved than the monuments about which the information is vague. Because of this great omission, we are losing a great legacy a large part of history.Currently, there is only a bilingual (Armenian, English) map-guide presenting the historical and natural monuments of Syunik region of the Republic of Armenia, which was created on the initiative of the "Debt of the Soul" patriotic non-governmental organization and with the support of the WFD Foundation "Figure 5". However, it is not possible to have information about monuments here or to classify those monuments in any category. This isa map printed only on paper where there is a little information about the density of the monuments in Syunik region.

Since the 19th century, geodetic methods have been used to obtain site maps and building plans. Over time, these methods were improved; it became possible to obtain not only the layouts of objects and accurate images of facades, but also to minimize the human factor in the process, as well as anthropogenic errors [5]-[6].

Currently, the process of geodetic survey of monuments can be divided into the following stages:

• Survey of the monument and adjacent area, collection of information from different sources selection of the most effective research method.
• Conducting field research, data collection.
• Cameral processing of collected data.
• Creating a geographic database.

They are most widely used for large-scale topographic surveying, aerial photography, surface-to-air scanning, and photography with unmanned aerial vehicles.Topographic survey. When studying monuments, it is very important to have not only the horizontal position of the main building but also the location and position of the smallest fragments at a scale of 1: 500 Ꙇ larger(1: 100 Ꙇ 1: 200 horizontal Ꙇ 1:50 scale vertical (facade)) topographic surveying methods.

Aerial photography. The use of this geodetic method is effective when the object under study is not a separate monument but a large monumental complex or monumental field. The essence of aerial photography is that the ground is photographed during the flight of a plane with the help of special equipment that shoots in a plane parallel to the ground "Figure 6".

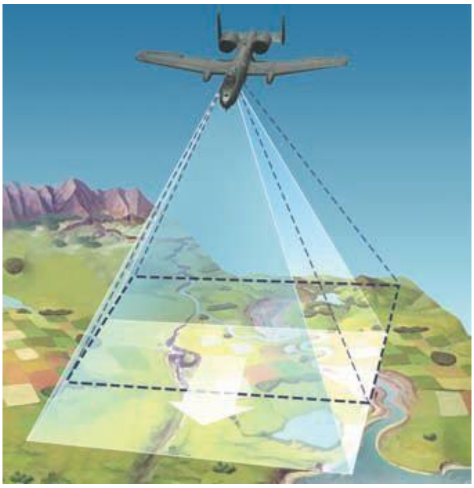

Figure 6. Aerial photography

Surface scanning. This method is younger than the previous ones, but has an exceptional efficiency for detailing the vertical components of the monuments. There are currently stationary Ꙇ portable scanning systems "Figure 7" that scan at a speed of 1 million pixels per minute.

Figure 7. Stationary Ꙇ mobile scanning systems

CONCLUSION

By creating a database of monuments (electronic), which will allow us to attach it to the electronic map, we will get a general look and consolidated information. All data is collected and classified in one database, then all this is placed with an electronic map. Various data related to the monument are filled in the database [table.1]. By studying these data, each specialist can form a rough idea about the structure. In the case of decay can provide recommendations for strengthening or rehabilitation, and after examining the data completed in the section of interventions may know information about further steps or other assertions.

no	Name of monument	Registration number in the state list	Location/ address	Style	Built date	Functions		Current situation					Building material	Archive materials		The radius of the protection (buffer) zone	Description of decay	Description of interventions
						Republican	Local	Ruins	Deteriorated	Standing	Restored	Initial appearance		Drawings	Photos			

Table 1.

It is more visible and accessible to the public to have photographs and diagrams, such as a hint of a short story about a monument or a text description. However, specialists and the mass of research need more professional information. ELMA has answered this question: when you click on each monument on the map, a small page will open "Figure 8" where it will give the reader a little information, then the specialist will need more information, which he can get in the electronic classification system of the electronic map.

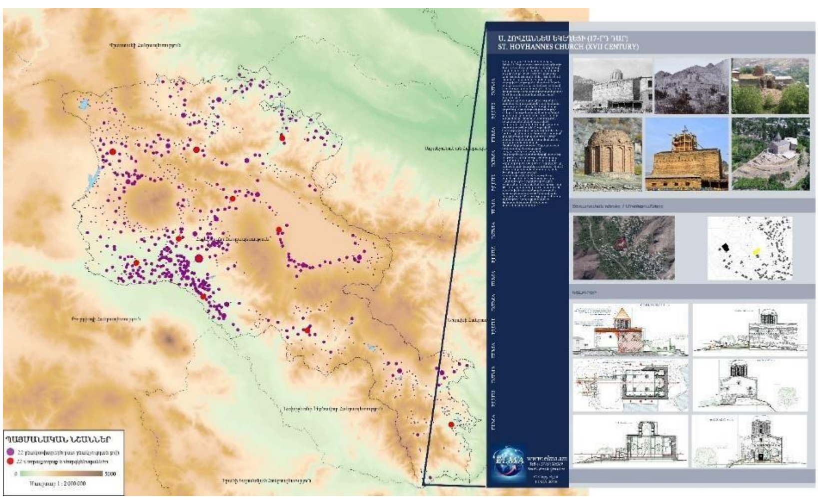

Figure 8. Example of ELMA information page

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58- Creating insulated building structures with Hemp and Earth.Why bio-based materials are essential for sustainable construction

Thomas Adrian Woolley
Rachel Bevan Architects, Northern Ireland

ABSTRACT

Buildings have been constructed and renovated with hemp and lime for 20-30 years. This is a very successful technique that can provide well insulated and low embodied energy solutions fora wide range of construction applications. However, the right kind of lime binders are not readilyavailable in many parts of the world and attempts to use poor quality lime has led to hempcrete building failures. It is possible to replace lime with earth as a binder and achieve similar results to hemp and lime. Two approaches have been pioneered in the UK, one with hemp and cob and another with hemp and kaolin powder. Both methods have potential as a cheaper and lower embodied energy approach. The talk will illustrate the development of hempcrete through a rangeof case study project and show examples of work with earth and clay with hemp.

Tom Woolley, B.Arch. PhD, is an architect, based in Northern Ireland, author of 8 books on green and sustainable building and has contributed to many international conferences and book chapters. He has a chapter in the new Encyclopedia of Vernacular Architecture of the World. He was Professor of Architecture at Queens University Belfast and has been a visiting professor in Malaysia, Sweden and at the Centre for Alternative Technology in Wales. He is chair of the UK Clean Air Steering Committee and a consultant to several environmental organisations. He has run training workshops on hemp construction in South Africa, Canada, Chile, Sweden, Netherlands, Poland, Ireland, England, Scotland and Wales.

59- Earth architecture cycles in Hadramaut, Yemen

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ABSTRACT

Even traditional earth building is, in general, a technique in defence under contemporary conditions, the city of Shibam in the Hadramaut valley in Yemen is the outstanding example of an area where earth architecture adopted to the hot arid climate still dominates the picture. Shibam as a World Heritage Site and the wider valley have as only few landscapes the chance of preserving sustainable building practice in large level, yet modern procedures favour techniques that require less maintenance. Technical innovation can fill this gap only partially.

Stabilizing the sustainable practice of traditional earth architecture in such an area requires a bundle of approaches including community-based support of local initiatives and coordinated strategies with the related authorities. The traditional building system can only sustain as a cycle adapted to local life conditions and adaptive to modern expectations alike, a building industry that attracts young men and ensures the continuing handover of skills to next generations, based on a permanent use of structures and a high identification with this "way of life".

A community-based approach as the best response to the challenges requires reliable local partners and the inclusion of social and communal concerns. In the case of Hadramaut, the World Heritage Site of Shibam proved to be a good base for a successful revitalization of the earth building practice.

Local cycles can contribute to sustainable economy if local demand accept it, but it needs also new comprehensive and holistic approaches by experts and active stakeholders.

Keywords: Earth architecture, community-based approach, traditional building cycle

1. INTRODUCTION

Wadi Hadramaut belongs to the few remaining landscapes where earth architecture still dominates the scenery. It is a large desert valley system in eastern Yemen, with its historic former capital city of Shibam listed as a World Heritage Site built completely in earth brick. Yet the challenges of the modern conditions and expectations bring earth architecture in the Wadi in defense, too, and rivalling building techniques, mainly based on cement block or concrete, are on the rise.

Still, the vaste majority of existing and even new houses are built in earth architecture, but in declining numbers, and the coherence of the settlements is declining continuously. This not only affects preservation expectations and the beauty of a unique cultural landscape, but threads the sutainability of earth building as part of local life cycles. This technology is adapted to the particular climatic and life conditions, it saves energy, resources and avoids emissions, i.e. it achieves to a high degree what other societies and economies want to develop. Therefore, it would be highly desirable to preserve and stabilize the sustainable building industry in response of the contemporay challenges and changes.

Technical innovation and international support can have a share in this support, yet intentions and processes within the involved communities are in the centre of the cycle, and succesful recovery has to go hand in hand with them. A community as a "soft factor" is a complex structure and in constant change, and dealing with it combines architectural and technical aspects with social, economic, environmental and political components. There is no real blueprint to this complexity; yet the example of Hadramaut provides valuable experiences.

2. EARTH ARCHITECTURE IN HADRAMAUT – BACKGROUND

Think globally, act locally – this fashionable slogan reflects an essential paradigm of sustainabiliy concerns. New approaches to deal with vernacular building technlogies should apply generally and internationally, but any successful approach must be based on the particular regional context with all its geographic, historic, cultural, economic, social and individual components.

The region of Hadramaut covers the largest part of Yemen´s east at the southern tip of the Arabian Peninsula. While most of Yemen´s population lives on the highland around Sana´a, Hadramaut is situated within the large deserts of the peninsula, defined by an extreme hot and arid climate, influenced by the tropical monsoon system of the Indian Ocean. Most of the region is unhabitable or sparcely inhabited by beduins, with the exception of the coastal strip along the Arabian Sea (with the capital of Hadramaut, al-Mukalla) and the unique valley system of Hadramaut, home of the historic and vernacular earth architecture we will discuss here.

Figure 1. Adaptive Arcitecture: Al-Khoraiba in upper Wadi Do´an

2.1. THE CITY OF SHIBAM

The most famous site in the architectural and tourist sense is Shibam, listed as Yemen´s first World Heritage Site and known as an iconic view by a wide public internationally. Indeed, as the only city worldwide built entirely by five- or six-floor tower houses made of earth brick and as a walled-in city, surrounded by palm yards in a rare authentic appearance, the value of Shibam is widely accepted and ensures the city good prospects of being preserved as national authorities and international donors concentrate their preservation efforts on Shibam. This prominence could support similar engagements within the wider surrounding of the wadi.

On the other hand, old Shibam as a small urban structure of approx. 350 by 250 m, inhabited by 3000 people, is today rather a small country town even in comparison of other towns in the valley, and the concentration on rehabilitation activities in Shibam could widen the gap between the conservation of a historic (and potentially touristic) site and the wider region in which preservation has only low relevance. In terms of sustainability, it would be essential to stabilite the practice of earth building in the whole wadi region as well.

2.1.1. HISTORY

Shibam has been the urban centre of the Wadi in the early Middle Ages, following the destruction of the old capital Shabwa around 240 AD. This event marked the end of the kingdom of Hadramaut, the wealthy keeper of a royal monopoly of incense trade, one of the four kingdoms of South Arabian civilization. None of these kingdoms survived, but Hadramaut alone kept its name and ethnic identity. For more than 2500 years the canyon-like valley was an island of sedentary and urban life within the infinite seas of desert – unknown to the West until ca. 1890. This isolation explains much of the way Hadrami people see themselves – as *hadhari* people, which means "sedentary" in a funny coincidence with the valley´s name in a rather nomad region. And the isolation is definitely the reason for the extreme conservationism of the local architecture. Shibam as an urban fabric as much as its tower house type is deeply rooted in South-Arabian antiquity, as scientists concluded soon after Shibam´s discovery (1) – a very old but still lively heritage.

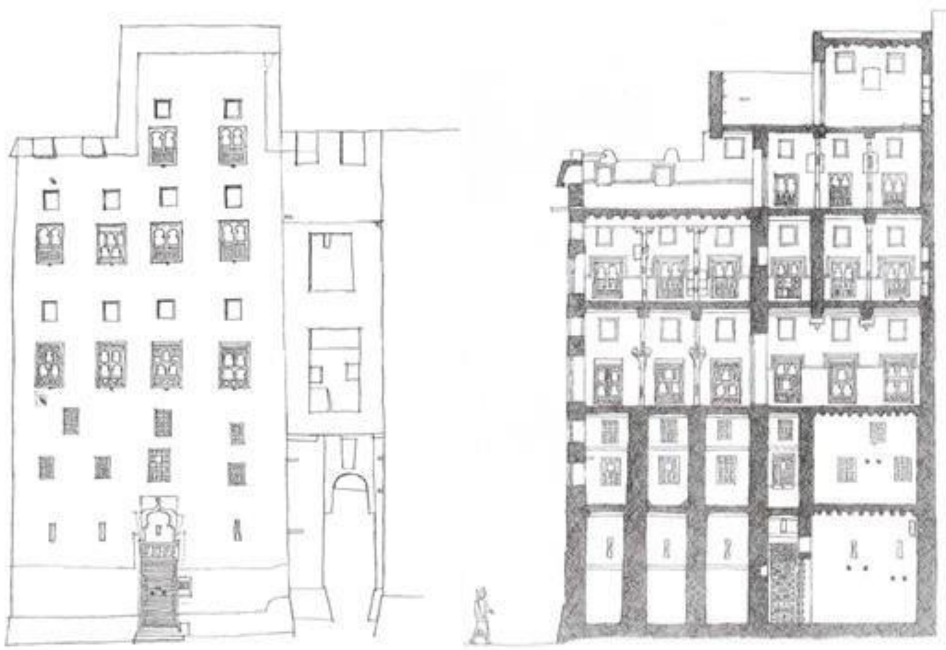

Figure 2. The art of the Tower House: Section and elevation of house B 37, Shibam

2.1.2. THE ART OF TOWER HOUSES

The tower house of Shibam is the local adaption of the South Arabian tower house known from Sana´a and the old towns and villages of the Yemeni highland. The tower house was not a singular phenomen in the Ancient Orient – in Egypt and Syria archeological findings show similiar types. But while in most Middle East countries the courtyard house dominates vernacular building, the tower house tradition in Yemen reflects the autonomy of Yemen´s culture at this Southern tip of the Arabian world. And more than in the highlands, tower houses in Shibam still preserve much of their appearance developed more than 2000 years ago, due to its continuous isolation.

The walled city of Shibam is built on a mount within the seasonal flood zone of the valley, an island during floods that still can occur once or several times per year which supported the extreme urban density. And as a dense fabric requires adaption to the whole (e.g. by access, light or sewage rights), the density of an urban fabric is a sustainability factor, too.

The type of the six-floor tower house is an elaborate construction system with many particularities that have their logic but contradict conventional modern building in many respect. For instance, walls are not vertical but rather conical, for the wall thickness diminishes from more than a meter at ground floors to a handspan (*shibr*) at sixth floor. In general, this architecure is defined by sensitive hands rather than on plans and numbers. Special solutions characterize stairs, light wells, natural air ventilation, chimney outlets and waste water removal. The typology also requires special solutions for climatic and cultural demands, as in pre-modern times roof terraces were essential to spend hot summer nights as living and sleeping space but in the same time, they have to be protected against viewing women by outsiders. And, an essential aspect, earth constructions have to be protected against water by a number of typical elements such as plastered surfaces exposed to rainwater or internal water use, special water runoffs and a complex traditional system of dry shaft toilets (2). The technology of maintenance and building is inherited from generation to generation by the master builder system that is still more or less intact.

2.1.3. CARPENTRY

The construction of tower houses in the ancient orient was based on two technical achievements: 1. the making of plaster out of the local limestone by traditional high-temperature kilns, and 2. the complex use of carpentry to stabilize high-rise structures and support their eartquake resilience. According archeological evidence, wooden reinforcements were the standard construction in wide parts of the ancient orient. In most regions, deforestation forced to reduction of wooden elements. In the desert valley of Hadramaut beams are mainly used for ceilings and columns, completed by diagonal anchors below the ceiling corners called *a´ud balalik.*

Apart from these constructive elements, doors and windows in Shibam are made out of *´ilb*, the local hardwood (*spinus christi*). Both are elaborate elements, displaying rich decorative carving of a century old tradition in a large variety and creativity. And the glassless grid windows allow ventilation and lighting while protecting interiors from being viewed and rain or dust, if needed. The colums and wall cupboards in the thickness of the walls, richly carved as well, are other details of this highly adapted architecture (3).

