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Kerpic'23

26-28 October 2023

Diyarbakır / TURKEY

“GAIN INFORMATION FROM THE TRADITIONAL EARTHEN ARCHITECTURE“

Organized by
Prof. Dr. Bilge IŞIK
Doç. Dr. Şefika ERGİN

Supported by
Kerpic Akademi, Kerpic Network
Dicle University, Faculty of Architecture

Edited by
Dr. Öğr. Gör. Aysel TARIM

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"GAIN INFORMATION FROM THE TRADITIONAL EARTHEN ARCHITECTURE"

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- Sustainability in building materials
- Sustainable architecture and sustainable cities
- Rebuilding cultural landscape after disaster, war
- Social, cultural, touristic reuses of heritage
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Prof. Dr. Bilge ISIK
Conference Chair Istanbul Technical University (Emeritus), Istanbul, Turkey

We are pleased to announce the call for the 10h International Conference on kerpic2023 "GAIN INFORMATION FROM THE TRADITIONAL EARTHEN ARCHITECTURE" and the post-conference workshop on earthen building production. The Conference will be held on 26 October – 28 October 2023 and organized by Kerpic Akademi, Kerpic Network and Dicle University, Faculty of Architecture.

The aim of the conference is to gather the findings and knowledge regarding the theme "Gain Information from the Traditional Earthen Architecture" 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.

Since 1978, Kerpic Network has been conducting research on seismic response and comtemporary production techniques of earthen construction. The durability research is based on gypsum 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.

PROCEEDINGS: ABSTRACT AND FULL PAPER OF AUTHOR (S)

Kerpic'23 – Gain Information from the Traditional Earthen Architecture
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Paper Number: 2

Load Bearing Capability of Earthen Structures


Aya Ahmad[1]
Ayşe Pekrioglu Balkis [2]
[1]Final International University, North Cyprus
[2]Cyprus International University, North Cyprus
[1] aya.ahmad@final.edu.tr
[2]apekrioglu@ciu.edu.tr

ABSTRACT

Scientists from all around the world are focusing on earth-based materials, particularly adobe, due to the need to create building materials with advantageous sustainability qualities, the requirement to conserve local building cultures, and the desire to protect and improve existing earthen buildings. Adobe is one of the world's oldest and most used building materials. An estimated 30% of all buildings in the world are composed entirely or partially of earth. However, the lack of adobe building norms and regulations makes it impossible for architects and engineers to adapt the material for modern construction. Earth can therefore be employed in these constructions as a load-bearing material or as fill inside another bearing structure. A wall is a crucial load-bearing element in structures made of raw soil. Because adobe walls are a primary load-bearing part of raw earth constructions, damage to them frequently leads to structural problems. A load-bearing adobe wall must have a minimum thickness of 0.40 m, according to Peruvian standards. A minimum wall thickness of around 25 cm is allowed under the New Mexico Earthen Building Materials Code for unstabilized adobe walls. Adobe construction is confined to one-story structures, with the exception of two-story structures built by a qualified design expert. For the outside walls of one-story buildings, the International Building Code 2021 mandates a minimum thickness of 254 mm. The internal load-bearing walls' minimum thickness must be 203 mm. Any wall made of adobe units is only allowed to reach a height that is not more than ten times its thickness. When tested in accordance with ASTM C67, Adobe units must have an average compressive strength of 2068 kPa. Under seismic pressure, catastrophic breakdown and destruction of these structures inevitably result in the loss of human lives and economic losses. A load-bearing wall is a crucial component of raw soil constructions.

Keywords: Building Code, Earthen Materials, Load Bearing Walls, Adobe

1. INTRODUCTION

The global use of freshwater, harvested timber, and produced energy by the building sector accounts for 16% of the world's total emissions of greenhouse gases. Additionally, this sector contributes about 40% of the world's carbon dioxide emissions and uses around the same percentage of primary energy (30–40%), resulting in 40% to 50% of the world's greenhouse gas emissions [1]. Scientists around the world are focusing on earth-based materials, particularly adobe, as a result of the need to create building materials with favorable sustainability characteristics, the necessity to protect and enhance existing earthen structures, as well as the need to preserve local building cultures.

One of the oldest and most popular construction materials in the world is adobe. There are always fatalities and financial losses as a result of the catastrophic breakdown and destruction of these structures under seismic stress. Adobe is a building method that creates a bearing wall out of raw clayey dirt that has been combined and molded into blocks. However, the lack of adobe building norms and regulations makes it challenging for architects and engineers to incorporate the material into contemporary architecture. Over 30% of the world's population still resides in earthen constructions, and earth has been used to create buildings for thousands of years [2, 3].

Earth is a commonly available, affordable, and sustainable building material. Standard Adobe and Alker Composite Producing earthen wall material requires a lot of effort and makes it sensitive to moisture. As a result, earthen building technology has to be made more durable, productive, and workable [4]. Earth has been stabilized with various additions during the course of its history as a construction material.

In raw soil structures, walls have a significant load-bearing role [5]. The main application for earth blocks is the construction of load-bearing and non-load-bearing walls, both internal and external. Adobe wall deterioration frequently results in the overall damage of the structure because it is the main load-bearing component of buildings made of raw soil. The damage to the adobe wall, which is a crucial load-bearing component of buildings made of raw soil, frequently causes damage to the entire building. Buildings made of rammed earth have external walls that are at least 300mm thick, which offer great protection from climatic extremes. Because of the material's thickness and density, heat or cold cannot easily pass through the wall, and the inside temperature of the building stays fairly constant, making it seem warmer in the winter and cooler in the summer [6–10]. To get the optimal mechanical and thermal qualities, adobe walls also have to be thick [11]. The forces experienced by the thick earth walls are often well within the material's limited capabilities because the majority of earthen buildings are low-rise, single- or two-story [12].

2. WALL THICKNESS OF ADOBE

A load-bearing wall is one that supports weight (Fig. 1). It is an active structural element of a building that transfers the weight of the elements above it to the foundation structure in order to support that weight. A load-bearing wall transfers the weight from the slabs above to the base. Block, masonry, or concrete materials can be used to build these barriers. The bulk of the outside walls of a building are considered to be load bearing.

Figure 1. Load Bearing Wall

Rammed earth walls typically have a thickness of 300 mm [13]. For a load-bearing earth wall, a minimum structural thickness of 250mm is required [14]. The minimum insulation R ratings and thickness requirements for both structural and non-structural rammed earth built by to walls built by Rammed Earth Enterprises Pty Ltd.are listed in the Table 1.

Table 1. Rammed Earth Wall Insulation Rate and Thickness

Width	Structural (Load Bearing)	Insulated	R Rating
200 mm	X	X	R< 0.5
300 mm	✓	X	R 0.7
400 mm	✓	✓	R 2.5
450 mm	✓	✓	R 3.5

Different design codes have different minimum suggested thicknesses for rammed earth walls as shown in Table 2.

Table 2. Minimum Wall Thickness

Reference	**Thickness of Wall**	
	Internal	**External**
Standards Australia	125 mm	200 mm
New Mexico Code	305 mm	457 mm
New Zealand Code	250 mm	
Zimbabwe Code	300 mm	

The suggested exterior values from Australia, New Zealand, and Zimbabwe are generally similar, but due to the strong seismic activity in the area, the New Mexico Code offers much larger values for the minimum wall thickness [15]. According to Kandamby [16], using cement stabilized rammed earth (CSRE) instead of brickwork can result in cost savings of up to 50% for the building of load-bearing walls. The external wall thickness to wall height ratio in Alker construction is typically 1/5. It also holds true for internal walls, which have a thickness of 1/10 [17].

Ahmad et al. [18] evaluated the effects of using shredded plastic wastes (SPW) on the material Alker, and they discovered that doing so improved Alker's mechanical properties and cracking behaviour. The average compressive strength during a 28-day period increased by 30.1% in the modified Alker samples with 1.0% shredded plastic wastes, and the speed at which cracks propagated in the images of the modified Alker samples with 1.0% SPW increased by 19.13%. According to Onochie and Balkis [19], the Alker was reinforced with polypropylene fibre and similar outcomes were obtained. The average 28-day compressive strength of Alker reinforced with 0.5% polypropylene fibre (PPF) increased by 148.9%, while the behaviour of cracks in 0.5%PPF reinforced Alker image analysed for 28-days indicated a 13.54% improvement in Peak Signal to Noise Ratio. This shows that crack propagation was constrained when drying. The enhanced Alker-SPW bond prevented the formation of voids within the modified Alker's internal structure.

3. LOAD-BEARING WALL IN ADOBE

Adobe brick is a readily available, inexpensive, recyclable, and environmentally friendly building material that requires little energy to produce and use. Additionally, adobe walls have particularly excellent thermal, acoustic, and fire resistance capabilities because they are load-bearing, meaning they transport their weight into the foundation rather than another structure. The weight of adobe walls is supported by the foundation rather than by another construction since they are load-bearing [20]. When compared to other building materials, the cost of adobe brick is significantly lower, increasing its accessibility. Due to their substantial thermal mass, they provide good passive temperature management within the building [21]. For lateral load resistance, adobe masonry walls rely on their own weight. The greater the load needed to force a wall to topple over at its base, the thicker the wall must be. A very minor increase in wall thickness greatly increases the wall weight since the wall's self-weight is the primary cause of the resistance to the overturning moments [22].