2.2. THE ARCHITECTURE CONTEXT IN THE WADI

The Wadi Hadramaut with its several tributary wadis, all o them cut in the uninhabitable desert plateau (*Jol*) by rocky cliffs. Only the valley floors allow vegetation and human life, but in the same time serve as flood drainage for seasonal torrential floods. As a result, most villages and cities (except Shibam and very few villages) stretch along the cliff foot, often on steep foothills – like the earth architecture, depending on water and protecting from it alike. Oasis cultivation and earth architecture both are sensible systems, highly adapted to local conditions.

Each section of the long winding desert valley has its own local character and its particularities in vernacular architecture. To name some, Seyun in the eastern central Wadi is the historic capital of the Kathiri sultanate and today the capital of the semi-governorate of Hadramaut, Wadi and desert. The old palace, today a museum, is described by some as the world´s largest earth building. An architectural style of rich ornamentation is home around Seyun and the small town of al-Ghurfa. Between al-Ghurfa and Shibam exists a remarcable group of large country tower mansions. The eastern town of Tarim is especially known for religious institutes, many historic mosques and more than 25 palaces in a Indian-Neoclassical style, and long ties to countries around the Indian Ocean. At narrow Wadi Masila, Qabr Hud is the unique example of an uninhabited earth-built city around the grave of the pre-Islamic prophet Hud that comes to life only for the annual pilgrimage.

Further west, three large tributary valleys lead further south: Wadi ´Amd, Wadi ´Amd and the left and right Wadi Do´an. The latter is home to a very elaborate and dense tower house architecture in an amazing symbiosis to a dramatic landscape. Al-Hajjarein, central town of the lower Do´an valley, is built above a spectacular cliff setting. Both are listed as tentative World Heritage Sites

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Figure 3. Water and Earth: Sewage works in Shibam; mudbrick makung in front of Shibam

2.3. RECENT REHABILITATION APPROACHES

From 2002 until 2011, a joint Yemeni-German urban project led by German GIZ with SFD, Sanaa and local authorities, started rehabilitation in Shibam, awarded in 2006 by the Aga Khan Award for its communiy-based approach (4). Later, an infrastructure project installed new sanitation and electricity networks and paving in old Shibam. Since 2016 the author undertook further rehabilitation measures, in particular at the suqs and on behalf of the German Foreign Office, and since 2020 UNESCO Doha with SFD support rehabilitation mainly of private houses in Shibam. The Buqshan Foundation supports rehabilitation projects mainly in the Wadi Do´an area. As a result of all these activities, a professional network supporting earth architecture in the wadi is in the rise, yet activities are still rather punctual.

3. TRANSFORMATIONS AND CHALLENGES

Earth architecture in Hadramaut is highly adapted to the extreme conditions and eco-friendly, and it is part of a certain way of life. Earth houses need frequent maintenance providing regular income for male youth but a financial burden for inhabitants. Houses need to be inhabited by people who care for it, i.e. are present in times of rain and have an eye on the structures. This technology is therefore interwined to many aspects of life that have to be included in all considerations and attempts to support it.

3.1. DEFICITS AND THREADS

Today, earth building practice is confronted with modern construction methods for several reasons, among them: limited acceptance of a traditional and "primitive" technology and the influencr of the Gulf "way of life", the high demand of maintenance, the way architects and other stakeholders are trained and calculate, the offical procedures of a centralized administration and the growing investment of businesses and appartment building types unfavourable to earth building.

3.1.1. SUBURBAN SPRAWL, TOWN PLANNING AND INFRASTRUCTURE

Yemen is one of the countries with the highest birth rates, and suburban sprawl transformed the valley in recent decades radically. Pressure to the vulnerable landcsape, growing dependance of individual car traffic, decline of palm yards and dramatic drop of groundwater levels are obvious. The risk of extreme floods like the last desastrous flood of 2008 is rising, and resiliant building zoning is not realistic. Townplanning is mainly concentrated on infrastructure projects and division of land by estates, following conventional models of wealthier countries. More flexible alternatives and ecological considerations are unknown. Uncontrolled sprawl threads resources, reduces fertile land and damages the integrity of fabrics and building practice.

3.1.2. THE VICTORY OF CEMENT BLOCKS

Like in all emerging countries, cement blocks are widely seen as a low-cost construction that does not require much maintenance. This affects all settlements except Shibam where preservation expectations are high. The wealthy elite often introduces imported models (e.g. fancy villas) and influence the building of practice of the wider public. Especially mosque buildings, often oversized and based on the destruction of historic assets, are often prestigious donations with low sensitivity to surroundings, a significant thread to the integrity of settlements. As another challenge, governement or public buildings are generally concrete buildings as planning is organized by the capital without considerations of local concerns, and adminstrative procedures contradict the involvement for traditional building industries.

3.1.3. PLASTERING AND PAINTING

Arab countries are known to have the highest per capita use of cement worldwide. This tendancy also affects the earth buildings itselves. Cement plaster or oil cover (in bright colors) are believed to protect earth structures from rain and make further maintenance unnecessary. The result is not only a violation to the appearance of settlements defined so far by the organic colors and surfaces of earth. More worrying, this practices often support the rise and growing of salty humidity inside the structures that can not vapour and eventually destroys structures – an effect that in turn again undermines the reputation of earth architecture.

3.1.4. PROPORTIONS AND DETAILS

The influence of modern techniques, imported examples and media also affects the way motives and proportions are treated. This affects not "only" esthetic and preservationist concerns, but also the quality of architecture in the social and urban sense and the way space as resource is used - and it diminishes its role for identity in the fragile context of the Middle East.

3.1.5. IMPORTED MATERIALS

Especially metal elements have been introduced to the contemporary building in Hadramaut. Steel rails are the usual method of ceiling constrcution even in earth-built houses, and smaller rails are used as lintel for window and door openings. Aluminium elements are used for windows and other elements. Beside, new products of the home building market such as ceramics, pseudo-stone or gypsum ready-made details become fashionable. While a certain influence of fashions is a normal side-effect of a lively building practice, it would be important to support sustainable local materials and limit the need of energy-intense imported goods.

3.2. CRISIS RESPONSES

Since 6 years, Yemen is shaken by a war that is interwoven in complex regional constellations and driven by internal instability. The isolation of Wadi Hadramaut has kept the region outside direct conflict involvement but the situation adds economic pressure and lack of perspectives and normal development to a country already confronted by shortages and challenges. Under these circumstances, authorities and strategies have only low chances to achieve improvements. This even increases the central role of approaches based on community and local initiative.

3.3. MODERNIZATION NEEDS

Following rapid changes in life conditions in the wadi, modernization needs, expectations and potentials result in inevitable transformations of housing and building in the wadi. Unfortuately, in a region where people wait for modernity and at least some wealth, concerns of sustainable dealing with resources and ecological impact find only low attention. On the other hand, especially as the region is poor and most people can not afford the lifestyle of wealthier Gulf countries, efficient use of resources would be urgently needed. But while sustainable approaches have already reached the attention of these Gulf countries, it does not reeach the wider Yemeni public where such structures are still much more intact. The challenge is to combine helpful modernization with traditional techniques in a way that solves main challenges and finds local acceptance alike.

3.4. ENVIRONMENTAL IMPACTS

The vulnerable and extreme life conditions of the desert valley currently become more fragile. Air-conditioned concrete villas and car traffic are options that ignore natural conditions, while sustainable solutions like earth architecture rather try to adapt to them.

3.4.1. CLIMATE CHANGE

The desert valley of Hadramaut is an extreme environment for human life even without current climate changes. The summer temperature of around 47 degrees is already extreme, and there seems to be an increase of torrential rains and flashfloods, that affect the safety of settlements and the stability of earth-built houses in general. Air-conditioning and concrete are seen as a protection, but they add to emissions and thus increase the pressure.

3.4.2. WATER CYCLES

The traditional water cycle within the houses (supply by wells, low water use, dry shaft toilets, protection of earth surfaces) was very efficient while modern water supply and sewage not only multiplied water use but also brought the plague of the *has* flies that make staying at night on the roof terraces almost impossible – the traditional method for spending summer nights that required no energy at all. Social espectations make some modernization inevitable, but traditional knowledge is a resource of techniques that would be helpful to integrate. Ecological sewage treatment is a valuable technology in a desert climate but requires external finance sources.

3.4.3. OASIS CYCLE

The oasis around Shibam (and similar traditional oasis sections of the Wadi) is another cycle and indeed the base that made sedentary life in this dessert possible 3000 years ago. Canals and dams led seasonal floodwater to gardens to feed crops and protect the settlements from flooding – still the only life-insurance this earth-built city has. Yet this cycle is under pressure, too: groundwater levels drop, palms die, farming is not profitable, the invasive sesabana bush replaces the diverse vegetation, pumping stations depend on Diesel and contradict the flooding model. The building cycle and the oasis cycle are interconnected and show that a holistic analysis of the wider context is necessary, even interventions to support earth building can only be limited in their effects.

CONCLUSION

As a general rule in supporting earth architecture, functioning elements should be strengthened while critical or dysfunctional elements should be improved. In the background of the many deficits and challenges in the Yemen conditions, informal factors and effects are an essential component of any efficient approach and their careful study is the first step.

Given the special conditions in the Yemen context, the community level is the main working ground. Authorities and NGOS can be main partners, even they do not reflect the whole community and cooperation should be kept as open and flexible as possible. A decentral network of architects and activists can be a backbone of engagements, while visible pilot projects, preferably decentral, should serve as a catalysator for broader awareness and initiative.

Figure 4. The future of earthen architecture is in the hands of youth and community: Eidcelebration in Shibam

That requires the consideration of many contradictions, like

Having a clear strategy in an environment of low respect for legal and administrative authority
Accumulation of deep knowledge in an environment where academic capacity is either low or even counterproductive (as it helps to replace traditional earth building by "modern" practices)
Working with authorities and NGOs knowing individual and informal relationships are often more essential and efficient
Supporting processes with external finance while the primary success factor is community engagement and ownership
Introducing international standards and professional methods in full knowledge they have to adapt to the traditional structures rather than the other way round

That requires the consideration of many contradictions, like

Sensible management can bridge the gap between preservation demands, modernization needs and (very individual) community perceptions. There can be no blueprint – potentials and risks are too complex. Yet straight commitment with a toolkit of several parallel approaches flexible enough to adapt to local developments will help. Visible improvements in the urban space are the most effective measures to convince public and authorities and donors. The involvement of many groups is an essential success factor: master builders and their staff, house owners and tenants, local business, architects and authorities including all parts of the communities and last not least, motivated and educated youth. Assistence by external players can have a supporting role.

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60- A Critical Reading on Regionalism in Modern EarthenArchitecture

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ABSTRACT

Residential architecture in recent years tends to combine the qualities of local craftsmanship with the beauty of the local geography, in order to recreate a contemporary architecture with a `spirit of locale' they perceived had been lost in Modernism. Their critical attitude towards Modernism can be placed in an international context, where criticisms against the homogenizing tendencies of the International Style were growing, notions of locality were explored in the tendencies of regionalism. Ten criteria set forth by Kenneth Frampton [1] in 1987 on regionalism were adopted, these ten items were analyzed, and ten design criteria were determined, which investigated the "spirit of the place" within the scope of environment-nature relationship, form, material, scale parameters. The earthen architecture of residential areas such as Santa-Fe in New Mexico, Sonsuz Şükran village (Hüyük-Konya) in Turkey, were discussed and examined through the new context and design criteria they created. The main aim of the research is to ask modern architecture uses which regionalist design approaches and techniques while mixing with the traditional architecture in these adobe focused buildings. New generation earthen architecture not only repeat traditional styles but also uses traditional materials in modern ways by creating a new context according to the structural and environmental characteristics of residential areas.

Keywords: Regionalism, adobe, earthen architecture, modern, traditional

1. INTRODUCTION

About one third of the world's population lives in traditional earthen dwellings, and in the last fifty years, it is seen that the interest in earthen materials in contemporary architecture has been revived. Many researchers report that almost 30% of the world's population lives in land-based dwellings [2]. It is estimated that there are around 80 million earthen dwellings in India and 100 million people living in earthen dwellings in China. In France, 15 percent of rural buildings are made of rammed earth, and the United States is the leading consumer of adobe in the industrialized world [3]. In the first part of the study, the design and construction techniques of adobe, its material properties, its benefits in terms of sustainability and contemporary building examples applied with this material are mentioned. Contemporary adobe buildings are analyzed, and the concept of sustainability is questioned in terms of environmental, economic, and social dimensions, while the new context they create in terms of architectural design is tried to be defined. Building with soil reduces the environmental impacts of construction while expressing local geophysical features. From a design viewpoint, earthen materials can be used by architects to express the "spirit of the place" emerging as a critical aspect of sustainability. Clay and soil represent sustainable materials due to their easily recyclable and natural decomposition, low environmental impact, and are preferred in healthy living spaces and buildings. In this context, adobe, a traditional material, is a comfortable building material with its heat insulation and moisture-balancing structure. In addition, when the adobe reaches the end of its useful life, it participates in recycling without harming the nature. In the second part of the study, the fieldwork aims to present a survey of projects in terms of "spirit of place" in New Mexico and Hüyük-Konya that are exemplary of contemporary earth architecture through critical regionalism criteria developed by Kenneth Frampton. The main aim of the research is to identify use of which kinds of regionalist design approaches and techniques in modern earthen architecture, within the scope of environment-nature relationship, form, material, scale parameters.

2. ADOBE AS ECO-FRIENDLY BUILDING MATERIAL

The traditional adobe construction method is a long and labor-intensive process, hence today the method of casting and ramming earth mortar directly into ready-made molds is preferred. The multiple reuses of molds used for this construction technique ensures minimal waste production. Owing to the economical and sustainable material nature of the earth, the adobe walls can be used with its own layered texture that does not require plaster skin etc. technic after construction [4]. Earthen architecture is appropriate to build in the climates with high humidity and comparatively moderate temperatures. In colder climates, earth structures may require additional insulators, while in locations with high rainfall, they need additional protection against rain [5].

Figure 1. Nk'Mip Desert Cultural Center, Canada, 2006.

The Nk'Mip Desert Cultural Center structure, where Aboriginal culture is exhibited, has adopted an environmentalist approach in design through its the rammed earth walls that do not have toxic properties and do not cause greenhouse gas emissions. The architects worked with local experts for building materials and construction technics that wouldn't impact the desert ecosystem, home to many endangered plants and animals. Wooden molds were used in the production of earth walls, which have homogeneous color transitions like geologic earth layers, and the molds used provided the wall to have a textured surface. Desert plants, which doesn't require irrigation, were sowed by laying 8-inch soil on the roof of the building, and the continuity of the surrounding desert was ensured with the soil roof created. Radiant pipes placed on the floor and ceiling were used to heat and cool the building. In the summer period, the building, requires no air conditioning, was cooled by giving cold water to the pipes on the ceiling, and in the winter period, the building was heated by giving hot water to the pipes on the floor [6].

Figure 2. Split House, Beijing, China, 2002.

There are an estimated 90 million homes in China that use adobe, mud, and rammed earth. Located in the Jundu Mountains north of Beijing, Split House is a contemporary design that recalls China's longstanding building traditions with "earth and wood". The techniques used to construct the rammed earth walls are based on local construction methods. Local soil was mixed with lime which works as stabilizer to provide added strength. Interpreting the traditional courtyard houses in Beijing's historic center, Split House creates a courtyard enclosed on all sides by the building. Splitting the house preserved the trees that already exist on the site, the public and private functions are separated and opened it to the view of the valley. The concept of "slit" also divides the functions of the two main materials. Thick, compacted earth walls surround the house with minimal environmental impact. However, the walls support the laminated timber frame roof and the second floor. The house creates a prototype; The relationship between the two halves of the house is designed to harmonize with the views, streams, topography, and proximity of the mountains that complete the courtyard. Split house preserved the trees that already exist on the site, separated the public and private functions of the house, and opened it to the view of the valley.

3. APPROACHES OF REGIONALISM IN MODERN EARTHEN ARCHITECTURE

Kenneth Frampton [7] identifies ten points on an architecture of regionalism as: vernacular form, modern movement, myth and reality of a region, information and experience, space and place, typology and topography, architectonic and scenographic, artificial and natural, visual and tactile, postmodernism and regionalism. Frampton emphasizes that vernacular architecture is based upon local needs, materials and practices grounded within current conditions, while modernism is often associated with homogeneity and mass production, removed from cultural ideologies. Frampton highlights the spatial arrangements of architecture and how these relate to the context. "Architecture cannot be limited by physical space it must be considered with culture, ideology, character and social structure", Frampton tries to reconcile the relations of life, interaction, and community with formal spatial arrangements. Typology, a classification of type, relates to culture and function. It reflects cultural progression and vernacular ideologies. Topography relates specifically to the site in question, the natural environment and becomes the physically defining characteristics of place. Critical regionalism acknowledges and embraces the multi-sensory concept; it promotes the use of materials that have certain local affinities, structures that provide certain bodily responses, and the regional seasonal changes that permit diverse emotional reactions. Assorted sensory experiences presented in the context of modern buildings may create new, unique and local experiences of place [8].

Ten criteria set forth by Kenneth Frampton [9] in 1987 on regionalism were adopted, these ten items were analyzed, and ten design criteria were determined, which investigated the "spirit of the place" within the scope of environment-nature relationship, form, material, scale parameters. The earthen architecture of residential areas such as Santa-Fe style in New Mexico, Sonsuz Şükran village (Hüyük-Konya) in Turkey, were discussed and examined through the new context and design criteria they created. The main aim of the research is to ask modern architecture uses which regionalist design approaches and techniques while mixing with the traditional architecture in these adobe focused buildings.

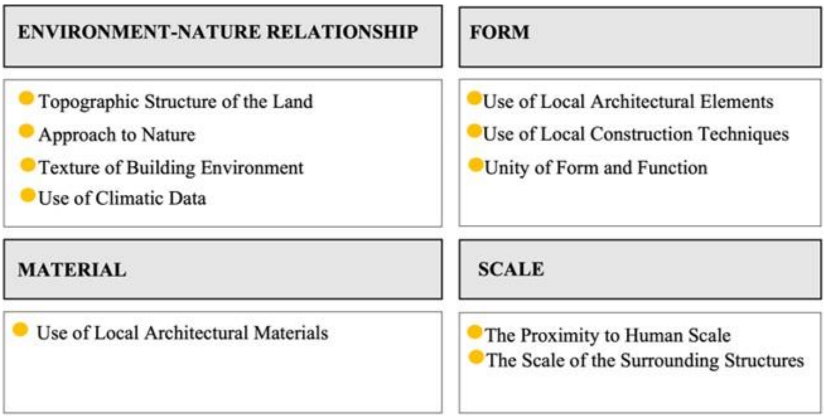

Figure 3. Design criteria of a building based on Frampton's critical regionalist approach.

Ten criteria set forth by Kenneth Frampton [9] in 1987 on regionalism were adopted, these ten items were analyzed, and ten design criteria were determined, which investigated the "spirit of the place" within the scope of environment-nature relationship, form, material, scale parameters. The earthen architecture of residential areas such as Santa-Fe style in New Mexico, Sonsuz Şükran village (Hüyük-Konya) in Turkey, were discussed and examined through the new context and design criteria they created. The main aim of the research is to ask modern architecture uses which regionalist design approaches and techniques while mixing with the traditional architecture in these adobe focused buildings.

3.1. SANTA-FE STYLE: REGIONAL APPROACHES TO ADOBE ARCHITECTURE IN NEW MEXICO

The history of architecture in New Mexico included the development of the Santa Fe style in the early 1900s. The architectural heritage of Santa Fe stems from three major roots: the New Mexico Indian building legacy of massive communal dwellings, the Spanish inheritance from the Moors of adobe construction and the Anglo importation of eastern building styles and materials. The Spanish Colonial era ended with Mexico's independence from Spain in 1821, the architecture in New Mexico during Mexican rule, however. remained unchanged. Although this political period ended with the annexation of New Mexico by the United States in 1846, the original style of Pueblo/Spanish architecture continued for some years until the supply of building materials and tools began to flow over the Santa Fe Trail. Local sawmills and brick kilns made possible the development of the Territorial Style, as well. The Territorial period began with the entrance of the United States Army into New Mexico; however, this style was not New Mexican; it was Eastern and of the Greek Revival manner. Expedience, the lack of a quantity of eastern building materials, and only the very beginnings of a milled lumber industry forced a merging of Pueblo/Spanish style elements with the Greek Revival taste of these Anglo newcomers. Windows and doors were set near the outside face of the adobe wall with a wood casing and simple, unadorned pedimented lintel [10].

Santa Fe Style refers to Pueblo Revival or Spanish Pueblo or Adobe Revival. This revival architectural structure represents imitations of Indian Pueblo and Spanish Colonial architecture, Spanish Pueblo, Pueblo Revival and Territorial are all modes or variations of the same basic elements. This style was very different in origin, purpose, and appearance from the adobe houses in rural New Mexico. The main elements of the style were flat roofs, adobe walls, or at least thick enough to give the impression of adobe, earth-colored plaster on the exterior and white plaster on the interior. The exterior woodwork was painted dark brown or white. In the interior, thewoodwork was similarly painted and included a number of details such as consoles, benches, fireplaces and portals [11]. Most of Santa Fe's finest Pueblo/Spanish style buildings date from theperiod between World Wars I and II (Figure 4).

Figure 4. (a) New Mexico Museum of Art, 1917. (b) Hotel La Fonda, 1919.

The massive adobe brick wall with projecting vigas and rounded parapets, interspersed with roof drains, exposed wood lintels over inset doors and windows, and portals with round columns and corbels were all continued onward from their earlier antecedents. Pueblo/Spanish Revival has a massive, archless, irregular look with the set-back upper stories and flat roofs of the traditional Indian community house. Taos Pueblo was obviously a major inspirational source. Also, squat towers derived from early Franciscan mission churches are occasionally seen on larger public, even commercial, buildings. Stucco with a smooth but uneven hand-applied look is universal. Whether built of adobe brick, hollow clay tile, brick or concrete block, in all cases the resultant appearance must be that of adobe bricks. Facades and building corners often have rounded stuccoed buttresses, albeit for visual effect only. High, thick round-topped stuccoed walls with emphasized wooden gates enclose rear, side or front patios [12].

Museum of Fine Arts on the Santa Fe, designed by Colorado architect Isaac Hamilton Rapp, represent an archaeologically conscious statement of New Mexico architectural traditions. It involves some regional references from three distinct New Mexico sources: the towers of the 18th century San Estevan Church at Acoma Pueblo, the parapet of San Jose Church at Laguna Pueblo, dating from 1701, and the stepped massing and picturesque roof ladders of Taos Pueblo. The architect added a rough-hewn, inset veranda known locally by the Spanish word "portal" at the front entrance, along with slightly battered and buttressed walls typical of New Mexico adobe churches. He also placed projecting viga ends at appropriate locations to suggest the traditional viga-and-latilla roof. The museum's walls effectively emulated the irregularities of adobe at the parapet lines. The walls also were punctured by relatively small, deeply-set windows, stuccoed, and painted adobe brown [13].

While this revival continues today, changing economic realities within the construction industry have had a strong effect upon the buildings completed since the end of World War II. Rising labor and material costs resulted in buildings that are generally flatter, thinner, and without the variety or hand-worked detailing. They must be put up faster, and in proportion, at less cost. There is but the rare building executed within the Pueblo/ Spanish manner which has the true quality and character of the earlier Revival structures. All the same features are discernible, but the spirit is weak. Wood studs have replaced adobe brick for most homes and the resultant walls arc flatter and smoother with an obviously fake batter at the parapet and sometimes at comers. The viga endswhich project through the wall are frequently simple log stubs attached to the outer surface only [14].

At the large scale, the Inn at Loretto, a multi-story steel-frame structure built in 1975, carries the notion of three-dimensionality to its largest extent. Its symmetrically designed cubic setbacks defining the hotel rooms give the entire structure an appearance of an architect-designed Taos

Pueblo (Figure 5). The building's regularity of features lends it an appearance quite different from the consciously irregular Museum of Fine Arts nearby, yet they share the visual effect of dramatic three-dimensionality in their facade treatments. The hotel's low setting along the Santa Fe River means that the approach is from above, so that this dominant building appears to nestle neatly among the much smaller buildings along the street as one approaches, and further nestles below the round-topped mountains behind. As with Old Santa Fe Trail, in no case does any street in the "styled" portions of Santa Fe extend to the horizon; all vistas are terminated in some way. Thus, Santa Fe exerts a sense of complexity, where one is confronted with an unexpected unfolding of opening and enclosure that creates a dynamic urban pattern in what is in fact a small area [15].

Figure 5. Inn at Loretto Hotel, Santa Fe, 1975.

3.2. ANALYSIS OF A REGIONALIST ARCHITECTURE: LA LUZ COMMUNITY, 1967-1974, NEW MEXICO

Figure 6. La Luz Community by Antoine Predock Architect, 1967-1974, New Mexico.

3.2.1. ENVIRONMENT-NATURE RELATIONSHIP

The La Luz project, designed by Antoine Predock, is a townhouse development on the west side of the city of Albuquerque, adjacent to the Rio Grande River. The community's openness to nature, unity with the land and adaptation to the climate represents a distinctive regional architectural approach. La Luz integrates into responsively the natural environment with the landscape of harmonious with mesa and mountains of New Mexico. Preserving the existing natural elements, the structure adapts to the changing topography of the land, and the housing units open to the adjacent river and Sandia mountains views. With its site-specific design approach that regards topography, landscape, climate, light, tectonic form, and residents' needs, La Luz is a living example of what Kenneth Frampton [16] called "critical regionalism" in 1983. Behind its regional orientation, it also offers a modern architectural perspective. In plan and façade, Predock efficiently and practically combines regional and modern architecture. This represents a functional and spatial approach to regional architecture, rather than seeking regional ties through superficial aesthetic embellishments or revival styles. La Luz's massive adobe walls, 16 inches thick, play an important role in responding to the local climate of the area due to their thermal mass. The walls of the building absorb the daytime heat, keeping the units cool. They regulate the temperature of indoor spaces by releasing the heat collected at night. Some walls are covered with white plaster to reflect sunlight onto terraces or rooms. West walls help protect units from afternoon sun and dust-bearing spring wind. The eastern facades of the buildings are mostly made of glass, nonetheless, overlook Sandias and the cottonwoods adjacent to the Rio Grande.

3.2.2. MATERIAL

Mud brick, brown cement plaster and white decorations are common to the Pueblo style that emerged in the region in the early 1900s; La Luz's architecture combines these traditional materials with concrete and large glass openings without the decorative ornament typical of Southwestern architecture. The building units were designed with mud brick, but finished with modern industrial materials such as concrete, timber and sheet glass [17]. In addition, wide driveways, large glass windows and sharp edges are among the modernist elements that define the building.

3.2.3. FORM

Use of local architectural elements such as flat roofs, adobe walls, and use of construction techniques such as earth-colored plaster on the exterior and white plaster on the interior present similar behaviors in between traditional and modern. Nonetheless, there is visual continuity of interior and exterior space through the use of large sliding glass doors, unlike traditional New Mexico buildings. There is a unity of form and function in the structure, it also presents a new model for suburban development. Each residence is linked to this public space and has its own private open space and access to semi-public communal terraces and squares. Through the close placement of housing units sharing smaller enclaves of open space in the form of plazas and patios, a greater sense of community will be evoked than generally exists in suburbia.

3.2.4. SCALE

Throughout the La Luz Community, the architect separated automobile and pedestrian movement, defines a new scale of modernity which regards the human needs. With design of circulation network inside the development, cars can directly access garages via a small peripheral loop road. Street alignments will follow the topography in gently curving loops. Each living unit faces the street but is protected by an enclosed walled front garden and its garage. The exterior walls are designed in accordance with the human-scale as well.

3.3. SONSUZ ŞÜKRAN VILLAGE: REGIONAL APPROACHES TO ADOBE ARCHITECTURE IN HÜYÜK-KONYA

Sonsuz Şükran Village is an art and culture campus established by writer and director Mehmet Taşdiken, near Çavuş Mahallesi, within the borders of Hüyük District of Konya Province. While designing the houses in Endless Şükran Village, which was built on an empty land allocated by the municipality, the old adobe structures in Çavuş Village were taken as an example. The buildings are constructed in harmony with the existing rural structure and climate, considering socio-cultural values such as privacy. While the houses in the culture-art village were built, local building materials (adobe, wood, stone, straw, and reed) were preferred from the natural environment, and they were designed with flat roofs in accordance with traditional adobe structures and geographical and climatic conditions. There are approximately 45 adobe houses in the traditional structure built in the village of Endless Şükran. The houses were built collaboratively with the support and will of the founder Mehmet Taşdiken, the residents of the village of Endless Şükran and the people of Çavuş village. The co-up working of the local people, local mudbrick masters and the residents of the Sonsuz Şükran Village during the construction of mud-brick houses, supports the collective identity of the culture-art village. The fact that women and men from the local people worked together during the construction of the mudbrick houses displays the local people benefited economically from the endless Şükran Village project. The adobe houses were built in two different forms as one- and two-storey adobe structures, spreading over the village land in a completely organic form, without being forced into the village plan boundaries. Wood, stone, and adobe were used in the construction of the houses. For the flat roofs suitable for rural architecture, materials such as straw and reed obtained from the immediate environment were used, and the original and traditional architecture suitable for rural architecture was preserved. [18].

3.4. ANALYSIS OF A REGIONALIST ARCHITECTURE: SONSUZ ŞÜKRAN VILLAGE, 2011, HÜYÜK-KONYA

Figure 7. Sonsuz Şükran Village (a), Mehmet Taşdiken House nearby the lake (b)

3.4.1. ENRIVONMENT-NATURE RELATIONSHIP

Sonsuz Şükran Village is placed close steep lines and forests of Taurus Mountains and the shore of Lake Beyşehir. Mud-brick exterior walls of the houses in Sonsuz Sükran Village are protected from the rainwater by overhanging large eaves. Adobe walls are built on a foundation of concrete or stone to protect them from moisture damage. Aside from its environmental and health advantages, adobe has good thermal mass, meaning that it is slow to transmit heat or cold. It keeps heat in the winter and retains interiors cool during the summer months. Mehmet Taşdiken house, which is placed in the topography in a position that completely dominates the village and lake view, adapts to the natural environment, as well.

3.4.2. MATERIAL

Sustainable, ecological, traditional natural building materials like stone, adobe, wood and reed were preferred for the construction of the dwellings in Sonsuz Şükran Village. Konya region was a poor region in terms of stone and forest. For this reason, stones were merely used for the foundations of the buildings and trees were used for the roofs. The adobe used in the construction of the houses, was cut and dried in the empty spaces near the house to be built, and then stacked for use in construction. The mud bricks were produced by mixing them with soil mixed with straw, then pouring them into wooden molds. The wood lintels are placed over the windows and door frames. The wood beams are respectively covered with wickerwork, reeds, insulation and earth on the roof Plaster, mixture of straw, clay and water, is applied to the adobe walls. In Mehmet Taşdiken house, mud brick was used as the building material and the roof setup was built using flat roof, straw and soil materials.

3.4.3. FORM

The houses in Sonsuz Şükran Village are individually designed encompasses a range of single and double storey with balcony or cumba, lean-to roof or flat earth roofs. The Mehmet Taşdiken house has a rectangular shaped plan which is divided according to functions. Windows are designed in 1/2 ratio of Turkish type and wooden materials are used. The simple entrance door is integrated into the structure as a single wing lame casing. There is an organically shaped veranda on the facade of the building facing the lake.

3.4.4. SCALE

All of the houses in Sonsuz Şükran Village are designed in accordance with the human-scale. Besides, the open and semi-open spaces of the structures, having standard scales and forming a common rhythm, not only in housing scale but also in the scale of street and the village creates an entirely, as well. Hence, the space organization based on human scale supports spatial continuity and the sense of place.

CONCLUSION

Earth-building technologies are the oldest known construction techniques on the world, but their use does not necessitate a historic style, nor does it reflect a retrogressive technology. Today, New Mexico, the leading consumer of mud brick in the industrialized world, hosts variable territorial styles of modern earthen architecture due to its multi-layered social structure. Santa Fe, which has a distinct sense of place and local identity, uses adobe construction techniques are supported by many as the cornerstone of regional architecture. The design of structures in New Mexico, Santa -Fe emphasizes the three dimensionality in both facade decoration and building plan. This feature displays itself not only in details such as recessed windows and doors that reveal the thickness of adobe walls, but also in a set of recessed walls as buildings stand behind extended thresholds or small courtyards. Since the flat roof is essential to the Santa Fe style, recessed walls move upward to the highest parapet, resulting in a sense of incremental depth extending step by step from the street edge to the top of the building. Horizontal measures are dominant in street-structure relation and the structure units (enclosed and open spaces) are designed in accordance with human-scale. As a modern interpretation of Santa-Fe Style in New Mexico, the La Luz's openness to nature, unity with the land and adaptation to the climate represents a distinctive regional architectural approach. The structure supports a functional and spatial approach, rather than seeking regional ties through superficial aesthetic embellishments or revival styles. It integrates traditional earthen materials with concrete and large glass openings without using any decorative ornaments. There is a unity of form and function in the structure, it also presents a new scale of modernity which regards the human needs for suburban development.