In order to preserve energy, Prof. Bilgi Işk built VAN Adobe Office with exterior load-bearing walls that are 45 cm thick and inner load-bearing walls that are 30 cm thick [4]. The walls of contemporary adobe buildings might be substantially thinner. Unstabilized adobe walls can be built with a minimum thickness of around 25 cm (10 inches) in accordance with the New Mexico Earthen Building Materials Code [23]. If the material characteristics or other criteria change over the course of their service life, the stability of adobe walls with such a thin thickness may become a problem. A load-bearing adobe wall must have a minimum thickness of 0.40 m, according to Article 6 of the Peruvian building code [24].

In one-story buildings, outside walls must be at least 10 inches (254 mm) thick. The walls must have lateral support every 24 feet (7315 mm) or less. Interior load-bearing walls must be at least 8 inches (203 mm) thick. Any wall made of adobe units is not allowed to rise more than ten times its own thickness unsupported. Adobe construction is only permitted for one-story buildings, while two-story construction is permitted when it is planned by a certified design professional [25]. A structure cannot have more than one storey of adobe masonry made of unburned clay units unless it is natural (raw) adobe or stabilized adobe. Every wall in these units cannot be taller than ten times its thickness or longer than 24 times its thickness if it is laterally supported at the ceiling line by ceiling joists or rafters. Rammed earth walls were first used in architecture, along with its structure and advantages, by Niroumand et al. [26]. They demonstrated how using thick and dense wall materials results in very little heat or cold transfer through the walls, keeping the interior temperature of the structure almost constant. The minimum thickness for earth walls varies between 0.2 and 0.457 meters [27-30]. According to Minke [29], the minimum thickness must be at least eight times the building's height. The maximum height of the walls, should be a factor of the wall thickness [32-34].

4. CONCLUSION

In recent years, there has been increased interest in earth as a building material due to changes in thinking, worries about the environment and climate change, and a desire to minimize the carbon footprint and establish sustainable construction solutions. The mechanical properties of the material, as well as the design dimensions of load-bearing walls, are critical components in Alker structure load-bearing capacity. Alker walls can be built with blocks as well as by compressing, ramming, or injecting the material into a wall form. During an earthquake, load-bearing walls should be able to sustain horizontal acceleration forces. As vertical loads grow, the momentum caused by horizontal forces decreases, resulting in stability. This property of load-bearing walls is beneficial in earthen construction. Rammed earth walls are good load bearing walls, therefore structural supports are not required. This can assist in reducing construction costs while also providing design options that other materials cannot.

5. RECOMMENDATION

According to previous studies, the effect of waste materials on the mechanical properties of Alker was enhanced. However, it is recommended to study the thermal properties and thickness of Alker walls as load-bearing walls.

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Paper Number: 4

Educational Campaign for Southeast Anatolian Region (GAP): Adobe Construction Model Proposal for Primary Schools:


Zafer Sağdıç, Nur Urfalıoğlu
YTÜ, Faculty of Arch., Dept. of Arch.
zafersagdic@hotmail.com
nururfalioglu@msn.com

ABSTRACT

Increasing efforts have been made to engage more children in primary school education on the Southeast Anatolian Region of Turkiye especially during the last two decades by goverment agency offices and by private social platforms in Turkiye, such as Ministry of Industry and Technology Southeastern Anatolia Project Regional Development Administration and Herkes İçin Mimarlık (Architecture For Everyone) platform. To reach a wider segment of society and to ensure continuity for the development of personal and environmental awareness several participatory school exaples have been constructed, yet through those examples none of a common modeling of primary schools could be developed. This might be seen the basic problem of none having success on educational campaign on this region. Here, establishing a common model for fast and low-budget school buildings in order to provide formal education on a wide spread area is of great importance in order to ensure the aforementioned education mobilization. Thus, it seems that, the adobe can be defined as the most basic structural solution product that can solve these architectural needs and necessities. In this sense, it should be once again remembered the importance of the building constructional examples of Hassan Fathy in adobe material that he created for the geography of Middle East, and how these examples could be easily and fastly constructed and used on a longlived period by Eayptian modern civilization. It should not be forgotten that, the main philosophy of local material based modern architecture creation focused Hassan Fathy's architecture dominated the 20th century architectural field, which includes a series of architectural principles, such as creating an architectural language to the common benefit of the society, which is not breaking the relation with traditional background, while actualizing the constructing, both formally, technologically and as a way of production on designing the fastest, cheapest and the most function-oriented examples. One of the latest Project of Fathy, the Dar al- Islam, Islamic Education Center, is one of the most important community project that designed by him. As a nonprofit educational organization in Abiquiu, New Mexico, the center is constructed in 1979. The design principle of the center is based on Nubian vernacular models that return New Mexico's traditions of adobe construction to their Arabic origins in North Africa. This building can be seen as an important example of the preference to the use of a public space rather than adobe residential housing architecture. Therefore, adobe material based architectural production can be still defined as the most trustful construction methodology of creating the modern building examples on regional structural needs in different functional basis.

In this context, the research text will focus on the construction modelling of fast, easy-to-produce and low-budget school models based on adobe materials, which will provide the best possibility for primary education mobilization on the GAP region of Turkey.

Keywords: Adobe, Southeast Anatolia (GAP), Primary School modelling, Hassan Fathy

1.INTRODUCTION

In contemporary architecture, the use of locally-sourced and sustainable materials has become increasingly important. One such material is adobe, which has been used in construction for thousands of years and is still widely used in earthquake-prone regions of Anatolia. Adobe is a natural material made from mud, straw, and water, and is highly resistant to seismic activity. Here are some reasons why the use of adobe material is important in contemporary architecture, especially in earthquake-prone areas of Anatolia. As adobe is a low-cost, locally-sourced material that is widely available in Anatolia. This makes it an ideal choice for construction in rural areas where resources may be limited. In addition, adobe is easy to work with and can be molded into any shape or size, allowing architects to create unique and beautiful structures that are both functional and sustainable. Secondly, adobe is highly resistant to seismic activity. In earthquake-prone regions of Anatolia, where earthquakes are common, adobe buildings have proved to be more resilient than those made of other materials. Adobe buildings have a unique ability to flex and absorb energy during seismic events, which helps to prevent collapse and minimize damage to the structure. Basicly, the use of adobe in contemporary architecture promotes sustainability and environmental responsibility. Adobe is a natural and renewable material that has a low environmental impact. It is also energy-efficient, as it provides excellent insulation and helps to regulate indoor temperatures, reducing the need for artificial heating and cooling systems.

Finally, the use of adobe in contemporary architecture helps to preserve traditional building techniques and cultural heritage. In Anatolia, adobe has been used for centuries to construct homes and buildings, and its use in contemporary architecture helps to maintain the region's unique cultural identity. There is no doubt that the use of adobe material in contemporary architecture is important, especially in earthquake-prone regions of Anatolia. Adobe is a low-cost, sustainable, and highly resilient material that promotes environmental responsibility and cultural heritage. By using adobe in their designs, architects can create beautiful and functional structures that are both resilient and sustainable.

2. HASAN FATHY CREATIVE POINT OF VIEW ON ADOBE SCHOOL ARCHITECTURE

The adobe school buildings of Egyptian architect, Hassan Fathy, are important examples of sustainable architecture. Fathy believed in using traditional, locally-sourced materials and building techniques to create structures that were both beautiful and functional. His adobe school buildings are a testament to his commitment to sustainable design and social responsibility. One of the most important features of Fathy's adobe school buildings is their use of adobe bricks. Adobe is a natural, locally-sourced material made from mud, straw, and water, that has been used in construction for thousands of years. Fathy believed that adobe was the ideal material for building in the Egyptian climate, as it is highly resistant to heat and provides excellent insulation. Another important feature of Fathy's adobe school buildings is their use of traditional building techniques. Fathy believed that traditional building techniques were not only more sustainable, but also more beautiful, than modern construction methods. He incorporated elements of traditional Egyptian architecture, such as domed roofs and courtyards, into his designs, creating buildings that were both functional and aesthetically pleasing. In addition to their sustainable materials and traditional building techniques, Fathy's adobe school buildings also prioritize community and social responsibility. Fathy believed that architecture had a social responsibility to serve the needs of the community, and his designs reflect this belief. His buildings are designed to create a sense of community, with shared spaces and courtyards that encourage interaction and collaboration. Overall, Fathy's adobe school buildings are important examples of sustainable architecture that prioritize community, social responsibility, and traditional building techniques. By using locally-sourced materials and incorporating elements of traditional Egyptian architecture, Fathy created buildings that were not only functional and efficient, but also beautiful in aesthetic point of view and culturally significant.
These are the most significant adobe school buildings designed by Hassan Fathy:

1. New Gourna Village School, Luxor, Egypt
2. Dar Al-Islam School, Abiquiú, New Mexico, USA
3. Talkha Primary School, Talkha, Egypt
4. The High Institute of Social Anthropology and Folk Art, Aswan, Egypt
5. Fares School, Fares, Egypt

As pioneer architect figure on sustainable architecture, Hassan Fathy's adobe school buildings can be seen as a testament to his commitment to creating environmentally-friendly designs that were also functional and aesthetically pleasing. Here are the most important architectural features of Fathy's adobe school buildings:

1.New Gourna Village School, Luxor, Egypt:

The school was designed to blend in with the surrounding village, using traditional materials and building techniques. The classrooms were arranged around a central courtyard, which served as a gathering space for students and teachers. The roof was designed to collect rainwater, which was then stored in underground cisterns for later use.