Sonsuz Şükran village has come into existence as a model project to keep the regional characteristics and cultural heritage of the village and its environment. The building typology of adobe in the village has a common layout as the rectangular and square shape type. Apart from enclosed spaces, most of the houses has verandas which regulates the climatic conditions,increases ventilation, and offers a mild microclimate to live. Considering the topographic landscape in the village, the houses are one or two stories, and they are placed according to the slope from the starting point of the parcel to its end. Mehmet Taşdiken's adobe house in Sonsuz Şükran Village, located in the topography overlooking the natural landscape and lake view. The dwellings in Sonsuz Şükran Village used the ecological and site-specific building materials like stone, adobe, wood and reed for the construction. As in Mehmet Taşdiken house, mud brick was used as the building material and the roof setup was built using flat roof, straw and soil materials. Further, the houses in Sonsuz Şükran Village are designed in accordance with the human-scale. The open and semi-open spaces such as gardens and verandas of the structures having standard scales and forming a common rhythm strenghtens "sense of place" not only in housing scale but also in the scale of street and the village. In both case studies, the earthen architecture is shaped by environmental, regional values and experiences transferred by local people. Most of modern earthen architectural structures are built with architectural elements that use local building materials and local construction techniques and have a strong relationship with the place- "sense of place" (genius loci). Modern earthen architecture not only repeat traditional styles but also uses traditional materials in modern ways by creating a new context according to the structural and environmental characteristics of residential areas.

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61- Rural Heritage Values of Doğanbaba Village and SustainableDevelopment at Lake Salda

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ABSTRACT

Doğanbaba is a rural settlement located within the borders of Burdur Province in the Mediterranean region. It is one of the two villages on the shore of Lake Salda. The lake area has recently drawn attention as an alternative domestic tourism venue. In the meantime, we observe an increase in social media awareness of preserving the environmental elements while intense tourism activities occur. Similarly, the lake region has also gained an academic interest within the scope of measuring the tourism potential of the region. However, tourism activities at Lake Salda should be associated not only with the ecology of the lake basin but with the rural settlements in the vicinity.

Rural tourism activities are generally developed without prior planning and infrastructural measures. However, establishing communication and bonds between the cultural texture and tourism are effective tools for maintaining the social, cultural, and architectural integrity of the region. Population mobility and radical changes in economic activities in the region, with the effect of "urbanization," results in the destructive process, which Butler (1980) defined as the "resort cycle," comprising the stages of discovery, inclusion, development, consolidation, and pause. Therefore, sustainable tourism activities in rural areas should be evaluated in the concepts of sustainable cultural heritage management, sustainable development, and sustainable natural environment.

Doğanbaba village has the most robust connection to the lake regarding its location and economic activities; therefore, it was selected for prospective structural analysis. The objective of the present study is to understand the rural cultural heritage values, including traditional construction techniques and intangible heritage values of the village. As a result, a region-specific rural tourism model has been proposed within the concept of sustainable rural development. For this purpose, besides the literature research, interviews were conducted with those who still reside in the village. In addition, the current situation has been determined and documented with the field surveys carried out in August 2021 in the region.

Keywords: Doğanbaba, Lake Salda, rural architecture, rural heritage, rural tourism

1. INTRODUCTION

Doğanbaba is a rural settlement in the Yeşilova district, within the borders of Burdur Province, in the Mediterranean region. It is one of the two villages in the area, with a shore on Lake Salda. In recent years, Lake Salda and its surroundings have gained attention as an alternative domestic tourism venue. Consequently, there has been various news on social media about maintaining the intense tourism activity without harming the natural environmental elements. Likewise, an increase is noticed in the number of academic studies measuring the region's tourism potential [1].

However, the lake basin's ecology and natural landscape components should be considered along with the rural areas and settlements where the lake is located to assess the tourism activities at Lake Salda.

The economy in rural areas is mainly founded on agricultural activities. Urbanization and the growth in the urban population introduced with the industrial revolution have also been extending in our country since the early years of the Republic. The figures published by the Ministry of Environment and Urbanization, based on the World Bank data, show that 75% of the population in Turkey lived in cities in 2018. Since 1927, this rate has been increasing, higher than the average of the World and EU countries. Therefore, demographic, economic, and spatial-environmental changes require a re-evaluation of the definition of rural areas and their content (Lane 2009, 355). The Rural Development Council of the Organization for Economic Cooperation and Development (OECD) (1993) classified the rural areas primarily into three main groups. This definition has been developed regarding the criteria of geographical proximity to urban settlements and related agricultural areas or forest land size.

Rural tourism has been characterized by Bernard Lane referring to the concept of "pure" rural, which includes diversity and reflects the integrated nature of the rural environment, economy, and history [2]. In addition, Clemenson and Lane stated that rural tourism is a system of niche markets tailored and intertwined according to the demands of a particular consumer group [3]. Rural tourism comprises various activities, such as eco-tourism, nature tourism, organic agriculture, organic life, extreme sports, or adventure tourism for different or similar target groups. However, rural tourism is considered the sum of suburban activities nowadays. In our country, especially in recent years, the number of tourists and daily sightseeing activities have been expanded in coastal settlements in the summer and smaller settlements near the metropolises on the weekends [4]. In summer, as an alternative to the beaches, some people prefer to travel to the regions with natural resources such as Pamukkale, Şirince, Cappadocia, GAP (Southeast Anatolia Project), Black Sea plateaus, and Isparta lavender gardens or regions rich with intangible cultural heritage and archaeological sites.

Various activities in rural areas that were established without prior planning and infrastructure precautions and without establishing a communication between the cultural texture and touristic intentions would damage the region's social, cultural, and architectural integrity. Urban tourism traffic initiates profound changes in economic activities in the rural settlements, with the effect of "urbanization" introducing the destructive process, which Butler [5] defined as the "resort cycle," consisting of the stages of discovery, inclusion, development, consolidation, and pause [6]. Therefore, tourism activities in rural areas should be designed considering sustainable cultural heritage, sustainable development, and sustainable natural landscape.

In this study, a region-specific rural tourism model has been proposed based on sustainable rural development by examining the geographical features of the Lake Salda basin along with rural cultural heritage values, including original architectural and intangible heritage values. For this purpose, in addition to the literature research, interviews were conducted with those who still reside in the village. The current situation in the region was determined and documented during the field surveys carried out in August 2021 in the region.

2. THE DESCRIPTION OF LAKE SALDA

Lake Salda is one of the tectonic lakes such as Acıgöl, Beyşehir, Eğridir, and Burdur in the region defined as the Göller Bölgesi (Region of Lakes). Apart from the dolomitic limestone formations around Kayadibi at 1139 m above sea level and southeast of the lake, it is situated among ultra-mafic rocks [7, 8]. Lake Salda, a closed basin with a depth of 184 m (DSI 2013), is fed by several streams, groundwater resources, and rainfall. The water balance in the lake is achieved by evaporation. Temperature data of the region for 1963-2012 (TMMOB 2020) indicates an upward trend of approximately 1 degree in the lake region, which is under the influence of the Mediterranean climate. While the average temperature in July and August was around 23℃, the average temperature increased to 24℃, according to the data for 2022.

The precipitation amount between 1950 and 2020 in the region reveals that the annual average is 483.2 mm, according to the data of Tefenni Meteorology Station. There is no significant change based on seasonal and annual distribution. However, the increase in temperature values, the amount of evaporation, and the changes in agricultural irrigation will increase water usage, disrupting the water balance in the lake. Depending on these changes, there has been a 3-4 m recession in the water level in the last 70 years. As of August 2021, the annual shoreline change can be detected in Figure 1. Dereli and Tercan studied the changes in the lake's shoreline using a GIS and RS-based methodology. They have observed that the lake area generally decreased, and accretion was observed [9]. The shoreline changes between 1975 and 2019 were calculated as 556.45 m.

Lake Salda is a closed system with a very alkaline freshwater pH greater than 9 [8]. Differences were observed in the concentration values of Mg2+, Na+, and Ca2+ that make up the water alkalinity between the measurements made in 1987 and the values obtained in 2018 [10]. Accordingly, it is understood that the increase in the concentration values, especially in the sodium (Na) element, is related to the increasing evaporation.

Lake is distinguished by its high alkali and magnesium content and the rich diversity of phytoplankton and zooplankton associated with these geochemical features [11, 12]. Previous studies stated that hydro magnesite-rich stromatolite formations in the lake accompanied algae and cyanobacterial species. However, the extensive geomicrobiology studies carried out by Balcı et al. revealed that the lake has a wide microbial diversity despite its extreme conditions. The lake water contributed to at least two different metabolic pathways, such as aerobic respiration and photosynthesis [10].

It is essential to preserve the distinct ecological balance for the Lake Salda stromatolites, which grow with a symbiotic relationship depending on the environmental conditions, climate, water geochemistry, and microbial diversity balance. In addition to the increase observed in the temperature and evaporation amount mentioned above, the unplanned agricultural activities developed in the last ten years around the lake have caused a significant and dangerous decrease in the water level because of the irrigation dams.

Figure 1. Northwest shore of Lake Salda 11.08.2021. (The blue line shows the coastline in August 2021. Photograph: Sinan Güneş Doğan).

3. THE RURAL HERITAGE CHARACTERISTICS OF DOĞANBABA

Doğanbaba, which is 1,344 m above sea level, was established on the southwest slope of Kocakuz Hill overlooking the plain (Fig. 2). The functional and formal design of residential units does not change depending on the altitude in the region, including settlements such as Salda, Kayadibi, and Güney[13]. The cultural texture of the Burdur, Bucak, Yeşilova, and Teke regions reflects the tradition of the Sarıkeçili nomads belonging to the Kayı tribe of the Bozoks, known as the main branch of the Oghuz. They settled in the territory around the second half of the 18th century. In the interviews with the residents of Doğanbaba, they stated that their origins are based on Sarıkeçili nomads.

Figure 2. The location of Doğanbaba (Photograph: Sinan Güneş Doğan).

Figure 3. Two-story adobe houses at Doğanbaba (Photo: Sinan Güneş Doğan).

The original building material of the rural architecture of the region consisted of stone, adobe, and wood, depending on nature and environmental conditions. The houses were two-story, and the ground floor was used as a warehouse or a barn in its original design (Fig. 3). Wooden protrusions were commonly employed along the facades of houses. As in the traditional houses of the Burdur region, the overhangs have wooden buttresses. Square-section wooden lattices were placed on the first floors of rectangular windows. Masonry stone was used on the ground floors, and adobe brick was applied on the upper floors. The load-bearing system supported by wooden beams was covered with straw-added adobe plaster on the exterior. It has been noticed that the ancient stone blocks found in the region were utilized as spolia on the ground floors or as grinding stones. The wooden material is generally a pest-resistant juniper and larch wood [13].

One of the most important parts of the houses was the overhanging section called the terrace or the sofa. Depending on the economic activities, the overhangs where winter preparations were made and where people gathered during the summer were covered with wooden screens or fabric curtains in some parts to provide privacy.

Besides the residential areas, vineyard houses are the secondary accommodation type placed on the plain extending to Doğanbaba beach. Although the seasonally used dwellings in the region are few, they consist of barns, vineyard houses, and types known as huv used for transhumance [13]. Because of the climatic features and landforms, the limited agricultural areas were mainly reserved for chickpea, wheat, anise, and corn cultivation in the past. Viticulture activities were common due to the geographical and soil characteristics of the area, similar to the Thrace, Aegean, Mediterranean, and Central Anatolia regions [14].

4. DETERIORATIONS OF ORIGINAL RURAL ARCHITECTURE

In the study conducted by Bayram Çetin in 2010, the rural architecture of the Yeşilova region was divided into three phases of change [14]. These phases, which were divided into pre-1950, between 1950-1980, and after 1980, were determined due to the economic and demographictransformations reflected in the dwellings. The primary factor in the texture deterioration between1950-1980 was replacing the original material, especially earthen plaster, with cement. Consequently, modern tiles in the roof covering have become widespread. However, modificationsin plan type and room division have been limited. In the third stage, external migration was the most significant reason for the deterioration.

According to the İcmal registry number 3274 of Burdur and surrounding districts, dated 11 Dhu al-Hijjah 1249 (Gregorian 21 April 1834), Doğanbaba was the fifth settlement with the largest population of 116 among 39 settlements in Irle and Yavice (Yeşilova) districts [15]. According to the 1935 Village Population statistics, the population of Doğanbaba village, which was connected to Denizli province then, was 760. The population, determined as 1274 in 1985, decreased to 500 in 2000. In the last twenty years, there has not been a significant change in the number of residents in the village. The rural population migrated to cities such as Denizli, Burdur, İzmir, and Ankara, as well as to countries such as Germany, Netherlands, Switzerland, and France. The demographic structure of Doğanbaba and the surrounding rural settlements changed dramatically in the 1960s, as is the case throughout Turkey. Between 1965 and 1973, 4846 people were sent abroad through the Employment Agency in Burdur Province [14]. Especially the younger population leaving the village has continued in the following years and caused changes in the economic activities. However, wedding ceremonies are typically held within the village according to cultural traditions. Those who went to the cities and abroad from the village continued to come to Doğanbaba seasonally during wedding celebrations, holidays, and annual leaves. Thus, during the summer, the settlement population triples with the visitors.

For this reason, since 2000, new houses have been constructed in the village. These residences are built using multi-story and modern construction materials instead of traditional ones and have architectural plans that do not correspond to rural architecture (Fig. 4). Moreover, the exteriors of these 4-5 story residences are multicolored, thus disrupting the organic texture of the settlement. Village people, mainly the elderly, make their living with the help of the second or third generations who work outside the village instead of doing agricultural and animal husbandry activities.

Significant changes in the environmental landscape of Doğanbaba village occur because of the shift in the variety of crops cultivated. The TMMOB 2020 Salda Report states that although dry agriculture has been traditionally practiced in the lake basin, using chemical fertilizers to increase productivity also raises the necessity for irrigation. While the region's typical industrial plant anise production was 4900 tons in Burdur Province in 2003, this figure decreased to 1846 tons in 2021 (Burdur Tarım 2003; Burdur General Briefing 2021). On the other hand, walnut production increased from 2088 tons in 1994 to 6088 tons in 2021. Similarly, pomegranate and cherry production expanded in Burdur and around Lake Salda. As the need for agricultural irrigation increased with unplanned agricultural activities, dams such as the Düden were built on the water resources feeding the lake. The increase in evaporation and the decrease in the amount of water coming into the lake affect the lake water level rapidly. Another damaging element in the ecological balance is the rise in the village's population in the summer. Inadequate recycling and waste collection infrastructure create garbage areas on the hill where Doğanbaba village is located (Fig. 4).

Figure 4. The contemporary dwellings along with original buildings at Doğanbaba (Photo: Sinan Güneş Doğan)

5. PRESERVING THE ORIGINAL TEXTURE OF SETTLEMENTS WITH SUSTAINABLE RURAL DEVELOPMENT

The abandonment of rural settlements and change in the economic activities leading to a decrease in agricultural production appears to be a significant problem in Turkey. Especially during the COVID-19 pandemic and Ukrainian-the Russian crisis, the effects of the insufficient national strategy for rural development and the importance of national self-sufficiency have been apparent. On the other hand, rural areas formed by the interaction between man and nature protect the landscape and biodiversity. The rural settlements also reflect the local culture and environment shaped by experience.

The main component of conserving rural settlements and landscapes is to prevent the migration of younger generations. Accordingly, the investments in agricultural production would encourage revitalization and return of former residences. Güler and Kayha analyzed various approaches for the conservation of abandoned rural settlements, including reforestation, museumification, tourism, and resettlement [16]. They proposed that all these approaches could be applied separately or together depending on the nature of depopulation and the unique cultural and economic structure and locations.

While the main reason for depopulation in the countryside is the lack of quality rural infrastructure, tourism has become the main economic activity, particularly in the rural areas with natural sites such as the settlements around Lake Salda. Butler describes sustainable tourism as "tourism which is in a form which can maintain its viability in an area for an indefinite period of time." It should maintain the relationship between humans and the physical environment. According to Kernel, a collaborative approach allows identifying the priorities of different shareholders to "balance the economic, social, and environmental interests in a change process towards sustainable tourism" [17]. However, as in the case of Lake Salda, some of these priorities could conflict with each other.

The concept of the multifunctional rural landscape introduced by Potter and Burney includes producing food and sustaining rural landscapes, protecting biodiversity, and generating employment [18]. This definition is particularly important regarding the sustainable tourism activities in rural areas such as Doğanbaba. Assessing rural regions as the diversity of needs and functions provides opportunities for sustainable rural development in the "ecological, aesthetic, amenity, and recreational spaces" [19].