Figure 1. New Gourna village, Eaypt, by Hassan Fathy. (https://www.archnet.org/collections/2303)

2. Dar Al-Islam School, Abiquiú, New Mexico, USA:

The campus of Dar al Islam, which is the last community project undertaken by Hassan Fathy, is located around a Mosque and a school building on a hilly plateau across from the historic village of Abiquiu in Northern New Mexico. The campus of Dar al-Islam is a nonprofit educational organization established by Nuridin Durkee, an American Muslim Scholar and Sahl Kabbani, a Saudi businessman, who were also co-founded the project in 1979 with backing from the family of King Khalid ibn Abdul Aziz of Saudi Arabia. The school was built using adobe bricks made on-site, which were then finished with mud material based plaster. The classrooms were arranged in a U-shape around a central courtyard, which was used for outdoor activities. The roof was designed to collect rainwater, which was then used for irrigation.

Figure 2. Site plan of Campus of Dar al-islam, Egypt.
(https://www.archnet.org/collections/2303)

Figure 3. Site view of Campus of Dar al-islam, Egypt.
(https://www.archnet.org/collections/2303)

The landscape of Abiquiu in Northern New Mexico is similar to those of many Muslim lands, and because of the existing tradition of building with adobe material, the organization of the Dar-al Islam decided to constructed the campus on this geography. Fathy presented his project to the commitee of the organization of Dar-al Islam in 1980 and the commitee of the organization would like the project to be built as soon as possible as if to create an iconic islamic center on West, where the land and the wheather are so in common features with Arabic peninsula. During the construction process, Fathy brought Nubian masons with him to New Mexico. He also by himself demonstrated brick-making and building techniques to the whole of the working team. As the remaining plan has been altered and moderated to adhere to local building codes, the mosque was built to design as the iconic building of the campus. The campus of Dar-al Islam opened in 1982, and by the beginning of the year of 1986 there had been 7 full time teachers and 6 full time students. It is also known that the administrative board of the campus provided workshops to train educators about Islam. On the same year, approximately 30 families had joined the community, which has been planned to house 150 soon after.

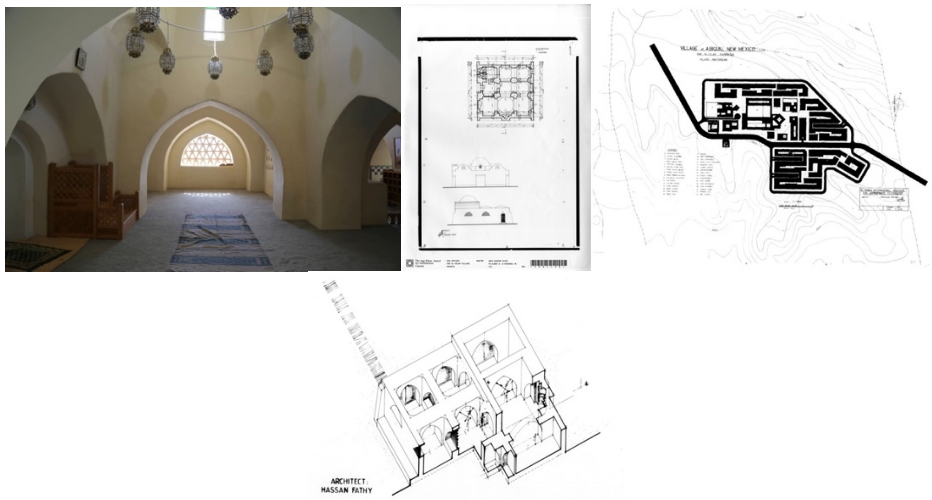


Figure 4. Dar al-islam, the historic village of Abiquiu in Northern New Mexico, by Architect Hasan Fathy. (https://www.archnet.org/collections/2303)

Figure 5. Dar al-islam, the historic village of Abiquiu in Northern New Mexico, by Architect Hassan Fathy. (https://www.archnet.org/collections/2303)

Fathy and his team of Nubian masons, who came to the USA specially for the purpose of constructing the campus, built the campus in the low-technology building techniques of vault and dome construction that were quite commonly used especially in upper Egypt. Constructed entirely with mud brick, the mosque has load-bearing walls that carry arches and domes which cover the prayer hall. The campus, which occupies an eleven-square-mile site on a plateau above the Chama River Valley, is intended for 150 Muslim families to be grouped into comprehensible neighbourhood clusters, which present little wall surface to the east and west for better thermal performance, all relate to a main square in the middle of the community. A secondary square on the concept of a "piazza" nearby, provides a place for community to get together in groups. A mosque, which has been the first building to be built in the community, is located right at the hearth of this piazza, as including a madrasa that is attached to it. As if the mosque is the iconic center of the campus, it is quite compact and fine on its' design, as if to Show the humble soul of the believer on the contect to the creator Allah. In a very efficient way, the mosque building is based on a nearly square plan that provides a forward prayer space for men and a screened area for women. While the humble design criteria of architectural style that was chosen by Fathy for the village may seem foreign in this western context, it does have much in common with the local, adobe tradition. Judging from both the technical and economic complexities involved in using adobe on this campus, however, it would seem that the intentional choice of adobe material and construction technique was made environmental on common cultural reasons, as the result seems more iconographic on the architectural point of view. By 1990 the administrative board of campus of Dar al-Islam was partially due to the economic downturn struggling. The other problems of the campus administrative board had been partly about the member attrition due to the challenges of living in such a remote location. During this time, it is known that, Walter 'Abdur Ra'uf Declerck, administrator of campus of Dar al- Islam, helped restructure the organization. In the end, some land was sold to create an endowment that would help fund continued operation, and the mission was refined.

3. Talkha Primary School, Talkha, Egypt

The Talkha Primary School is the first recorded project done by Fathy in 1928, after his graduation from architectural school. The building is a real proof of evidance of a classical Beaux Arts education of him. Only fragmentary details remain to show the young architect's concern with the niceties of a well proportioned monumental stair flanked by Doric columns and capped with fretwork, dentils and acrotyrion.

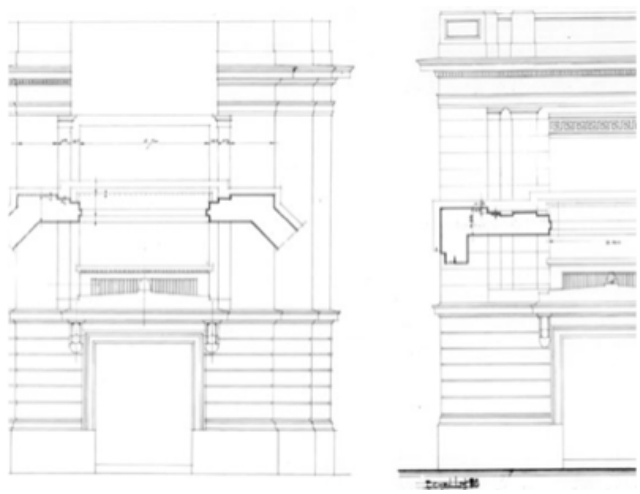


Figure 6. Project Details of Talkha Primary School, Egypt. (https://www.archnet.org/collections/2303)

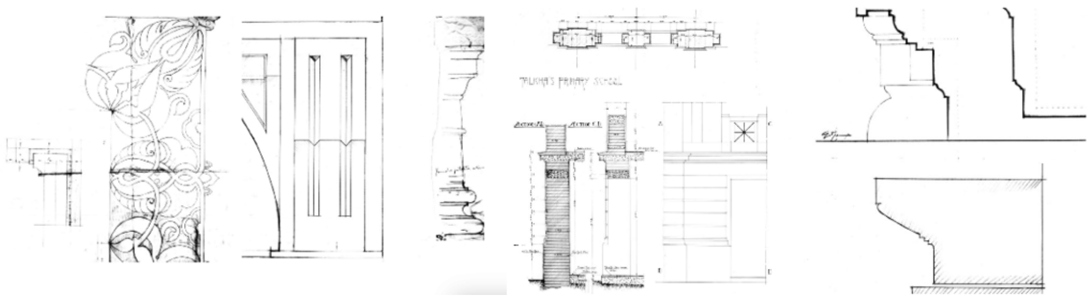
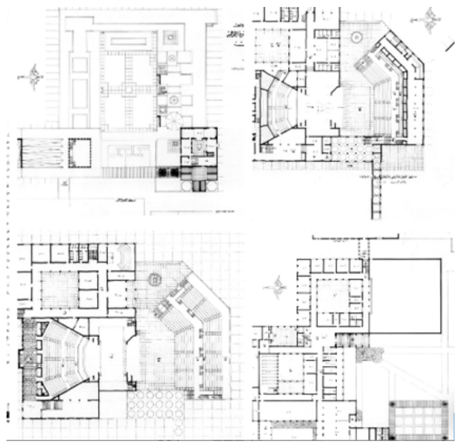


Figure 7. Project Details of Talkha Primary School, Egypt. (https://www.archnet.org/collections/2303)

4. The High Institute of Social Anthropology and Folk Art, Aswan, Egypt

The school was designed to be energy-efficient, with features such as solar panels and a geothermal heating and cooling system. The High Institute of Social Anthropology and Folk Art, without doubt confirms architect's dedication to natural systems and vernacular forms.The building was constructed using sustainable materials, including adobe bricks and reclaimed wood. The classrooms were arranged in a spiral pattern around a central atrium, which served as a gathering space for students and teachers. The project intendes to present a synthesis of Egyptian cultural history in a single place. The Institute is commissioned by the Ministry of Culture, is seen as a potential arena in which to emphasize the most glorious architectural periods in the nation's history through the replication of many of its most famous monuments. The model is meant to be set amongst modern facilities such as concert halls, museums and galleries for the performance of music and dance and the display of Egyptian art.