In the Lake Salda region, the conservation of rural architecture and culture depends on various components, including a governor-controlled architectural planning, agricultural activities, and the development of a tourism strategy that considers the organic relation between rural landscape and natural landscape. The tourism activities have suddenly triggered in the area without a well-planned strategy due to the increase in domestic tourism in Turkey. While the seasonal circulation expands the outcome of the local people and raises the land prices, the oversize number of tourists causes environmental population and damage to nature.

The residents of Doğanbaba should be encouraged to preserve rural architectural practices. Social and economic transformation leading to the deterioration of architectural values would eventually generate the monotony of the culture. However, rural settlement and social structure should be integrated into the cultural landscape to maintain the sustainability of tourism activities and ecological balance. Vernacular architecture is a sum of lifestyle, nature, economy, identity, and shared history. The construction materials and building techniques that define structures' mechanical, physical, and chemical properties have been shaped according to surrounding environmental and geological features and culture. Therefore, the conservation of local architectural values would preserve intangible heritage values.

On the other hand, the properties of rural materials have long been neglected, and the material characteristics have not been thoroughly studied in Turkey. While the mixture of earthen building materials, including plaster, brick, and mortar, is considered a fixed recipe, the characterization studies of construction materials of Gölcük vernacular houses in Kocaeli suggest that the preparation of earthen materials depends on the function and location of the houses (Muşkara and Bozbaş 2022). The analysis of historic building materials and construction techniques would provide an understanding of the region's vernacular architecture and traditions of local craftsmanship. Thus, the results could be used as guidelines for preparing materials in the interventions of houses to compete with the historic fabric. The studies on the material properties of the rural house also provide the integration of local craftsmen for maintaining heritage values. Although many rural dwellings have been destroyed at Doğanbaba, the remaining should be evaluated to determine traditional construction techniques. They should be preserved and officially registered as unique representations of heritage values of the region. Likewise, new structures for the accommodation of residents and tourists should be constructed using rural techniques. Subsequently, the agricultural activities should be designed based on the landscape and water resources of the lake basin. Therefore, dry agriculture should be supported instead of the current crop diversity. The traditional vine cultivation and vineyard houses could be integrated into tourist attractions since they could also support economic sustainability.

CONCLUSION

The rural tourism model proposed in this study presents the relation between economic activities and the preservation of traditional heritage values in rural areas. Although tourism activities may likely impact the area, separating ecological and environmental issues from economic concerns, the well-planned regional development based on traditional practices would eventually balance the needs for economic sustainability and ecological sustainability. The agricultural production would provide further employment, and tourism activities would contribute to investments in the region. The tourism activities at Lake Salda should comprise the natural site of Salda, the biodiversity of the lake area, and the cultural diversity of the nearby settlements.

The foundation of a relationship between the multifunctional rural areas and diverse tourism activities may lead to the mutual agreement of all parties concerning the economic, environmental, and social priorities. As McAreavey and McDonagh (2010) stated, a new perspective on sustainable development should constitute interrelated layers and functions of rural settlements; otherwise, the conflict between different parties would endanger rural areas and rural heritage.

On the other hand, the preservation of rural architectural heritage requires public awareness of the benefits of earthen materials. The application of original construction materials is the most important element in rural development since they represent the social and cultural balance of the landscape. Earthen materials are also renewable and recyclable resources that reduce energy consumption and address environmental issues. Therefore, in Doğanbaba

- The mechanical, physical and chemical properties of construction materials should be analyzed
- Structural features of dwellings should be evaluated
- The decay mechanism of the original materials should be investigated
- The methods of repairment and strengthening of construction materials should be studied

- Digital photogrammetry approaches coupled with Heritage Building Information Modeling could be discussed as an alternative tool for conservation and the design of structures with a new function.

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62- Advantages of Adobe Structures in the Design of Zero EnergyBuilding

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ABSTRACT

The majority of the energy consumed in today's building designs is provided by fossil fuels. The energy consumption of buildings corresponds nearly 40% of the total energy consumption. That amount creates approximately 74% of the electricity consumption. Therefore, it is still unclear what rate of this need will be compensated by fossil fuels in the future with the increasing energy requirement. The climate change in progress, daily increasing greenhouse gases (methane, ozone, carbondioxyde, nitrogen oxyde, water steam, etc. gases) reduce the energy consumption in buildings and makes it compulsory to increas the energy efficiency and using renewable energy resources. The global climate change caused rapid increase of the energy demand and in order to solve the problem of buildings having the largest share in energy consumption, priority must be given to passive house, zero energy building designs. Design of "zero energy buildings" gain importance by minimizing costs related with energy consumption in buildings. Adobe material is an important structure material with heat insulation, energy storing and ecological aspects. Adobe building materials are envisaged as the most important building material of the future due to its structural characteristics. In this study, zero energy building designs, amount of energy consumed in zero energy buildings, applicability of adobe building material in zero energy buildings and studies in this area for our country will be researched.

Keywords: Fossil fuels, climate change, energy consumption, passive houses and zero energy buildings, adobe material

1. INTRODUCTION

The natural damage created by the use of fossil fuels indicates that we will be facing with an important climate change problem in coming years. Discussions about that issue initiated after 1979 but scientific researches reveal that the current situation is not adequate for solving the problem (URL-1).

Figure 1. Non-renewable energy sources

After the Intergovernmental Panel on Climate Change (IPPC) held in 1988, the first intergovernmental negotiations started in 1991 and the UN Framework Convention on Climate Change, which was signed in Rio-Brazil in 1992, entered into force worldwide in 1994. Recognizing that, with this convention, all countries should cooperate in the widest extent appropriate to their common but different responsibilities, opportunities, social and economic conditions, and participate in effective and appropriate international studies; The aim was to stop the effect of greenhouse gases accumulating in the atmosphere of countries on climate change at some level. In the reports published in the Intergovernmental Panel on Climate Change (IPCC), held by the UN Environment Program (UNEP) and the World Meteorological Organization (WMO) in 1988, the seriousness of the situation is shared with scientific studies.

Along with the global climate change, extreme weather events have been experienced in Turkey in recent years. Excessive and instantaneous precipitation, temperature and flood disasters as a result of overheating of the air increase the use of energy along with the collapse of the urban infrastructure.

70.2% of the energy consumption in 2012 is due to the building heating, cooling and lighting needs. This consumption is equivalent to 440 million tons of carbon dioxide equivalent greenhouse gas emissions. (one). Due to our high dependence on foreign energy, our primary energy consumption has increased by 64% between 2000 and 2015. (Fig. 2). Researches conducted in 2015 show that the rate of energy consumption from imported energy sources has increased and reached 75.9%. The energy consumption used in the building sector was 32.8%, even more than the industrial sector (URL- 2) (URL-3)

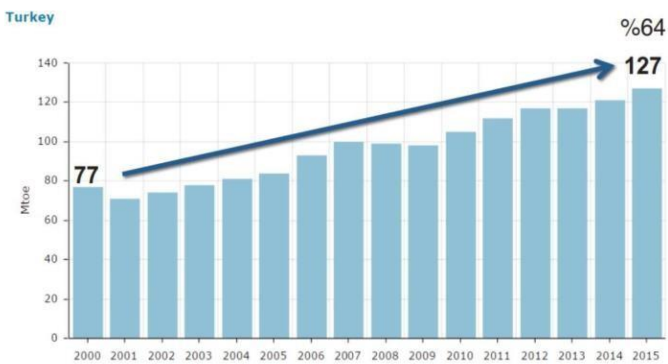

Figure 2. Turkey's energy consumption between 2000-2015

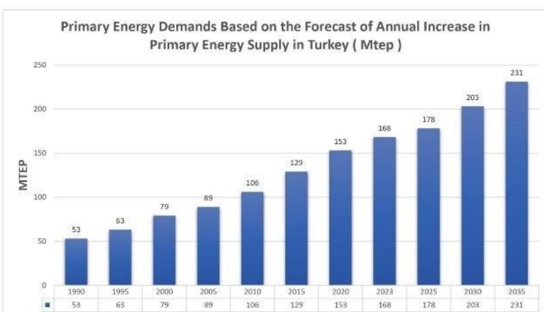

Figure 3. Turkey B. Energy Supply Demands (mtoe) Based on Primary Energy Annual Growth Rates Estimate (Source: EIGM/MENR General Energy Balance Tables 3)

Figure 4. Climate Change

With the signing of the Paris Climate Agreement, until 2053, Turkey entered the period of determining Net Zero Emission targets in climate policies. In this period, however, it became imperative that achieving the targets required a total transformation for the transition to 'Zero Energy Buildings' with regulations and incentives.

In the Eleventh Development Plan (2019-2023) of the Presidency of the Turkish Office of Strategy and Budget, the "Zero Energy", which has become mandatory in the EU as of January 1, 2021, for a healthier and more livable world by expanding the efficient and self-generating buildings. The decisions to transform into Buildings have been included in the action plan, which includes Turkey.

The use of energy consumption in the world and in Turkey is 35-40%[4]. The portion of energy use in buildings used for heating, cooling, air conditioning and hot water supply is approximately 80%[5]. The effects of gas emissions thrown into the external environment on climate change are gradually increasing. The results of these effects are shown by scientific studies.

The high amount of energy used in the housing sector requires re-examination of the energy systems used in building designs and innovations in the building materials used. Along with the important problem caused by the energy shortage, the designs made under the concepts such as "Green Building" and "Zero Energy Building" have increased the efficiency of energy use and the orientation towards renewable energy sources. "Net zero energy buildings" discussed in this context are defined as buildings that consume less energy compared to the houses built today, that minimize the interaction with the climate and environmental conditions outside the building, that provide the energy they need from renewable energy sources, that can work integrated with the national energy distribution lines, that are environmentally friendly, sustainable and at the same time aiming for zero CO2 emissions. is defined.

When the features that make up Zero Energy Buildings (NSEB) are listed, the building should be placed in appropriate directions to benefit from sunlight and energy savings during the layout, and this process should continue with thermally insulated windows. By insulating the building envelope, heating/cooling losses from the external environment should be minimized, panels or wind turbines for electricity generation and solar collectors for hot water should be used.

Buildings with zero energy efficiency are given different names such as "Energized Buildings (ZEB)", "Near Energy Buildings (NZEB)", "Passive House", "Green Energy Buildings". It is aimed that the energy used in these structures is low and the energy resources are used less.

The goals of the European Union in the building sector for 2020, 2030 and 2050 in terms of energy efficiency and reduction of emissions are given in Table 1 below (URL-4) (URL-5).

2020 Target	• 20% reduction in greenhouse gas emissions compared to 1990 levels • Meeting 20% from renewable energy sources • Increasing energy efficiency by 20%
2030 Target	• 40% reduction in greenhouse gas emissions compared to 1990 levels • Meeting 27% from renewable energy sources • Increasing 27% energy efficiency
2050 Target	• 80% reduction in greenhouse gas emissions compared to 1990 levels

Table 1. Energy Related Goals of the European Union

Figure 5. Beach House

The declaration prepared by ZeroBuild Summit'22 includes the responsibilities and approaches of all stakeholders of the issue. The attitude that all countries that have signed this declaration expect from the Central Government is to determine the decarbonization roadmaps in the housing sector and make legal regulations regarding the energy savings targeted until 2053. In Turkey, it is an important necessity to carry out a standard study on this issue.

2. SUSTAINABILITY, SUSTAINABLE ARCHITECTURE, ZERO ENERGY BUILDINGS AND ADOBE STRUCTURES

2.1. SUSTAINABILITY

The Industrial Revolution, which first emerged in the United Kingdom, continued in Western Europe, North America and Japan and spread all over the world. The energy problems, also known as the Industrial Revolution or the Industrial Revolution, which continue to increase with the effect of new inventions on production in the 18th and 19th centuries in Europe and the creation of mechanized industry by steam powered machines, the increase in unplanned and rapidly developing industries today. With the increase in population around the world and the uncontrolled use of natural resources, the decrease in natural resources, the more use and production of non-renewable energy and materials, along with environmental pollution and many problems that threaten humanity. The concept of sustainability has emerged to reduce these problems, which emerged with the realization of the industrial revolution in the 1970s and continue to increase until today.

The concept of sustainability has gained more importance in recent years due to the decrease in natural resources, increasing population and non-renewable energy problems. The concept of sustainability is defined as "the evaluation or use of a resource in a way that the resource is not consumed or permanently damaged" (Kımilli, 2006). The generally accepted meaning is the definition made by the Brundtland Commission in 1987 as "Sustainability development is the ability to meet the needs of the present without compromising the ability of future generations to meet their own needs, that is, without harming the lives of future generations". This definition is accepted as the most comprehensive definition of the concept of sustainability (Haştemoğlu, 2006) (URL-6).

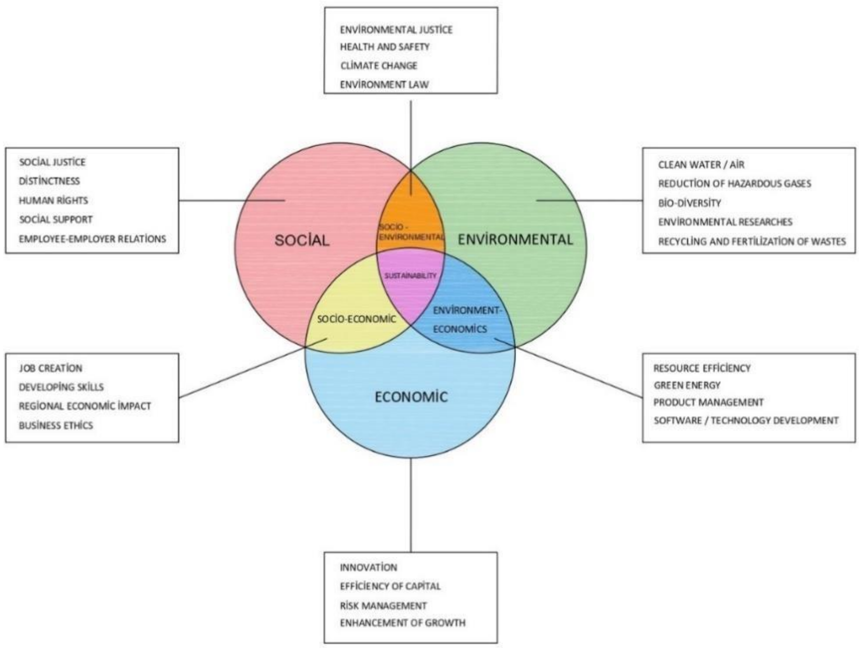

Figure 6. Components of sustainability

2.2. WHAT IS SUSTAINABLE ARCHITECTURE?

In its simplest form, we can call "sustainable architecture" an architectural approach that uses the least amount of natural resources, uses more renewable resources, does not create environmental pollution and is designed in harmony with nature.

Established in 1994 by the United States Green Building Council, this standard, created for the dissemination and preference of sustainable architecture, is called LEED Standards (Leadership in Energy and Environmental Design). Since 1994, certain updates and standards have been formed in the construction and design of nature-friendly and green buildings, which can be measured in the design. These standards and criteria aim at the basis of an efficient use of energy approach.(URL-7)(URL-8)


Figure 7. Sustainable Archıtecture; Figure 8. An Ecological Podium Skyscraper: TOWER C / Zaha Hadid Architects

2.3. WHAT IS THE PURPOSE OF SUSTAINABLE ARCHITECTURE?

The main purpose of Sustainable Architecture is to ensure continuity by incorporating renewable resources into the transformation by enabling people to connect with the ecosystem. Sustainable architecture aims to meet the amount of energy needed without polluting the surrounding natural area and by using the power of the natural environment. For example, when we look at the features of newly built sustainable buildings, attention is paid to the fact that they are capable of meeting their own energy needs. In order to benefit from solar energy in the building, it is important to find environmentally friendly technologies such as solar panels or wind turbines that will save energy. Thanks to these designs, energy resources such as natural gas, water and electricity are also saved.

It is one of the important objectives to ensure energy efficiency as long as the use of the structure continues. Building materials used in sustainable housing are also very important. These materials need to be selected in a way that does not have negative effects on the environment. Adobe material is an important building material due to its thermal insulation, energy storage and ecologicality. It is predicted that the mud brick building materials will be the most important building material of the next period due to its structural characteristics(URL-9)(URL-10)

Figure 9. Cultural Center Osoyoos, Canada

2.4. PRINCIPLES OF SUSTAINABLE ARCHITECTURE

All the work done in the field of sustainable architecture and architecture aims to leave a more livable world for the new generations without posing a threat to the future of the world. However, innovations in architectural building materials are prioritized to be compatible with social, economic and ecological sustainability. Another important issue can be called the need to analyze the natural resources and environmental conditions in the areas where architectural designs will be implemented and to participate in the design phase.