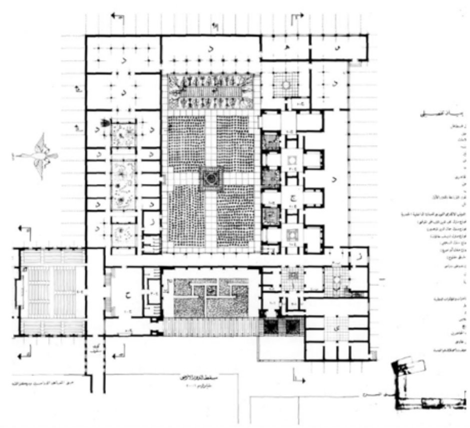


Figure 8. The High Institute of Social Anthropology and Folk Art, Egypt. (https://www.archnet.org/collections/2303); **Figure 9.** The High Institute of Social Anthropology and Folk Art, Egypt. (https://www.archnet.org/collections/2303)

5. Fares School, Fares, Egypt

The building was designed to be energy-efficient, with features such as a passive solar heating system and natural ventilation. The classrooms were arranged around a central courtyard, which was used for outdoor activities and as a source of natural light and ventilation. The roof was designed to collect rainwater, which was then used for irrigation. Fathy became interested in the possibility of providing an economical prototype for a school for the rural villages throughout Egypt, following the flurry of activity generated by these community-based projects. At the beginning of 1950, he started to design studies for such a prototype in his role as the Director of the School Building Department, to the name of the Egyptian Ministry of Education. -- The school at Fares, which is located between Luxor and Aswan, is the prototype without any doubt that Fathy put forward, and brings many of his previous ideas together in a single design. The plan of the Fares school intentionally separates the communal and administrative activities such as the library, mosque, and assembly hall, which face east and west, from the repetitive ranks of the classrooms.

Classrooms are facing to north and south and the architect created a courtyard between them in order to design a protected interior open air space against to the hot and dry wheather normals of the geography of the school. Quite likely to the other areas of the school the classrooms are originally intended to be naturally ventilated, due to the extreme difficulty and prohibitive cost of providing mechanical means of cooling. The architect divided each classroom into a square domed area and a rectilinear vaulted space next to the main unit to achieve the idea. The rectilinear space next to it was meant to contain a salsabil, or water pool, to further cool the air coming in through the slots in the vault above while the domed area is intended to be the seating for the classroom. Operable casement windows are paired with a circular fixed lunette specified to provide lightly and thus further ventilation is also expected to be supplied by them. In elevation, the classroom rows, which have alternating slotted vaults and rounded domes clearly intended function, even though they are now partially screened by a boundary wall. The boundary wall is built to separate the mentioned units from a main street running alongside. The salsabils are never installed, and the entire space is used for teaching, too in further process.

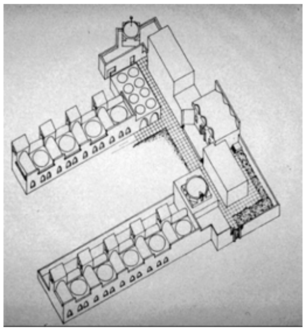



Figure 10. The Axonometric Drawing of Fares School & Figure 9 Fares School, Fares, Egypt(https://www.archnet.org/collections/2303)

3. THE IMPORTANCE OF DESIGNING ADOBE CONTEMPORARY SCHOOLS

Creating a new architectural model of preliminary school design using Adobe material is an innovative approach to sustainable and affordable school construction. Adobe material is a natural and locally-sourced material made from mud, straw, and water that has been utilized in construction for centuries. Adobe buildings are not only cost-effective, but also have unique thermal properties, making them ideal for the hot and dry environments that many schools are located in. Thus, it will be explored the key elements of this new architectural model of preliminary school design using Adobe material on this research. The first key element of this new architectural model is to create a functional and practical design. The school should be designed to meet the needs of the students, teachers, and staff, and should include classrooms, administrative offices, a library, a cafeteria, and outdoor spaces for recreation and sports. The school should also be designed to be easily accessible and safe for all students, with appropriate security measures in place. The second key element of this new architectural model is to incorporate sustainable and locally-sourced materials. Adobe material is an ideal choice for school construction because it is readily available and affordable. In addition to adobe, other locally-sourced materials, such as wood and bamboo, may also be used to create a sustainable and eco-friendly school environment. The third key element of this new architectural model is to incorporate energy-efficient and environmentally-friendly features. For example, the school should be designed to maximize natural light and ventilation, reducing the need for artificial lighting and air conditioning. The school should also incorporate rainwater harvesting and greywater recycling systems to reduce water consumption. The fourth key element of this new architectural model is to incorporate cultural and regional elements into the design. The school should reflect the local culture and traditions, incorporating elements of traditional architecture and design. This will not only create a unique and meaningful environment for students, but also help to preserve and promote local cultural heritage. Therefore, creating a new architectural model of preliminary school design using Adobe material is a sustainable and affordable approach to school construction. The key elements of this new architectural model include creating a functional and practical design, incorporating sustainable and locally-sourced materials, incorporating energy-efficient and environmentally-friendly features, and incorporating cultural and regional elements into the design. By utilizing these key elements, architects can create innovative and meaningful school designs that meet the needs of students, teachers, and staff, while also promoting sustainability and cultural heritage.

5.CONCLUSION

In primary school education on the Southeast Anatolian Region of Turkiye especially during the last two decades by goverment agency offices and by private social platforms in Turkiye, such as Ministry of Industry and Technology Southeastern Anatolia Project Regional Development Administration and Herkes İçin Mimarlık (Architecture For Everyone) platform each and every day increasing efforts have been made to engage more children to the education. It seems a common modeling of primary schools could be developed to reach a wider segment of society and to ensure continuity for the development of personal and environmental awareness several participatory school exaples have been constructed on this region. Without any doubt, a common model establishment for fast and low-budget school buildings in order to provide formal education on a wide spread area is of great importance in order to ensure the aforementioned education mobilization. In that sense, the adobe as the main construction material can be defined as the most basic structural solution product that can engage the architectural needs and necessities on the region.

Thus, the importance of the building constructional examples of Hassan Fathy in adobe material on the geography of Middle East, seem to be remembered to get as the prototypes in order to create new architectural models on Southeastern Anatolia. Understanding how these examples could be easily and fastly constructed and used on a longlived period by Egyptian modern civilization would give hint points on contructing new examples on adobe material for the mentioned region of Anatolia. The most prefable adobe material based school model for the Southeast Anatolian Region it seems could be created quite common to the Hassan Fathy's adobe material based school projects especially in New Mexico, in order to be designed suitable to the dense rain fall and cold wheather conditions of the Southeastern Anatolia as having bitumen such as asphalt or pitch, etc. Or as architect Zumhtor used a kind of special mixture on the construction of Brudel-Klaus-Kapelle Chapel of in Mechernich, Germany, a sensitive mixture of local earth and slightly amount of concrete on it could be used in order to protet the building structure from the dense rain fall and hursh winter weather conditions. Or a kind of likely plaster mix could be used or extra dense mud overall plaster could be used during the construction process as a finishing level it seems.

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Paper Number:5

A Theoretical Study of Mud Brick Techniques Around The Nile River in Egypt

Rasha Elborgy
Architect Ph.D.
rasha.borgy@gmail.com

ABSTRACT

Earth architecture is one of the most environmental material used since ancient times and in various civilizations from East to West. There are many methods of earth architecture, the most prominent was mud brick, as in the civilizations of Mesopotamia, which date back to 8000 BC, and that also found in Egypt. Mud bricks were used in Egypt in early time in the dynastic era, and the Egyptian history is full of different examples, it was used in the tombs of Abydos, Kom Ombo and Ramesseum, also has been used in building houses for people of different levels from the past till now, in ancient Egypt the design differed according to the level of the people. This shows that mud bricks were not using only in funerary buildings or temples. The evidence for using mud bricks in ancient Egypt is the drawings that illustrate the process of building with mud which found in temples, starting with bringing mud from the bottom of the Nile River, then preparing the mixture, and then pouring it into molds. The process of building with mud did not differ much from the past till now, whether in the mixture or in the method used in preparing the brick mold, In this paper, will present the theoretical technique of the mixture and the structure in building with mud brick, and how to take advantage of this technique to adapt it to revive this heritagewith, the presentation of some recommendations for the revival of such cultural heritage.

Keywords: Earth architecture, Adobe technique, Adobe in Egypt, ancient Egypt.

1. INTRODUCTION

Most Egyptian people lived in small houses. The house was built out of mudbrick, with wooden beams holding up the flat mud roof. Our word "adobe" for mudbrick comes from the ancient Egyptian word, "dbe", with the Arabic "al" added at the beginning. In ancient Egypt trees were scarce so wood was not widely used as a building material. Mud, clay, rock and reed were the only materials that were in abundance. The ancient Egyptian first lived in reed houses and later switched to unbaked mud brick, which was used even on palaces [5]. Around 2,700 B.C. they developed a method of constructing buildings from stone. Mud-brick architecture was by no means the first use of earthen architecture in ancient Egypt, but rather followed upon an established history of pit houses and wattle and daub structures. Unfired brick, made from mud, river, or desert clay, was used as the primary building material for houses throughout Egyptian history and was employed alongside stone in tombs and temples of all eras and regions. Construction of walls and vaults in mud-brick was economical and relatively technically uncomplicated, and mud-brick architecture provided a more comfortable and more adaptable living and working environment when compared to stone buildings. Mud-brick became the building material of choice, being the primary material used for domestic architecture. Likewise, mud-brick became a standard medium for religious and

funerary architecture, though stone increasingly was employed next to mud- brick in these latter situations. [3]
During the prehistoric period, mud plaster increasingly was employed for the lining of fire and storage pits, highlighting the potential of mud as an architectural resource. With a shift from ephemeral construction in reeds and mud or rounded subterranean abodes to increasingly permanent, entirely aboveground, rectilinear structures, mud-brick came into its own[3].
Unfortunately, given the historical trend in Egyptian archaeology to focus on cemeteries and temples, mud-brick domestic architecture is less well known than its funerary and religious counterparts; this trend increasingly is changing, however, as the study of urban sites, such as Amarna, and the residential and administrative areas of necropolis sites. So, the technology and components used in making mud bricks will be presented.

2. MUD BRICK FABRICATION

in ancient Egypt unfired mud bricks were the main construction material and remained a stable technology through the millennia. Unfired mud brick Ingredients is still made throughout the world today, and various methods are used in its manufacture, ranging from large-scale production using a bulldozer and grids of brick molds in some countries to small-scale production with a hoe and a single brick mold for individual construction jobs in villages in Egypt. Though the different size, the materials used to make the mud bricks are almost similar: a mix of sand, clay, and silt combined with chopped straw binding agent formed into regular molded units. The ratio of sand to clay to silt differs in the surrounding environment from place to place, but the mix that creates the best bricks, a mix containing no more than thirty percent clay or silt and no less than fifty percent sand, is standard and can be artificially produced. namely, the suitability of the soil to be used for the construction of mud brick is assessed according to the quantity of clay it contains and the proportion of granules. If the proportions are not sufficient, some sand or clay can be added to make it suitable. The mixture making up the mud brick block; consists of 2/3 (2 clay + 1 sand) + 1/3 straw + water. The mixing ratio between sand and clay is 30% and, or, in other words, two-thirds of the total soil content. The water should be added at the optimum rate, ie in its consistency. If water is added too much, it causes difficult drying of the brick, increasing the crack problem and decreasing the strength. Likewise, adding less water also decreases quality. [6]
So. The ratios we have given above are the amounts that have been known and used in Egypt since ancient times. Not all soil and all straw are of the same quality. Therefore, these rates may vary depending on the quality of the material. After all the required materials are supplied, the mixture is done and the mixture is prepared.

2.1 Production Process

To make bricks, the earth is cleaned, dumped in a circular area, broken up with hoes, and mixed with water to form the mixture. straw is then added to the earth mixture. The straw is kneaded into the earth mixture with hands or by feet, and the whole mixture is left to the fermentation for a night or two. The following day, the mixture is rekneaded and more water is added, at which point the mixture is ready to mold. Egyptian molds are simple rectangles made of wood. The mixture is carried from the preparation area, a brick field that has been strewn with straw to prevent the molded bricks from adhering to the ground surface while drying. The wooden mold is sprinkled with water to prevent the mixture to stick in it, then filled to over capacity with the mixture, which is compacted and flattened out. then carefully the mold is removed, and the process is repeated. the bricks are lined up to dry under the sun for almost three days where they are molded. The bottom of the mud brick is reversed to allow it to dry completely for another two or three days. It is then moved to a suitable area on the construction site and stored. However, it should not be kept for a long time in the site area. Thus, the total number of days needed to produce usable bricks varies depending on personal idiosyncrasies in technique [3,6]. As shown in the figures 1,2.
the reuse of old mud bricks in new constructions was common practice, being clearly notarized on the Theban west bank, where the large, stamped mud bricks of the various royal funerary

complexes increasingly were reemployed in domestic contexts. So, brick sizes are not sufficient to determine clearly either the date of construction or the function of a structure. The modern accounts of mud-brick production seem to accord well with what is known of ancient production. One of the most famous artistic sources for information concerning the ancient Egyptian production of mud-brick is a scene in the tomb of Rekhmira, vizier under Amenhotep II and Thutmose III. In this scene, which occurs on the lower portion of the eastern half of the south wall of the passage, a reconstructed, large standing figure of vizier Rekhmira oversees construction work undertaken by Egyptian. [3]

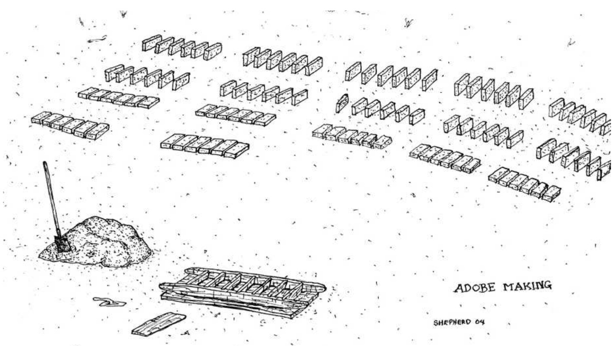

Figure 1,2. figure 1 is an Egyptian mural showing the process of producing mud bricks, Figure 2 show the site work [3]

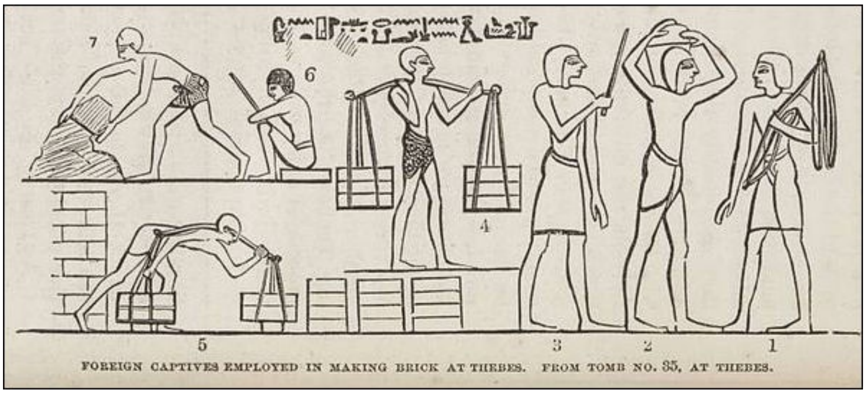

Figure 3. An Egyptian mural showing the process of producing mud bricks [3]

The technical construction part will be shown by presenting some cases of ancient Egyptian antiquities, which is represented in the following.

3. THE CONSTRUCTION

The structural aspect will be dealt with by presenting some Egyptian antiquities and clarifying each archaeological site separately.

3.1 Kom Ombo

it was originally an Ancient Egyptian city called Nubt (meaning City of Gold), famous for the Temple of Kom Ombo that was dedicated to the crocodile god Sobek, the falcon god Haroeris, along with Tasenetnofret and Panebtawy.

Excavations in the north-eastern part of the Balatalmi Temple in the area of the Kom Ombo Temple revealed an administrative building containing various rooms dated to the First Intermediate Period (2180-2050 BC), in addition archaeologists have found a 4,000-year-old complex of 20 grain silos at the Kom Ombo Temple in the Upper Egyptian province of Aswan. Kom Ombo prominence as an agricultural and commercial hotspot during the First Intermediate Period, a time of political instability that divides the old and middle kingdoms of ancient Egypt.

Many of the excavated containers included almost intact vaults, stairs and storage rooms. Many of the silos were almost two meters tall and a few were taller. On some walls, the use of pottery is also visible and also well preserved. [7,8]

The silos are almost taking a conical shape, with a circular base and ending in a smaller circle at the top with a flattened dome, the construction system is simple, mud brick courses are alternately stacked, the courses continuing to rise from the base upwards with an angle inward, to end with the flattened dome as in figure 4, It did not appear in the remains of the silos, as in the figures 5,6, any kind of internal or external supports for the upper part to resist the forces of the dome, the force generated from the flattened dome was directly distributed through the walls and then to the ground, The overall cohesion of the silos shape and the cohesion of the mud brick courses depended on the mortar material, which was also made of clay, it is clear that the quality of the soil used, whether in making mud bricks or mortar, is of high quality, as this soil is taken from the sediments of the bottom of the Nile for construction, with cohesion and porosity, which makes the constructed part as if it is one piece (like the stone's strength) to stand like this in a good condition for thousands of years.

Figure 4. one of the flattened dome of the silos

Figure 5. an open silo in a circular shape [7]

Figure 6. the depth of silos surrounded with thick mud brick walls [7]

3.2 Ramesseum

The Mortuary Temple of King Ramesses II (1290-1279 BC) and the god Amon Ra, known as Ramesseum, is located in Theban Necropolis - the Resting Place of the Ancient Egyptian Kings of the New Kingdom.