3. ZERO ENERGY BUILDING

In today's designed buildings, the energy used in air conditioning (heating-cooling-ventilation), lighting, and household appliances is inadequate to meet the energy needs despite the energy systems installed in the buildings. As a solution to meet this energy needs, which continues to increase rapidly, "Zero Energy Buildings (ZEB)" is proposed. To define zero-energy buildings, it is right to say that buildings that use efficient energy building techniques that provide the energy used from renewable energy sources and energy-efficient technologies.

At the heart of zeb design is the idea that all energy needs of buildings are met from low cost, locally available environmentally polluting and renewable sources. (Torcellini, Pless and Deru, 2006). In the EU Directive on Energy Performance in Buildings, it says: zero-energy building (ZEB) must demonstrate low primary energy (fossil-based energy) consumption and high energy performance (URL-11). It has important proposals that solve problems such as reducing the use of fossil energy fuels, eliminating the threats posed by carbon emissions, generating as much energy as needed, and combining energy efficient construction techniques with renewable energy technologies.

Sustainable, environmentally friendly, ecological, green, zero energy defined under different concepts such as zero energy buildings are designed in accordance with nature, sensitive to the environment, starting from the settlement of the land where it will be built, taking into account environmental and social criteria. In this sense, taking into account land conditions and climatic conditions, they are structures that use renewable energy sources correctly, do not produce waste with the use of natural and recyclable materials and consume only as much energy as they need (Environmentally Friendly Green Buildings Association, 2019). In summary, zero-energy buildings are buildings that aim to produce as much energy as they consume throughout the year and are built to equal the consumption of their annual production. Since the buildings cannot produce the energy they need when the appropriate weather conditions cannot occur, they get it from the national electricity grid and send the excess energy back to the National electricity grid during periods of high energy production. In this way, it sends back the energy it uses from the grid when it cannot produce the energy. In this way, two different types of design are formed. In cases where overproduction exceeds consumption, "positive energy building" is defined as "buildings with near zero energy" (NZEB) when production is lower than consumption.

Freiburg Zero-Energy Building application is one of the exemplary structures of zero energy building design. Designed with climatic conditions in mind, the building has gained passively from solar energy thanks to large surfaced windows on the southern façade. Transparent insulation supported walls on the façade prevent heat loss and at the same time the solar heat stored in the walls is transferred to the interior. Thanks to the modules added to the roof, electricity is generated from solar energy and hot water production is also carried out. As such, the building isa zero emission building (Figure 10, 11)(URL-12).


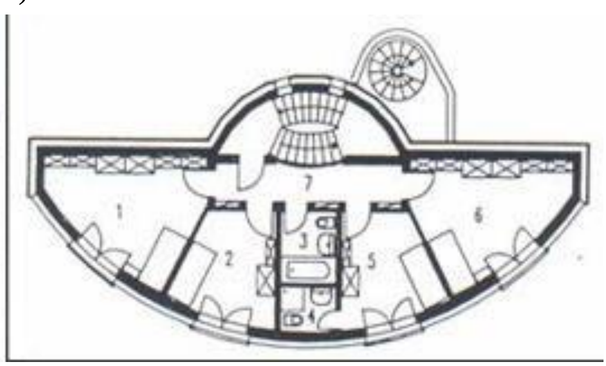

Figure 10: Freiburg Zero-Energy Building View; Figure 11: Freiburg Zero-Energy Building Plan

3.2. PASSIVE HOUSE STANDARDS

The "Passive Home Standard", which is formed by the development of low energy-use home design standards, can also be done with the use of design, building materials and technology. Passive houses form the building group that provides internal climatic conditions suitable for human health in summer and winter without the need for a traditional air conditioning system. The three main elements that make up the passive home standard are expressed as follows.

1- Controlling the energy used in air conditioning,
2- Ensuring indoor thermal comfort in accordance with ISO 7730 norms,
3- Providing energy needs and adequate indoor comfort with the help of cost passive system designs.

There are 5 important principles that should be applied in structures built in accordance with passive house standards. These are the ones that are going to

1- Heat Insulation: The outer shell is very well insulated,
2- Windows with high thermal insulation resistance: Insulation of opening gaps in the façade, i.e. window frames,
3- Waste Heat Recovery: Saving energy required for healthy indoor air quality,
4- Building shell airtightness (Sealing): In terms of air tightness of the exterior, compliance with air exchange norms should be ensured,
5- Blocking heat bridges: All edges, corners, connections and transitions should be carefully planned and made.

The representation of 5 important principles that should be applied in structures designed in accordance with passive house standard is as follows;(URL-13)

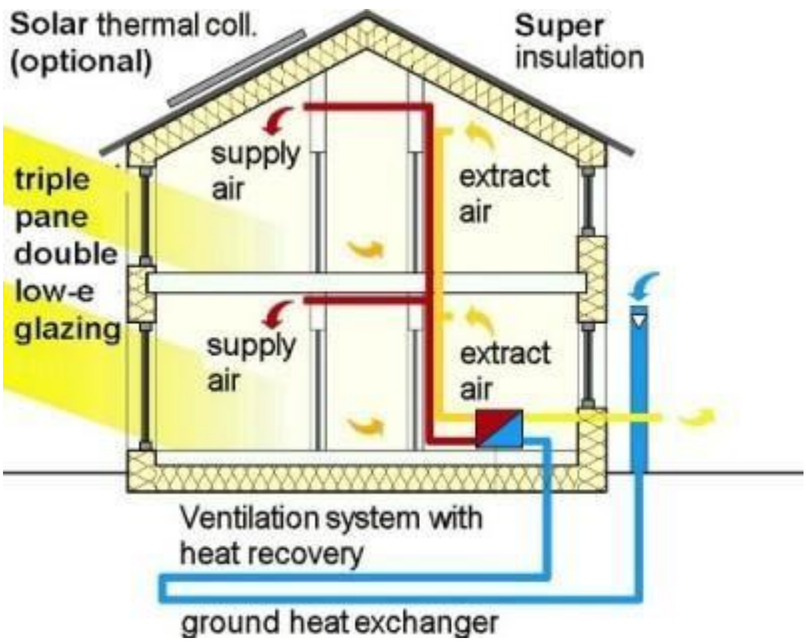

Figure 12. Schematic representation of the main principle of zero energy (Passive) house standard 5

Darmstadt Passive house was built in 1991-1992 and insulation in the building is very well planned. The building, which does not use traditional heating systems, has also benefited from passive solar energy by providing insulation of the outer shell, low-temperature windows and a south-facing orientation. At the same time, the conservatory, which is defined as a buffer on the north side, supports the structure in a different respect by supporting the soil heat with the waste heat recovery system in the reduction of heat losses and ventilation (Figure 13-14)(URL-14).

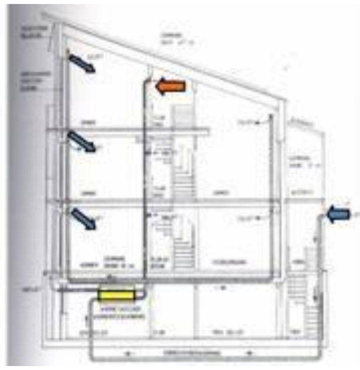

Figure 13. Darmstadt – Passive home appearance (Wolfgang Feist, Passivhaus Institut, 1992); Figure 14. Darmstadt – Passive house section, (Wolfgang, (Wolfgang Feist, Passivhaus Institut, 1992)

3.3. ADVANTAGES OF ZERO ENERGY BUILDINGS

Compared to existing buildings, zero-energy buildings save 50%-70% energy. By reducing carbon emissions, they release less emissions into the atmosphere. By reducing dependence on fossil fuels, they reduce their ecological footprint. Considering these characteristics, it is foreseen that it will play an important role in creating a healthier future without energy problems.

Zero-energy buildings produce the renewable energy they need when viewed in the form of annual periods, thereby reducing the energy use needed and ungenerated by the building industry.In order to reduce energy use in buildings, appropriate building materials are used first, and renewable energy sources are included to meet the remaining energy needs. These buildings, which are compatible with the environment, provide economic benefits as well as meeting the energy needs throughout the life of the building.

Zero emissions, minimum waste, high indoor quality, unplanned consumption of natural resources, making important contributions in the prevention of environmental pollution, reducing greenhouse gas emissions and, most importantly, being environmentally friendly structures are prominent features in solving the problem created by non-renewable energy sources.

Today, the zero-energy buildings designed are constructed with important objectives such as minimum emission, minimum consumption, minimum waste, efficient human-nature relationship, maximizing indoor quality, healthy indoor conditions, ensuring an efficient working environment, efficient use of natural resources and keeping adverse environmental conditions to a minimum. The problem posed by non-renewable energy sources is that they are environmentally friendly structures with benefits such as reducing energy consumption and therefore reducing greenhouse gas emissions, as well as effective use of rainwater, waste management and waste amount reduction, and protection of air and water quality and natural resources.

Another goal aimed at these buildings is to limit the damage to the ecosystem and to prevent environmental pollution. It is aimed to increase the number of zero-energy buildings (ZEB), reduce environmental pollution and make great contributions in the long term to improve energy security.

3.4. ZERO ENERGY BUILDING DESIGN

Some of the most important criteria that zero-energy buildings consider are the correct and effective energy use of energy efficiency. Zero energy buildings are of great importance in order to minimize the damage to the ecological environment and to save energy.

Energy efficiency and sustainability are of great importance during the design phase of zero energy buildings. To achieve this, some systems that can be integrated with the structures are shown on the sample building in Figure 15 (Yöntem, 2016:5).

Figure 15. Ankara, Xinjiang and Etimesgut TKGM Building energy efficiency applications, Ministry of Environment and Urbanization Ankara, Sincan ve Etimesgut TKGM Bina enerji verimliliği uygulamaları, Çevre ve Şehircilik Bakanlığı

In zero-energy buildings, some of the energy needed by the structure is provided from renewable energy sources within the structure. All heating and cooling energies used by the building and some of the electrical energy consumption are provided by these systems. Good building insulation and solar heat gain (Passive Energy) are important points to consider. Apart from these,the energy to be used is provided from renewable energy sources (Figure 16) (Berberoglu, 2009).

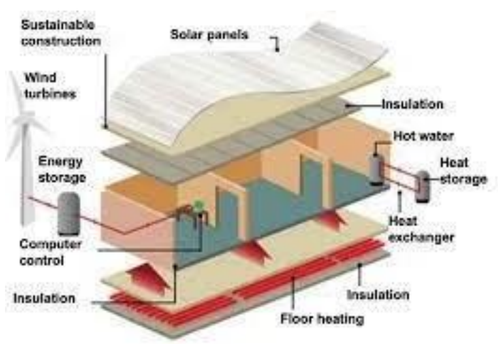

Figure 16. Example of zero-energy building

4. ADOBE STRUCTURES

When we look at today's building materials, we see that soil structures remain the healthiest and best thermal insulation material. Besides, it's breathing, so it balances the humidity of the environment. The construction of a soil structure is quite economical as it is made entirely with the materials in that region. From here, it is possible to make structures that are compatible with nature and recycled.

In human history, soil and production go back to 9000 B.C. In Anatolia, the settlements of Aşıklı Mound in 8000 B.C. and Çatalhöyük in 7500 B.C. are the places where the first soil structures were seen. Built in 1300 B.C., II Ramses' vaulted earth grain stores are still standing. This shows that the soil still remains the healthiest and best thermal insulation material. And because he's breathing, he's balancing the humidity of the environment. At the same time, it saves energy with its thermal insulation feature. The construction of a soil structure is quite economical as it is made entirely with the materials located in the place of that area. Moreover, like concrete-produced houses, they are not high energy consumption structures.(URL-15)

Figure 17. Windhover Contemplation Center, Stanford University

Today, designers make earth structures by combining traditional methods with modern techniques. Especially developed countries are working hard to investigate and implement these techniques to make more identity structures. In these days of energy problems, it is extremely important that soil structures are improved and reuse of them by taking advantage of today's technologies.

4.1. TRADITIONAL ADOBE

According to the TS 2514 (1967) standard; it is defined as "a product that can be used in construction by mixing hay or other vegetable fibers (plants of thatch type, coarse grass, hemp fibers, residual hay collected from barn mangers, dry shrubs, pine needles, tree branches, saws, grater chips) into clayy and suitable soil, and then poured into molds after kneading with water and dried outdoors."

The TS 2515 (1985) standard defined the adobe structure as "buildings with wooden ceiling and floor coverings, the walls of which are made with mud brick and mud mortar".

ADVANTAGES OF TRADITIONAL ADOBE
Adobe material is a construction material that is suitable for modern technology, compatible with the ecological system due to its material feature, providing the comfort and ease of use of the age, breathable, carrying many advantages in terms of design features, workmanship in terms of short construction time and more economical.

ADVANTAGES OF TRADITIONAL ADOBE ARE:
The availability of soil, which is its main ingredient, in every region;

Its production is done in a short time and there is no need for technical knowledge;
Being an economical material, low cost;
Being an ecological material;
Providing thermal insulation. Being resistant to fire (Table 2.),

MATERIAL TYPE	INTENSITY P (kg/m3)	THICKNESS D (cm)	FLAMING SMOKE	FIRE RESISTANCE TIME
SOLID ADOBE	2000	15-25	-	F 120 – F 180
LIGHT ADOBE	900	25	-	F 180
CONCRETE	2300	20	-	F 180

Table 2. Behavior of adobe materials in fire (Anon., 1993. VKF Vereinigung Kant. Feuerversicherungen, Brandschutzregister, Ausgabe)

Providing sound insulation according to material properties (Table 3.).

MATERIAL TYPE	INTENSITY P (kg/m3)	SOUND INTENSITY	SOUND INTENSITY	SOUND INTENSITY	SOUND INTENSITY
		30 dB	40 dB	50 dB	55 dB
SOLID ADOBE	2000	0,03	0,07	0,20	0,40
LIGHT ADOBE	900	0,04	0,12	0,33	0,73

Table 3. Sound insulation value of adobe materials (Anon., SIA 181, Schallschutz im Hochbau, SIA 381/1 Baustoffkennwerte)

Low energy consumption in construction and use,
Being environmentally friendly,
Easy maintenance and repair work.

MUD BRICK REINFORCED WITH PLASTER AND LIME (ALKER)
Alker is a adobe material that is formed by adding certain amounts of gypsum-lime and water to suitable soil and kneading it. Alker is not made with traditional adobe mixing methods (mixing with feet). The soil in the area where the building will be built is examined, and 10% gypsum and 2% lime are added in appropriate proportions and mixed with the help of a shovel or concrete mixer. (Kafesçioğlu R., Toydemir N.,Gürdal E., Özüer B., "Stabilization of adobe with gypsum as a building material" TÜBİTAK MAG 505. İstanbul. 1980.) (Işık, Bilge, Advisor: Ruhi Kafescioğlu, Assistants: A. Akın, H. Kuş, İ. Çetiner İ., C. Göçer and N. Arıoğlu, "Determination of Mechanized Construction Technology and Standards Suitable for Gypsum Additive Adobe Material")

MECHANICAL AND PHYSICAL PROPERTIES OF ALKER
It is a type of adobe made by adding 10-20% gypsum to the adobe soil while making alker. In terms of its structure and physical properties, it is more durable than traditional adobe. Thanks to the gypsum added to the soil, rapid setting occurs and provides the necessary strength when being removed from the mold. Since there is no drying process, there is no need for a drying area, no loss of time and labor, and it provides convenience in application.

Thanks to the rapid solidification that occurs in the plaster, it prevents cracking by not allowing shrinkage and deformation in cases where balanced drying cannot occur.

While this situation leads to an increase in strength, it also prevents water from dispersing the soil. Recent studies show that the physical and mechanical characteristics of the alker material have important properties. The properties in Table 4 should be known in order to reach the necessary comfort and safety conditions for masonry structures made using Alker. (Kafesçioğlu R., Toydemir N.,Gürdal E., Özüer B., "Stabilization of adobe with gypsum as a building material" TÜBİTAK MAG 505. İstanbul. 1980.) (Işık, Bilge, Akın A., Kuş H., Çetiner İ., Göçer C., Arıoğlu N., "ADetermination of Mechanized Construction Technology and Standards Suitable for Mudbrick Building Material with Gypsum Carcass" TÜBİTAK İNTAG TOKİ 622, İstanbul, 1995.) (Işık, Bilge, Özdemir P., Boduroğlu H., "Earthquakes Aspects of Gypsum Stabilised Earth (Alker) Construction for Housing in the Southeast (GAP) Area of Turkey" Disaster prevention Management, Workshop, Ankara 11 Mart 1999.)