Figure 7. the overview of the Ramesseum

Figure 8. the front view of the arches. [10]

Figure 9. the silos' arches with four courses [10]

The Theban Necropolis is located in Upper Egypt and stands across the Nile from the modern-day city of Luxor. It is dedicated to the memory of Ramesses II and to the God Amon Ra. Pharaoh of the XIX Dynasty, Ramesses the Great, spent 20 years for building of his grandiose Memorial Temple Complex. In comparison with the architectural standards of the temples of the New Kingdom, Ramesseum is unusually large. The basis of it makes a rectangle of 183 x 67 meters. In the north-west of Ramesseum there is a complex of royal warehouses, built of mud bricks. They are the earliest arched buildings in history. Ramesses II built a mud break palace where he stayed during visits to his mortuary temple. These warehouses were used for storing funeral materials, various worker tools, as well as grain storerooms. In ancient Egypt, grain was valued as precious as the gold, and from royal temple vaults it was shipped all over the country. The size of such granaries determined the generosity and wealth of the reigning King. [10]
The technique: it consists of the construction various buildings with mud brick vaulted roofs, using only local materials (rocks, earth, water and straw), basic tools, and skills that can be mastered relatively easily. The bricks were laid off and on (alternately) with inclination angle. thick and strong supporting walls were used in parallelism, to create a resistance to the forces that have been created from the barrel vault, the compressive stresses in vaults are transferred from the upper part of the vault to its sides, then to the walls and finally to the foundations and the ground. [2] as shown in figures 8, 9

The adobe barrel vaults in Ancient Egypt were constructed of courses of horizontal or straight bricks laid slant, at a slight angle to the vertical, Reverse the supporting wall. The bricks' slanting led most of each brick's weight to transfer to the lower course, that already had been laid rather than acting downwards, thus, the weight of each new brick was borne by those exist laid, and each mud brick was stuck to the other lower course by mud mortar. [2]
The number of courses used to form the adobe vault was from one to four, the spaces between the adjacent vaults were filled, sometimes, with rubble; as well filling was added above the vaults to create a flat surface. The adobe vaults and wall were plastered with thick layers of mud and whitewashed to increase their resistance and durability.

3.3 Workers' Town and Cemetery

Located to the south of the wall of the crow.The mud-brick wall turned out to be a tomb, with a long vaulted chamber and two false doors through which the dead could commune with the living and receive offerings. The remains of a large settlement site, known as Heit al-Ghurab, were discovered in the southeastern area of the Giza Plateau. This was where the workers who built the pyramid complexes of Khafre (c.2558–2532 BC) and Menkaure (c.2532–2503 BC) lived. The tantalizing remains of an even older settlement underneath may date to Khufu's reign (c.2589–2566 BC). Houses, magazines, three main streets, and a royal administrative building were discovered within the city walls, as were four huge galleries. These may have been the barracks in which the workers who built the pyramids slept and prepared their food. a continuous layer of mud-brick buildings was recorded, starting about 165 feet south of the valley Temple of Khufu and extending about 1 mile to the south. The tombs come in a variety of forms: stepped domes and gabled roofs. they dubbed one remarkable grave the "egg-dome" tomb. An outer dome, formed of mud brick plastered smooth with tafia, enclosed an egg-shaped corbelled vault built over a rectangular burial pit. [11,12]

Figure 10. Overview of the Workers' Town [12]

Figure 11. Some of remain mud brick walls

3.4 Abydos: The Tomb of Hor-Den

It is one of the oldest cities of ancient Egypt, and also of the eighth nome in Upper Egypt. It is located about 11 kilometres (6.8 miles) west of the Nile, near the modern Egyptian town of El Araba el-Madfuna. the sacred city of Abydos was the site of many ancient temples, including Umm el-Qa'ab, a royal necropolis where early pharaohs were entombed.
The ancient Egyptians began building using mud bricks since the Second Dynasty, and there are two buildings from this era, namely: "Shaunet Al-Zebib" and another building that became part of a monastery. [14,15]
From the First Dynasty to the Twenty-sixth Dynasty, nine or ten temples were successively built on one site at Abydos. The first was an enclosure, about 30 ft × 50 ft (9.1 m × 15.2 m), enclosed by a thin wall of unbaked bricks. Incorporating one wall of this first structure, the second temple of about 40 ft (12 m) square was built with walls about 10 ft (3.0 m) thick. An outer temenos (enclosure) wall surrounded the grounds. This outer wall was made wider sometime around the

Second or Third Dynasty. Today, Abydos is notable for the memorial temple of Seti I, which contains an inscription from the Nineteenth Dynasty known to the modern world as the Abydos King List, The figures below 12, 13, 14 show the remaining mud walls from the tombs of Abydos

Figure 12. Abydos, tomb of King Hor-Den [15]

Figure 13. The remain mud brick walls [14]

Figure 14. A remain mud brick walls [14]

4. CONCLUSION

Building with mud bricks is not a modern building method for man. the ancient civilizations have shown that, as in the civilizations of Mesopotamia, which date back to 8000 BC, and that also found in Egypt. Mud bricks were used in Egypt in early time in the dynastic era, the mixture from which mud bricks are made has not changed over the ages since ancient Egypt until now. The technique has been inherited and almost the same proportions. The mixture making up the mud brick block; consists of 2/3 (2 clay + 1 sand) + 1/3 straw + water. The mixing ratio between sand and clay is 30% and, or, in other words, two-thirds of the total soil content. The water should be added at the optimum rate, this mixture is the basis from which the brick mold is made, regardless of the size that will be poured according to the purpose of the building and also according to the parts of the building, whether it is a basement or a wall. The construction technique was shown in the paper by some archaeological sites from ancient Egypt, such as Kom Ombo, Ramesseum, Workers' Town and Cemetery and Abydos: The Tomb of Hor-Den, Examples showed that buildings in ancient Egypt were not only limited to religious temples and funerary buildings, and were not limited to building with stones only. Since the beginning of the dynasty, the Egyptians have used mud bricks in building silos to preserve grain and wheat, the most important food item on earth, as well as in building walls, forts, and homes for workers. They used the method of domes and vaults, which is difficult to apply in stone. Probably conclude that the ancient Egyptians resorted to building with mud bricks for life purposes that would not continue with them on the journey of resurrection and eternity, while the funerary temples and tombs of kings were built of stones until the journey of resurrection is reached again. But the quality of the soil and the mixture

used for making mud bricks led to the survival of parts of the buildings that were constructed for thousands of years.
Mud is one of the environmental materials found in abundance in many countries. It is environmentally friendly, and archaeological sites have proven its resilience for thousands of years against atmospheric factors and destruction. The methods of building with mud bricks have not changed for thousands of years until now. The same mixture and technology is still used in the manufacture of mud bricks in a large proportion, and it is possible that now the diversity has become more, The material is inexpensive in the construction, available locally, and these advantages in themselves encourage building with mud bricks, Governments can intervene by presenting realistic models of construction while giving advantages to this trend, such as reducing some taxes on contractors for each mud-brick project. if we can build with mud a globally, not just a local one, it will for sure preserve the environment, human health and solving the global warming phenomena that dominated the world.

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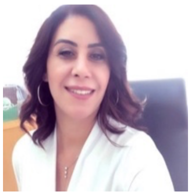
Paper Number: 6

Structural Analysis of Adobe Tandoori Houses: The Case of Van Province

Berfin Gökdemir, Şefika Ergin, İbrahim Halil Şeker
Dicle University, Faculty of Arch., Diyarbakır
gokdemirb@hotmail.com
erginsefika@hotmail.com

ABSTRACT

Adobe is one of the oldest materials that has been shaped and used since the caves, which were used for the need of shelter, evolved into building mastery. Its use in the past has been unearthed with the architectural remains of the ancient age, continues to exist particularly in rural architecture today. Adobe is a common building material in various parts of the world due to its suitability for arid climate conditions, high thermal insulation properties, humidity control, flexibility of use, sustainability and low cost. Moreover, as a traditional solution, adobe has become widespread in terms of creating the comfort and health conditions required in the indoor environment with minimum energy and cost. In this respect, it is important to investigate the examples and principles of adobe architecture to bring them into the literature, document them and ensure their sustainability. In this study, which aims to examine the structural analysis of tandoori houses, the material and construction techniques of the building envelope of the adobe tandoori houses selected in the rural settlements of Van province were investigated. The technical features and construction techniques of the adobe material used in the walls, floors and top covers of the tandoori houses built adjacent to the houses are explained with photographs and drawings. Tandoori houses, examples of traditional adobe architecture, are original examples developed as a result of the experience against physical environmental conditions. Therefore, it should be examined and documented as a cultural value and should be protected as its original structure.

Keywords: Adobe, tandoori house, rural architecture, traditional dwellings

1. INTRODUCTION

The fact that the emergence of a new material or construction technique is longer than the emergence of an architectural product suggests that it occurred directly in accordance with the purposes of the building activity. The use of wood and stone as building materials requires certain processing procedures. However, the final form of both potentially exists in their natural state. In this context, the first building material that humans produced and shaped as they wished in the early periods of settled life was adobe. Until the days when modern materials were used, arches, vaults and domes, which constitute the main elements of traditional large covering systems, emerged in regions where adobe and brick, which are earth-based materials, were the main building materials. Adobe material provides features such as adaptation to the physical environment, high thermal insulation, humidity control, flexible use and sustainability at low cost. Adobe stands out as the main material in rural residential architecture in regions where materials such as wood and stone are not accessible. Adobe material is the original main material of rural architecture in all settlement periods of history, among the soil-based materials that have a universal use in the middle zone of the world (Fig.1). The oldest historical data of the building tradition based on adobe and brick can be found in Mesopotamia, Iran and Central Asia [1]. Research shows that today, approximately 30% of the world's population lives in structures made of earth-based materials [2].

Figure 1. New Mexico Taos Native Houses (Pueblos) and Konya Çatalhöyük adobe architecture [3,4]

In traditional architecture in Turkey, adobe is used as both load-bearing and filling material. In the province of Van, which has a cold climate in the Eastern Anatolia Region, tandoori houses, which are used as a climatic design strategy as well as for cooking, are made of adobe. Adobe, a traditional building material, stands out with its advantages such as being easily obtainable, not requiring facilities for production, and providing heat and moisture insulation at low cost. Today, when the climate and energy crisis is an important problem, it is necessary to become more widespread in buildings using traditional materials and techniques, as opposed to mass-produced buildings that do not interact with the physical environment and provide comfort conditions at high costs. It is important to ensure that original examples of traditional architecture are researched and brought into the literature to guide new buildings. In this context, in the study, the material and construction technique-related features of the building envelope of the adobe tandoori houses selected from the rural settlements of Van province, Mollatopuz village of Özalp district was investigated. The technical properties and construction techniques of the adobe material used in the walls, floors and coverings of the tandoori houses built adjacent to the residences are explained with photographs and drawings.

2. RURAL ARCHITECTURE OF VAN PROVINCE

Van province, around Lake Van, is located in the Upper Murat-Van Section of the Eastern Anatolia Region (Fig.2). It is the largest city in the region in terms of population. The area around Lake Van is a residential area that has hosted different civilizations throughout history. In addition to its convenient location for settlement, it has rich surface resources. The human communities that settled here continued their lives by farming in the plains and animal husbandry in the highlands [5].

Figure 2. Satellite view of Van province and study area (Google Earth)

The average altitude of the Van region is 2200-2500 m, which is higher than the average altitude of the Eastern Anatolia Region. In the province of Van, where the continental climate is dominant, there are short spring and autumn seasons, a snowy, frosty, rainy, cold and long winter season, and a hot, dry and short summer season [6]. According to measurements made between 1939-2022, the month with the highest average temperature is July with 22.3 °C, and the month with the lowest average temperature is January with -3.1 °C (Fig.3). The average annual total rainfall is 392.7 mm [7].

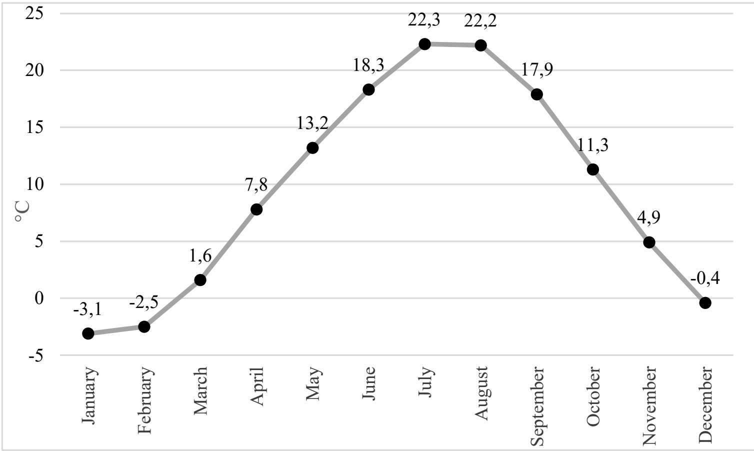


Figure 3. Van province average temperature (1939-2022) [7]

The adobe building material, which is obtained by shaping the clay soil and straw mixture with the help of molds and drying in the sun, has been widely used in military, religious and civil architecture in the province of Van (Fig.4). However, as a result of the decrease in the resistance of adobe to abrasion over time, there are very few examples of adobe architecture that have survived to the present day [8]. The social, cultural and economic conditions of the local people, especially the climate and topography, were effective in shaping the rural settlements in the high parts of Van province, where the cold climate prevails. Local building materials, stone and adobe, form the main elements of rural architecture. Depending on accessibility, adobe is used completely in some settlements.

Figure 4. The extant adobe building and Niyazi Dayıoğlu House in Van city center [8]

Adobe houses, which are still used in rural settlements and built with adobe bricks on stone foundations, ensure harmony between rural architecture and nature and help in thermal insulation at low cost in the harsh conditions of the cold climate with its heat retention feature (Fig.5). Adobe material, which is easy to construct and maintain, balances the humidity level in the interior by absorbing moisture from the air thanks to its porous structure. It protects the structure from undesirable hot or cold weather conditions of the external environment with its long-time delay feature [9].

Figure 5. Examples of adobe houses from the village of Mollatopuz in Van (Gökdemir Archive)

The houses in the study area are generally single-storey and consist of rooms, sofa, halls, kitchens, toilets, bathrooms, warehouses, sheepfolds, stables and tandoor units. The thickness of adobe walls in houses in the region varies between 40-65 cm. In Mollatopuz village where the study was conducted, this thickness is generally 50 cm. Earth, which is the main material of buildings, is also used in the top cover system of houses. Wooden beams, varying in thickness between 10-20 cm, are placed at intervals of 20-30 cm along the short direction of the space and covered with covering boards and thin branches. The coating is covered with 20-25 cm thick clay and straw (Fig.6). Rammed earth is generally used as a floor covering material in adobe houses [10].

Figure 6. Exterior and interior view of the flat earthen roof from Mollatopuz Village (Gökdemir Archive)

2.1 Tandoori Houses in the Rural Architecture of Van Province

In addition to the climatic strategies in the material dimension of the rural architecture, the tandoori houses used for activities such as cooking, sitting, resting and sleeping are both cultural and climatic elements (Fig.7). The tandoori, which was frequently burned by the users before, is now burned every 15 days. Tandoori houses, which are used for heating and hot water needs as well as cooking, especially in the cold days of winter, are burned for 3 hours a day, sometimes twice a day.

Figure 7. Sample of adobe tandoori house in use-Mollatopuz Village (Gökdemir Archive)

In tandoori houses where the masonry construction system is used, the main material is adobe. Wooden material was used in the upper covering system, lintels and doors. Window openings were kept between 60-85 cm as a climatic strategy. In some tandoori houses, there is no ventilation element other than a chimney (Fig.8).

Figure 8. Window and chimney view from Mollatopuz Village

In the study area, the tandoori houses made of adobe were planned adjacent to the rooms or separately from the mass. The houses are designed in two ways, with and without a sofa (Fig.9).

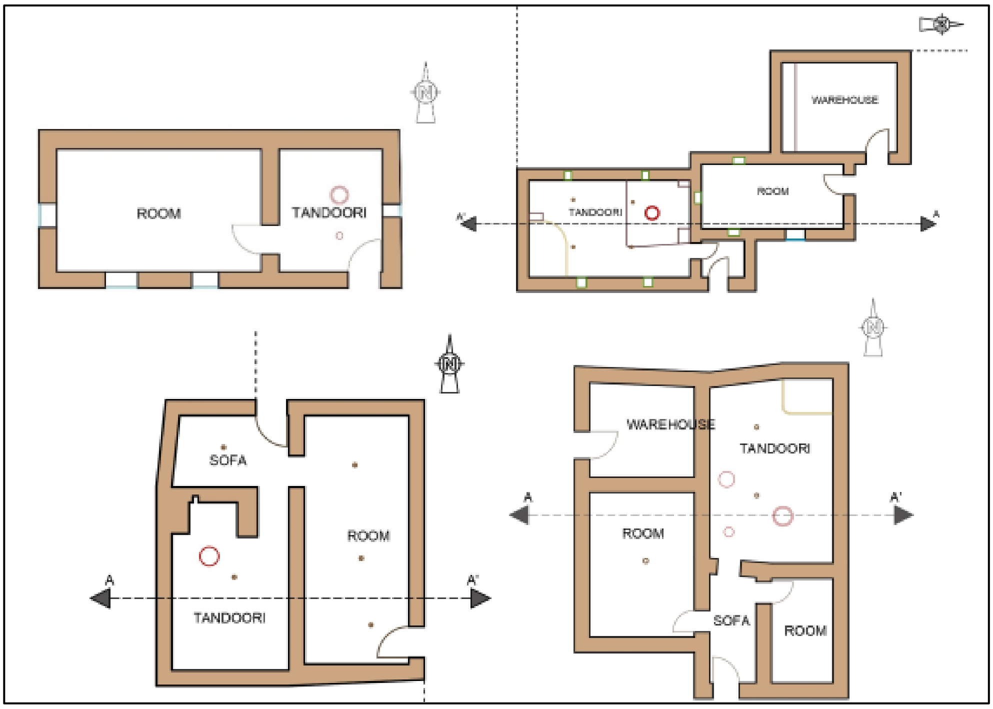


Figure 9. Plan of tandoori houses numbered 1-3 without sofas and tandoori houses numbered 2-4 with sofas in Mollatopuz Village

The wall thickness of tandoori houses built of adobe is 50-55 cm. The diameter of the tandoors used for cooking, heating and hot water is 60 cm wide and the depth is 80 cm. Chimney openings used for smoke evacuation and ventilation in tandoori houses have sizes between 20 cm and 30 cm. On the adobe walls, there are niches containing the ingredients used when making tandoori bread (Fig.10).

Figure 10. Views of adobe wall and niches

Wooden beams and soil, which form the upper cover of the houses, were used in two ways as a covering system in tandoori houses. The first system is the covering systems made as flat soil roofs with wooden rafters (Fig.11). In the second system, the corbelling technique is used.