FEATURE	VALUE
Shrınkage (%)	1,0 - 1,5
Water Absorptıon (%)	Very Low
Heat Transfer Coeffıcıent (W/mK)	0,4
Heat Storage	1,0
Long-Term Water Exposure (Excludıng Surface Impact)	-

Table 4. Physical properties of alker (Kafesçioğlu, R., 1980. Stabilization of adobe as a building material with plaster, TÜBİTAK MAG 505, Istanbul)

Even though the appearance of adobe structures manufactured with traditional methods changes in a short time, Alker mud brick structures are more robust structures due to both the short production phase and high strength. Table 5 clearly shows the differences between traditional adobe and alker. (Işık, Bilge, P.Özdemir ve H. Boduroğlu, "Earthquake Aspects of Proposing Gypsum Stabilized Eart (Alker) Construction for Housing in the Southeast (GAP) Area of Turkey",Workshop on Recent Earthquakesand Disaster Prevention Management, Earthquake Disaster Prevention Research Center Project (JICA), General Directorate of Disaster Affairs (GDDA), Middle East Technical University, Ankara, 10-12 March 1999.) (Işık, Bilge, "The Effect of the Use of Gypsum Mud (Alker) Instead of Brick in the Housing Wall in the Example of New Gözeli in the GAP Region on Annual Energy Use and Air Pollution" GAP Environment 2000, congress, HARRAN)

TRADİTİONAL ADOBE BUİLDİNG TECHNOLOGY	GYPSUM ADDED ADOBE CONSTRUCTİON TECHNOLOGY
Cutting adobe : no precipitation – summer	4 seasons production
Drying Adobe : No precipitation – summer	-
Construction period : No precipitation – summer	4 seasons production
Rest is required	-
Large area for cutting adobe	Casting on the wall
¤ Large area for drying	-
Gains strength in 15 -21 days	Gains strength in 20 minutes
30% clay	10% clay
The outside of the wall should be protected from precipitation	Can be left open
Not done in rainy areas	Can be done

Table 5. Comparison of traditional and gypsum-added adobe building technologies (Işık, Bilge., Akın, Alev., Kuş, Hülya., Çetiner, İkbal., Göçer, Caner., Arıoğlu, Nihal. December 1995. Determination of Appropriate Mechanized Construction Technology and Standards in Gypsum Additive Building Material, TUBITAK Research Report. Project number: İNTAG TOKİ 622)

These disadvantages in traditional adobe not only reduce the use of adobe, but also increase the interest in industrial products that are incompatible with the ecological system, do not recycle, do not have natural air conditioning systems, and do not save energy. However, the mudbrick structures built in recent years have suffered very little damage in terms of their lifetime and there is no deterioration on the building surface (Table 6 –7).

Quality	Threshing Brick	Perforated Brick	Concrete Block	Light Concrete Block	Alker
Internal Surface Temp. (C)	12,44	13,70	9,68	14,85	16,80
Heat Accum. Capacity (kJ/kgK)	75,24	54,34	110,00	57,60	139,80
phase shift (h)	4,50	4,47	4,03	13,58	29,00
Cooling Period (h)	14,29	12,87	13,97	17,28	66,68

Table 6. Qualifications of various wall types in terms of building climatology (Kafesçioğlu, R., Gürdal, E., 1985. Contemporary Building Material Alker, Ministry of Energy and Natural Resources, Department of Energy, Shell, Istanbul)

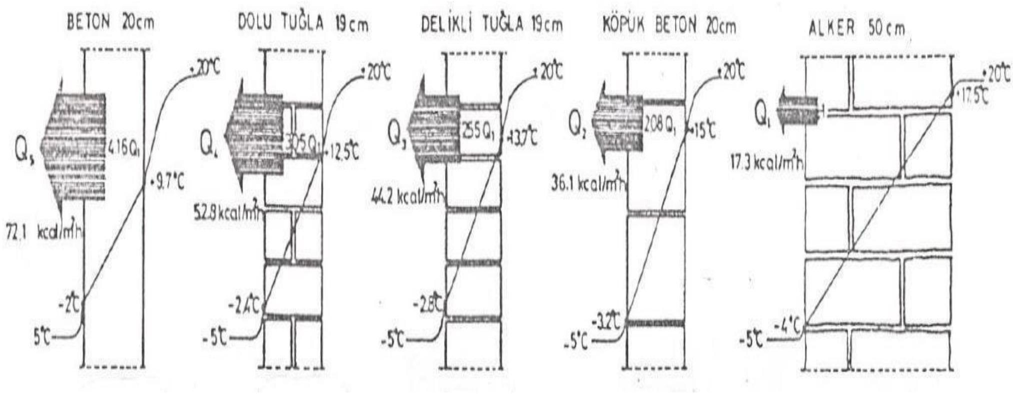

Table 7. Alker malzemenin ısı depolama değerinin diğer duvar malzemeleri ile karşılaştırılması (Kafesçioğlu, R., Gürdal, E., 1985. Contemporary Building Material Alker, Ministry of Energy and Natural Resources, Department of Energy, Shell, Istanbul)

CONCLUSION

With the decision taken by the European Union, it has been emphasized that, starting from 2020, new buildings, including public and residential buildings, will be zero-energy buildings, which will make very important contributions to the solution of the energy crisis and environmental pollution in the coming period. In this sense, it is important to increase the performance of the building envelope, to support the use of new building materials with energy saving and renewable energy sources. In this sense, it is important to increase the performance of the building envelope, to support the use of new building materials with energy saving and renewable energy sources. It is pointed out that healthier structures that produce their own energy, which do not create environmental pollution by minimizing the emission of emissions to energy consumption, by evaluating our solar potential and climatic conditions as our geography, are an inevitable necessity.

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63- Earth-based composites for 3D printing: numerical designand optimisation

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ABSTRACT

Earth is one of the oldest and, until now, intensively used natural building material. Recently, the use of earth materials in contemporary buildings have aroused interest, including inEurope, mainly due to its eco-efficiency and abundance. However, making earth construction a regular building practice is a significant challenge. Thus, the scientific community needs to strengthen confidence in earth construction and adapt it to current technologies. New digital production technologies can unblock the potential of vernacular materials, such as earth, as a futurebuilding material.

This work deals with combining a very traditional building material – earth – with high- tech advancements in fabrication and application methods, the 3D printing. From the perspective of materials science, earth-based printable composites (3DPearth) mix-proportioning are critical issues, namely due to i) the requirements at fresh state, ii) the needing of adequate stabilization, iii) the raw material natural variations asking for its characterisation.

A statistical factorial design approach was followed to reach printable 3DPearth by means of a central composite design. The 3DPearth mixtures consisted of a pre-defined range of proportions, including Turkish silty soil as the main constituent and were stabilised by a binary blend of cement and limestone, also locally available, water and superplasticiser. Slump test, Casagrande, mass loss, and mechanical strength were considered as output variables.

The empirical mathematical models revealed the influence of mixture design parameters and their coupled effects on the 3DPearth properties: deformability, shrinkage (mass loss), andcompressive strength. A numerical optimisation technique was applied to the derived models to select the optimal mixture, which maximises durability and eco-efficiency simultaneously and minimises shrinkage and costs while maintaining printability.

Keywords: Earth Construction, Earth materials, 3D print, DOE, sustainable construction

64- 3D Printer Based Adobe Architecture: Using of AravenaModel on Social Housing

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ABSTRACT

The Exchanging life standards brought hard conditions not only during providing of socio-cultural necessities, but also day by day finding a house unit for a standard family life started to be a nightmare to the majority of the civilization as the result of neo-liberalist economies. At first sight, it might be seen that this is a cliche for the Third World countries, however, it seems towards a near future even in most popular big cities and/ or capitals of the World, parallel to the necessity of finding a solution to the population growth, new alternatives would be found in the construction field. Besides, as we are living in a period, during which the basic resources of the World are gradually depleted, the value awareness that is needed to show to our environment should be strengthened. Nevertheless, this might be solved only by using more natural materials in the construction field. Since these two main problems of nowadays socio-cultural housing architecture are put at the focus, it seems that adobe is the best solution not only as it is a cheap natural construction material, but also it is in use of 3D construction printers, therefore using of adobe material can bring cheap and easy and fastly made housing solutions for the good of the majority of civilization. Alejandro Aravena, along with his many important awards in the architecture field, took the Global Award for Sustainable Architecture in 2008 and the Oscar of architectural field, the Pritzker Architecture Prize in 2016, as one of the living architects, whose built work demonstrates a combination of qualities of talent, vision, and commitment, which has produced consistent and significant contributions to humanity and the built environment through the art of architecture.

Thus, the paper will be focused on defining a new housing model which is based on Alejandro Aravena's model of creating a new system of constructing social houses in third World countries in a fast, easy and cheap way, which also "opens a door" to the user experience and will on the formation of the house construction process.

Keywords: Social housing, Alejandro Aravena, 3D printer, adobe

1. INTRODUCTION

This paper presents an integrated solution proposal for contemporary construction field as using the Aravena social housing production model on its core, and recommends the use of adobe material as the basic construction material in 3D construction printers, to produce more ecological based construction model for the common good of the society on a socially beneficial manner.

2. RE-NAMING THE ECONOMY: NEO-LIBERALISM INTO "LIBERAL PANDEMIC"

Starting from almost the 1980's by the integration of the governmental "touch" on the economy, it is seen that the liberalist policies of countries put on the agenda; all across the World liberal economy found a way for itself in the daily life to become visible. Governmental authorities opened up opportunities of using the new zones of the significant cities of Europe and the American continent, especially on which historic values can be seen at the very first sight, to big construction companies in extremely benefit able ways. The era of creating mega size-based mix-used projects including residences, offices, and shopping malls, etc., which were standing all on one to-do list, by this way became real. By coming up 2000's, the face of the World economic field, once again, has been exchanged, the era of neo-liberalist economies therefore started, in which there is no place almost for any definition. Now the World economic form might be defined as "the box of Pandora", in which nobody knows what is there and what could come out on the next move. There is a World now on, where every economic activity in every issue, in every form, could be possible. If liberalism can be defined as a "dragon" from which everyone can have a burnt scar, then neo-liberalism is a "multifaceted Exotic" character of X-men in form, nobody understands from where it puts a punction on the face at its next move. The covid-19 pandemic pushed the globe to have a "cold shower" in a quick process, during which the meaning of the life has been exchanged, along with the meaning of the house unit as well. Human being stucked at house units, apartments, residences, villas, etc. on which once he created for a modern way of living. City life could be defined by its possible space opportunities such as sport centers, cinema - theater- opera halls, parks, community gardens, etc. during the pandemic none of them could use neither public, nor private space than the house units. Without any doubt, house units became every possible needed space; schools, universities, gym-studios, entertainment halls, etc.

Figure 1. Exchanging on the meaning of a classical house unit during the pandemic; a house unit started to become a multifunctional place including online facilities.

Nevertheless, during this process, the significant value of house units was once again remembered. Online shopping was re-born on our computer and/ or cellular screens and house units of the pandemic process quickly exchanged into multi-purpose-based spaces. For sure, house units became the space of the new economic form, the liberal pandemic, on which the value of everything has been increased systematically, as Inflation in the countries all across the world increased too. As the value of every unit on the free market increased, the value of finding a house on an average standard became harder. The house now became an unobtainable space. Thus, the cliche once for Third World countries became a general situation definition for all of the globe. The globe, in another word, became face to face with a "nightmare" of finding a possible house unit during hard conditions not only including the providing of socio-cultural necessities but also day by day finding a possible humble "living unit" for standard family life. This is the time of liberal-pandemic and the new definition of house production.

3. CONSTRUCTIONS OF THE HOUSING OF NEW ERA

In the construction field, what is once seen as a cliche for the Third World countries, as finding new alternatives to catch a solution to the population growth would be the most basic trouble on the agendas of governments of most popular big cities and/ or capitals of the World. Besides, during a period of liberalist pandemic, during which the basic resources of the World are gradually depleted, and thus the value awareness of the necessity to show to our environment should be strengthened. Nonetheless, it seems this might be solved solely by using more nature-based materials in the construction field. Since the post-pandemic process is lived, the socio-cultural housing architecture is the basic architectural problem of not only the governments but also the architects at the focus. Since new opportunities are being looked for, it seems adobe is the best solution not only as it is a cheap natural construction material, but also it is in use by 3D construction printers quickly and economically; nevertheless, using adobe material can bring cheap and easy and fast move on housing solutions for the good of the majority of civilization.

Figure 2 & Figure 3. 3D Construction Printers [1]

3D printer-based construction is a brandly new core model in the construction field, which can be shown a variety of technological background, that is used in fabricating buildings or construction components. One another term, that is used to define this core model is additive construction. [2] [3]. Large-scale additive manufacturing (LSAM), Autonomous Robotic Construction systems (ARCS), or free-form construction (FC) refers to other sub-groups of 3D printer-based concrete extrusion technologies in the field [4]. Up to the present, the main 3D printing methods are including extrusion of concrete, cement, wax, foam, and polymers as the main material of the technological income, and powder bonding based on polymer bond, reactive bond and sintering are in use bonding as the main compulsory and with a touch of additive welding is in general use at the construction scale. It is known that, since the beginning of the use of the 3D printing in the construction field, it has had a wide variety of applications in the private, commercial, industrial, and public sectors. Potential advantages of this core system are that it includes faster construction opportunity, along with having a low-cost budget. The more is that to talk on the technological income is the ease of construction and potential DIY construction systems. Nevertheless, this new technological point of view brings increased complexity and/or the accuracy, greater integration of function, and less waste in the construction field, too.

Figure 4. A 3D printer-based Villa Project construction phase schema; Figure 5. A 3 D printer based produced Villa project Concept Design [5]

The owners of AAKaar Bombay define that, 3D printing has been known around since the 1980's, but at that time it was an expensive technology to use and yet difficult way for operations still to manage, that is why there have been a few examples since then. They added that it is only since the beginning of the millennium that it has become relatively straightforward and affordable, and thus, it became viable for a wide range of examples, such as product design, component, and tool manufacture, consumer electronics, plastics, metalworking, aerospace engineering, medical and dental applications, footwear, and etc. [6]

Dr. James Bruce Gardiner is known as the first architect, who used 3D printer core technology in the construction field on a project that he designed for his employer Laing O'Rourke [7]. Architect Dr. Gardiner named the process of 3D construction printing as FreeFAB, which is shown in the figure below.

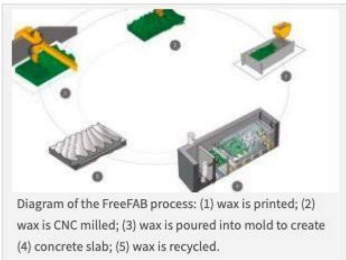

Figure 6. FreeFAB process [8]

Architect Dr. Gardiner claims that "Using 3D-printed wax molds for concrete components, we will have a completely different paradigm. This is transformative technology. With 3D-printed architectural components, we can incorporate aesthetic, structural, acoustic, and thermal into a single design. It will bring meaningful change into the construction industry. A process that would have taken days or weeks can be a two-hour process. And we recycle all our materials." [9] It is known that he designed various building and product design examples in concept up to recent days by using the FreeFAB process that he discovered, as one of his concept villa projects is shown as below on Figure 7.

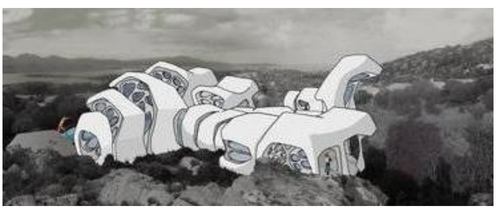

Figure 7. Architect Dr. Gardiner's Concept Design named Villa Roccia [10]

Office of the Future in Dubai is the first known constructed building based on 3D printer technology, which is designed by Killa Design and Gensler firm cooperation, in 2016. Office of the Future is currently the Headquarter of the Dubai Future Foundation, and it is also designed as well as an exhibition space and incubator for future emerging technologies in the region. The initiative comes as part of a Dubai 3D printing strategy launched in the same year, 2016, which focuses on the development of 3D printing technology to improve people's lives in the construction process [11].

Figure 8. The Office of The Future, by Killa Design, in Dubai, construction year of 2016 [12]

4. WHAT WE HAVE LEARNED FROM ARAVENA

Alejandro Aravena, along with his many important awards in the architecture field, took the Global Award for Sustainable Architecture in 2008 and the Oscar of architectural field, the Pritzker Architecture Prize in 2016, as one of the living architects, whose built work demonstrates a combination of qualities of talent, vision, and commitment, which has produced consistent and significant contributions to humanity and the built environment through the art of architecture. During his Ted Global Talk of 2014, he talks about creating cheap and easily produced house construction in Chile, which gives possible evolution alternatives according to user experience, and thus can be personalized in a long term. Actually, he defines two project of his studio Elemental that were created in the year of 2003 and 2010 chronologically. The first one is named as Quinta Monroy, Iquique, and the second one is named as Villa Verde Project, Región del Maule.

Figure 9. Villa Verde Project, Región del Maule, in Chile, 2010 [13]

Figure 10. Quinta Monroy, Iquique, in Chile, 2003 [14]

Arevena's model of producing house units in a cheap, fast, and easy process gives personalized opportunities in a long term according to user experience. He generates an ideal model, as becoming a solution to immigration to centers of significant cities of the world, that based on his analysis on 3 S menace, scale- space- scarcity, in his words means with which, "…we will have to respond to this phenomenon has no precedence in history. For you to have an idea, out of the three billion people living in cities today, one billion are under the line of poverty. By 2030, out of the five billion people that will be living in cities, two billion are going to be under the line of poverty. That means that we will have to build a one-million-person city per week with 10,000 dollars per family during the next 15 years. A one-million-person city per week with 10,000 dollars per family. If we don't solve this equation, it is not that people will stop coming to cities. They will come anyhow, but they will live in slums, favelas, and informal settlements". And he recommends a solution regarding to what his architectural team created; "we decided to include the families in the process of understanding the constraints, and we started a participatory design process, and testing what was available there in the market. In detached houses, 30 families could be accommodated. Rowhouses, 60 families. ["100 families"] The only way to accommodate all of them was by building in height, and they threatened us to go on a hunger strike if we even dared to offer this as a solution because they could not make the tiny apartments expand. So, the conclusion with the families — and this is important, not our conclusion — with the families, was that we had a problem. We had to innovate" [15].

Figure 11. & 12. Arevena on his Ted Global Talk, 2014; Figure 13. His formula of producing social house units for 100 families, in 40 m2, by using of a 10.000 US Dollars. [16]

And he claims that, "…a middle-class family lives reasonably well in around 80 square meters, but when there's no money, what the market does is to reduce the size of the house to 40 square meters. What we said was, what if, instead of thinking of 40 square meters as a small house, why don't we consider it half of a good one? When you rephrase the problem as half of a good house instead of a small one, the key question is, which half do we do? And we thought we had to do with public money the half that families won't be able to do individually. We identified five design conditions that belonged to the hard half of a house, and we went back to the families to do two things: join forces and split tasks. Our design was something in between a building and a house. As a building, it could pay for expensive, well-located land, and as a house, it could expand. If, in the process of not being expelled to the periphery while getting a house, families kept their network and their jobs, we knew that the expansion would begin right away". And on the conclusion, he defines that, "So, we went from this initial social housing to a middle-class unit achieved by families themselves within a couple of weeks" [17].

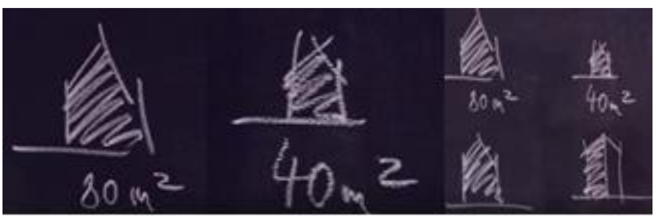

Figure 14. Arevena's formula of providing social house for 100 families by using of a 10.000 US Dollars, in 40 m2; producing the half of the building and let the other half be constructed by the users in long term according to their necessities, experience and pleasure [18]

According to England Shelter Organization, a social house means, "...homes are provided by housing associations (not-for-profit organizations that own, let, and manage rented housing) or a local council" (https://england.shelter.org.uk/support_us/campaigns/what_is_social_housing).. According to the examples of social houses, it is seen that, the units that have constructed on a worldwide tendency are dull, standing far away of being customized, and generally the same or quite similar in design. England Shelter Organization defines social housing as it "is more affordable than private renting, usually provides a more secure, long-term tenancy", which "gives social renters better rights, more control over their homes, and the chance to put down roots" [19]. Truly, on the model that Aravena provided with his team on his Chile based architectural firm Elemental, social house units could be designed and constructed on a pre-determined budget, on a well-located land at first, and on a process, the house units could have been expanded according to the financial background and the pleasure and necessities of the users, in another word according to user experience; even more, these units that would give more than a social house unit could give to its' users, personalized custom-based outstanding character. Besides, the way of possibility to extend their houses according to their necessities and will, users could catch a psychological opportunity to think that they are living not in a social house unit, but in a private custom-made house unit. The half of the social house unit would never been able to be constructed individually. Therefore, the community could find a way to help people those who need a shelter, and on the other side of the medallion, users could not only meet a chance to become an owner of a house, but also they could find a chance to exchange their house unit according to their pleasure and thus they could find a way to create a social ID for themselves inside a contemporary community. Arevena and his architectural team identified five design conditions that belonged to the hard half of a house, and they went back to the families to do two things: join forces and split tasks, which became successful in the action and the expansion would begin right away the project was created. The basic design idea of Arevena was to provide a frame, and from then on, families take over. So, the design group went from an initial social housing to a middle-class unit achieved by families themselves within a couple of weeks. Again, according to Aravena's own words, the design was something in between a building and a house; the design team under the head of Arevena was not only designing the building concept, but also the financial and construction system were designed. Thus, the building design and construction of the social house unit were the issues of the design team whereas exchanging the building into a "house" identity was opened to users own life point of view. These two different social house designs on the base are sharing same principles that have identified above. So, with the right design principles of Arevena and his team Elemental, slums and favelas may not be the problem of the worldwide size as a possible solution, which shows how design can contribute to sustainability, too.

5. NEW GENERATION ADOBE

In the study of Leblebiciler and Akıncı [20], they put through a new methodology to produce a new generation adobe construction material due to providing a contemporary ecological construction material. According to them, in the traditional adobe production, adobe material is produced in a way in which, the material is weak anyhow, on the meaning of its features. This situation shows us that, the material should be improved in order to evaluate its ingredient. They prepared soil selection to produce a new generation adobe example in the laboratory-based experiment. According to their claim, the best adobe formula should have good soil at first inside. They use semi-moist soil on a condition of which, a ball of that soil can be made however it should not be sticking to the hand when it is squeezed inside of the palm. Thus, samples were prepared by adding different proportions of gypsum, lime, pumice, waste glass powder, flax fibers as organic fiber, and volcanic tuff wastes of the region from Afyonkarahisar Fire Brick Factory (AKTF). By improving the technical properties of adobe, which is a natural and sustainable building material, with the studies carried out, bringing this material to the agenda again and expanding the usage area by raising awareness on this issue is targeted in their study, too [21]. In a wide view, concrete is, by far, the most popular construction 3D printing material. In large part, this is due to the flexibility in its formulation. 3D printer makers have also devised their own optimal formulation of 3D printing concrete that they claim is the best for use with their construction 3D printers. According to 3Drific [22] Texas located 3D printing building construction company, construction on 3D printing concrete in many ways is similar to normal concrete, but with added fibers, super-plasticizers, and other ingredients that make the concrete set-in optimal time for layer adhesion between the construction 3D printing layers, as well as strength to allow for less need of steel re-enforcements. This 3D printing construction company claims that, Lavacrete is one such example used with the Vulcan construction 3D printers by ICON. In any case, the major advantage of using 3D printed concrete is obviously its strength, as well as its similarity to conventional concrete, which allows for the transference of conventional construction material knowledge to 3D printed house construction as well [23]. It seems that by using a similar way of 3D printing concrete, which basically has fibers, plasticizers, and other ingredients to make it stronger, the adobe mixture could use with fibers, plasticizers, and some other ingredients in a strong way of producing more ecological based new generation evaluated building material.

CONCLUSION

By the light of the new technologies in construction field, it seems adobe material might be the new ecological, sustainable, natural construction material, that can be used on 3D constructional printers, soon. On the other hand, a new housing model which is based on Alejandro Aravena's model of creating a new system of constructing social houses, at first sight in Third World countries, and on a wide view, all across the globe, at where it is needed, can be used to create a fast, easy and cheap solution. Nevertheless, it seems this model of Aravena brings an opening door to the user experience, too, as on creating of the personalized houses according to user pleasure. Constructing half of a house unit in adobe material by 3D constructional printers, it seems, would be the solution to future social housing problematics in an enthusiastic way, which also brings more opportunities in a long term from a sophisticated point of view.

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65- Understanding the relation between social sustainability andthe theories of Western and Islamic philosophers about religious functions (case study: Yazd city)

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ABSTRACT

Nowadays, the world's attention focused on sustainability and its various dimensions, recently the issue of social sustainability with a focus on the quality of life of citizens has become very important, because not paying attention to this issue will reduce some urban spaces' qualities. On the other hand, throughout the history, philosophers have always presented their ideas about the utopia and how to achieve it. They shaped a society in which people's lives are combined with well-being and success. In the meantime religious functions has always been considered as a key element in a city which in addition to its main roles worship, is to provide the space for human communication. Therefore, the purpose of this study is to understand the components of social sustainability and search for them in the theories of Western and Islamic philosophers' ideas about religious functions, and finally the historical context of Yazd has been selected as a case study. The research method is based on qualitative research and the research tool is library study and field observations. For this purpose, after finding the mentioned relation, it has been explored in three mosques (Jame, Amir-Chaghmaq and Rig mosques) from the historical context of Yazd city.The findings show that after the arrival of Islam in Iran and the importance of mosques in the city,which was mostly influenced by the architecture and urban planning of Iranian historical periods,and it causes a new form of citizenship relations as well as strengthening participation and social interactions at both local and over local levels. These days, the historical context of Yazd owes a large part of its social capital to the provision of a suitable platform for religious functions.

Keywords: Social sustainability, Western and Islamic theories, religious functions, Yazd

The Different Uses Of Sustainable Soil Materials: The Examples Of The Rüstem Pasha Caravanserai And The Hazrat Mevlana Tomb Restoration

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The physical cultural heritage from the past to the present continues to shed light on the next generations with its various aspects. In this respect, the Turkic Republics continue to exist examples in this geography which are coming from various nations and religions, with the most architectural diversity and cultural heritage in the world. These outstanding structures have been restored many times.

Restoration is a difficult process. Restoration applications require expertise. Moreover the using materials have to similar with the original ones. Two of these materials were used in both restorations that are the subject of our research. These are handmade bricks and tiles. Bricks were used to complete the vaults on the roof of the Rüstem Pasha Caravanserai. Tiles, on the other hand, were used on the outer surface of the Tomb of Hazrat-i Mevlana. These materials were used by making them with traditional techniques, just like in adobe bricks. The bricks were shaped in wooden molds from mud and dried in the sun. The tiles, on the other hand, were hand-pressed in wooden molds with a technique called "pap pap" and dried in ovens. Both materials were applied to the structure with the help of Khorasan mortar. Felt was also thrown into the Khorasan mortar to strengthen the binding. Khorasan mortar is a traditional material as it is known. Therefore, the originality of the buildings was preserved and their sustainability was ensured. In addition, the original design of these materials has been preserved in the applications. As the research is an action research, the researcher was also involved in the entire process from the construction of the materials to the application. The aim of the research is to show the analogous construction techniques and usage patterns of traditional materials with examples.

It is thought that the research will shed light on the applications that future generations plan to do in the future.

Using Digital Fabrication Techniques with Earth-Based Building Materials

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Although earth-based building materials have a variety of advantages in terms of environmental concerns of buildings, they require intensive labor to achieve the desired efficiency in construction time and cost, and construction quality. However, advanced and innovative construction technologies provide ease of construction with less laborship, high quality, and less time. Furthermore, the development of robotic technologies in the construction industry offers unique and unlimited application methods. They also demonstrate the potential to broaden the limits of architectural design. This study mainly aims to explore earth-based building materials used with digital fabrication techniques for construction. It focuses on digital fabrication strategies for the construction of earth-based materials and the potentials and obstacles they provide. First, a systematic understanding of the earth-based building techniques is set forth through traditional, contemporary, and innovative perspectives. In this context, the background, development process, and future of robotic and digital fabrication technologies used with earth-based materials are examined following the footprints of existing applications. The potentials and disadvantages are then defined for future studies focusing on digital production techniques of earth-based building materials. In conclusion, the research reveals the capabilities of advanced digital processes within earth-based construction to produce cost-effective, self-constructed, sustainable design solutions by combining innovative digital fabrication techniques with local traditional materials.

INTRODUCTION

Earth has long been the most common building material used in the regions with hot-dry and temperate climatic conditions. Even today, one-third of the world's population lives in earthen buildings, which is higher in developing countries. It has proven that it is challenging to meet the significant housing needs of emerging economies with industrial building materials such as brick, concrete, and steel or with industrialized construction methods. However, the earth is the most abundant natural building material and is found almost everywhere. It is often taken directly from the construction sites by gathering from excavation works.

This research aims to recapitulate and analyze the current state of research on the digital fabrication of earthen structures, focusing on fabrication techniques as sustainable building methods. It also intends to provide a better understanding of the challenges that hinder the process of introducing this new construction method on an industrial scale.

TRADITIONAL EARTH-BASED CONSTRUCTION

Earthen architecture, as a subset of vernacular architecture, is a building style based on local materials, requirements, and the skills of local builders, in which buildings are constructed from a combination of earth and water and occasionally organic fiber. Earth materials have been used in construction by following these basics for thousands of years.

CONTEMPORARY EARTH-BASED CONSTRUCTION

A modern building must have excellent quality in terms of detail, precision, workmanship, and repeatability. Therefore, the building process should benefit from the latest technological advances in equipment and materials.

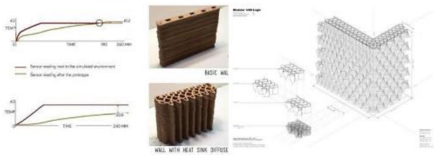
Contemporary earthen buildings can be divided into two categories based on their construction methods. In the first category, modern mechanical machines powered by fuel or electricity are used in the construction process for material handling, mixing, pumping, casting, pressing, and mold making. Around the world, there are new examples of earthen buildings that meet the modern criteria described, where the construction process uses modern technology and the building offers excellent quality, increased performance, and up-to-date aesthetics .

EARTH-BASED CONSTRUCTION WITH DIGITAL FABRICATION

Integrating local natural materials into digital building processes was first proposed in 2004. The contour-making techniqueis also introduced simultaneously. Numerous ideas have been developed for dwellings that can be manufactured remotely and autonomously using 3D printing technology and locally available materials. 3D printing technology is capable of producing both structural components and finish ing.

Clay

Clay has gained much focus in 3D printing applications for many years compared to other earth-based mixtures. The rheological properties which increase the controllability of the 3D printing process of the wet clay mix have caused that concern.



TerraPerforma

Remote Material Deposition Project (left), and the Clay Dome Project (right)

Sand

In 2012, a group of students from IAAC created a portable in situ robotic 3D sand and earth printing technology. The sand was the first earth substance to go through on-site manufacturing technologies.

Solar sintering of sand (left), and stone spray robot (right)

Adobe/Cob

The wet approach for the soil formation is used with adobe, cob, and clay. The fiber content added to the soil mixture distinguishes adobe and cob from clay. Adding organic fibers to the soil mixture increases the mechanical characteristics of earth walls, resulting in better thermal and structural performances.

3D printing adobe wall with built-in staircase

Rammed Earth

There are few examples of mechanized rammed earth buildings compared to clay, adobe, and cob. Even though compacted soil provides superior structural performance compared to alternative earth-based systems, the dry nature of the building process and the requirement for formwork make experimentation with automation more challenging.

Components of robotic rammed earth

DISCUSSION & CONCLUSION

There has been significant progress in combining earth-based construction and new technologies in recent years. Previous works, prototypes, and projects in this area demonstrate the great potential of earth-based construction as an innovative method with numerous environmental and economic benefits. However, traditional /contemporary and digital fabrication applications of earthen building techniques have similarities and differences in materials, equipment, labor, and techniques, as shown in table below.

Technique / Technology	Traditional/Contemporary Applications			Digital Fabrication Applications			
	Adobe	Cob	Rammed earth	Clay	Sand	Adobe/Cob	Rammed Earth
Material	earth, fibrous organic material (straw or dung), water	earth, fibrous organic material (straw), lime, water	earth, aggregates (gravel, sand, silt), clay	clay, fibers, water	sand, water	clay, water	earth, clay, sand, gravel, stabilizer
Equipment	hand tools			3D printer and robots			robots
	molds		molds				
Labor	manpower-based			automation-based			
Technique	wet compaction		dry compaction	wet compaction			dry compaction

Comparison of earth-based traditional/contemporary, and digital fabrication applications

This research focuses on digital fabrication techniques for earthen building construction and the potentials and obstacles they offer. Digital fabrication techniques and technologies are becoming increasingly crucial for the production processes, and robotic manufacturing has shown promise for expanding design.

A new understanding of construction is spreading rapidly, driven by the goal of combining low-cost and sustainable materials with the emerging digital construction sector. This new perspective incorporates local knowledge as the basis for current digital innovations.