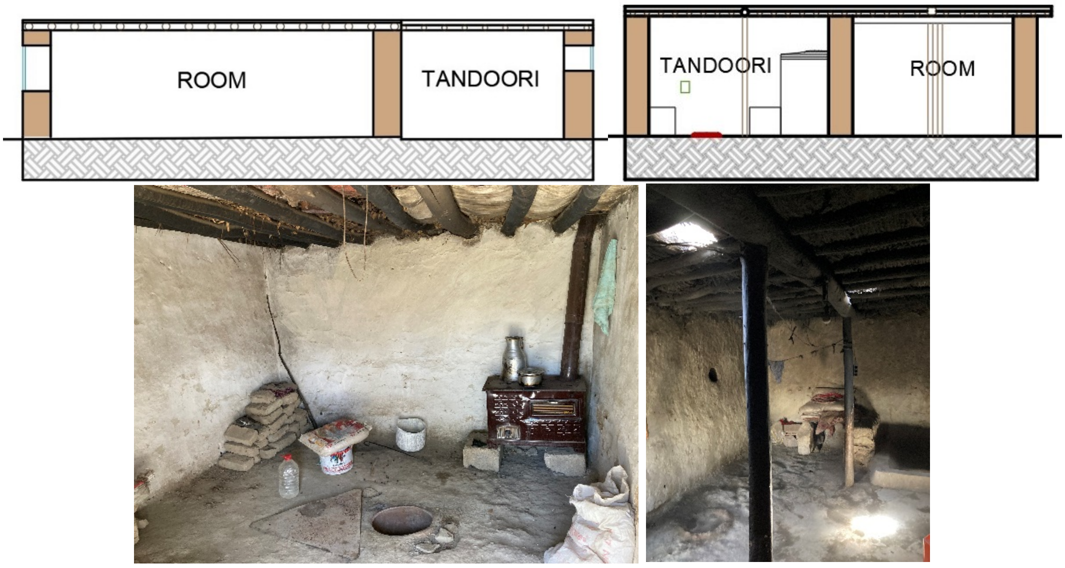


Figure 11. Example of flat cover system of tandoori houses numbered 1-4

In the corbelled roof system, 15 cm diameter rafters placed on 4 wooden pillars with 15 cm diameter form the framework. The corners of the square pyramid-shaped cover placed on the structure. An opening is left in the middle of the pyramid for smoke evacuation of the tandoori house. A pyramid is formed by placing rafters with a diameter of 7-8 cm on the structure in an inclined manner (Fig.12).

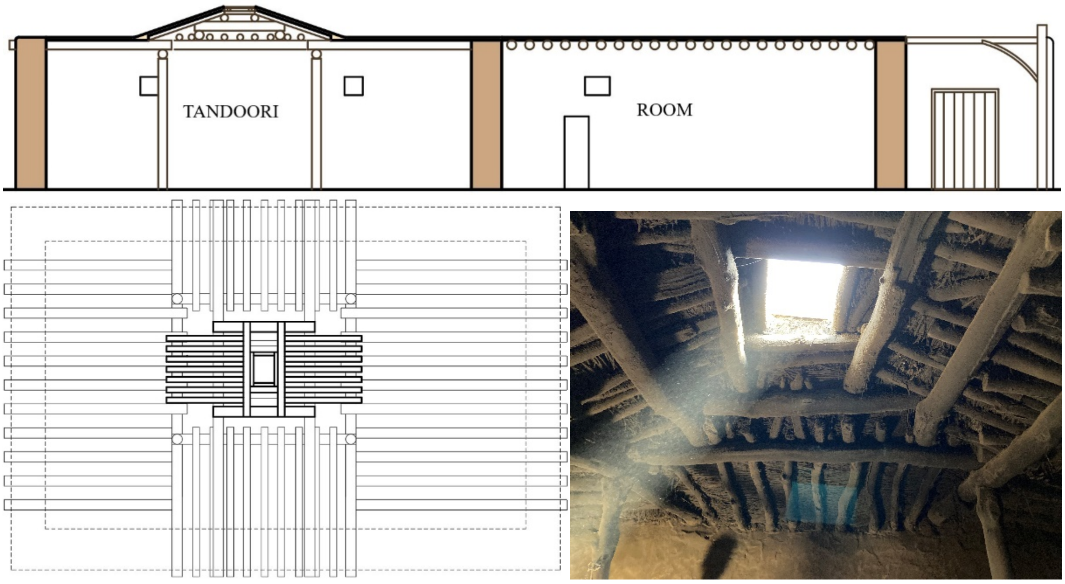


Figure 12. Corbelled roof section, plan and view of tandoori house numbered 3

3. CONCLUSIONS

In the study, tandoori houses in Van rural architecture, which are unique examples of adobe architecture in rural areas in Turkey, were examined. 7 tandoori houses selected for examination from Mollatopuz village were evaluated and presented in terms of materials and construction techniques. Tandoori houses were built on stone foundations using adobe load-bearing walls. Tandoori houses, which are built in accordance with the conditions of the physical and social environment with local building materials and construction techniques, have characteristic features with their main material, adobe and wooden overlap roof systems. Tandoori houses provide compatibility with the regional climate in terms of both typological features and building materials at a low cost. Tandoori houses, which are very common in Van rural architecture, are also important because they meet the comfort conditions with passive design strategies, especially in the winter period, against the cold climate prevailing in the region. The abandonment of rural settlements due to migration also causes the tandoori houses to disappear. Tandoori houses, which are unique examples in terms of sustainability and compatibility with the physical environment in which they are located, should be protected and should guide the new houses to be built in the regions with similar characteristics.

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Paper Number: 10

Learning Earthquake Safe Adobe Construction Technology

Prof Dr Bilge IŞIK
Istanbul Teknik University, 1978-2010
isik.bilge@gmail.com
www.kerpic.org

ABSTRACT

Earthquake occurred on Southeast of Turkey at 6th February 2023. According to the National Earthquake Information Center, there is an average of killed people approximately 50 500. The damage was caused by the collapse of buildings with people inside them. There is a need for making earthquake-proof loadbearing buildings. Because in the last century, engineers learned and introduced framework structure, new designs and building materials like reinforced concrete to better equip buildings and did not get much information on loadbearing wall-structures to withstand earthquakes.

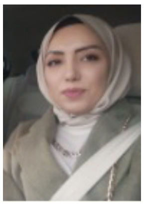
The horizontal load by earthquake, causes the "diagonal rupture" and the entire loadbearing wall structure collapse. The engineers use the methods: vertical reinforcement in the wall or reinforcement of the wall surface for earthquake safety. Test on the reinforced wall system shows that it is not trustworthy. Istanbul Technical University studied on earthquake-proof earthen loadbearing wall buildings since 1990, and the findings helped buildings withstand earthquakes. The main earthquake proof loadbearing wall is constructed with force absorber in the loadbearing wall horizontally at 20cm or 60cm levels. The method tested in laboratory and the design is used on the real buildings at İTÜ-1995, faced the real earthquake at 1999. The second building was constructed at 2000 in Urfa and faced the earthquake at 6February 2023. The buildings were not affect from earthquake.

The study will summaries the research on 1. durability of earthen construction material, 2. industrial construction technology, and 3.to handle vertical forces and earthquake safety of loadbearing wall system.

Keywords: Earthen construction, earthquake, safety, force absorber,

Paper Number: 11

Investıgatıon On Structural Systems Of Tradıtıonal Hüseynik Houses In Elazığ

Şefika Ergin, Hülya Gürgöze

Dicle University, Faculty of Arch., Diyarbakır

erginsefika@hotmail.com

hlya.bhcc@gmail.com

ABSTRACT

Vernacular settlements are characterized, in the most basic sense, as 'the architecture of the people'. These settlements contain important design solutions that reflect the architectural identity of the region and period to which they belong. Local structures have been shaped by trial and error in the historical process; in line with the possibilities and needs of users; It was built in accordance with the characteristics of the region such as climate, topography and materials. As a result of this, a traditional building typology unique to each region has emerged. For this reason, traditional Anatolian houses, which are basically the continuation of the same cultural heritage, contain regional differences. Traditional buildings, with their unique design features, are important cultural heritage items that have become the architectural symbols of the region they belong to. This traditional civil architectural heritage should be preserved, kept alive and passed on to future generations to ensure its continuity. Therefore, the analysis of local architecture data is a critical step. The determination of the structural systems that sustain the building is important for the preservation of this local architecture. For this reason, traditional civil architecture should be examined, structural system solutions should be analyzed and data should be documented.

This study examines the original construction system and material properties of traditional houses in the Hüseynik region of Elâzığ province in Turkey. The region was established in the northeastern part of the province of Elâzığ and is a very old settlement. The fact that the region has preserved its original texture and the lack of studies examining the region from this point of view in the literature have been effective in the selection of the site. Locally-specific construction techniques and the use of materials can be easily read throughout the settlement. For this purpose, the structures located here were examined; Structural system features in the region were determined. This study, which is based on fieldwork and literature review, is important in terms of determining the construction techniques and details specific to the region. General qualifications on the construction technologies of traditional Hüseynik houses are presented with photographs and detailed drawings.

Keywords: Vernacular architecture, traditional construction techniques, traditional materials

1. INTRODUCTION

Vernacular architecture; It contains local materials and construction techniques. In this respect, local architecture reflects the traditional construction methods and architectural identity of the region to which it belongs, and builds cultural bridges between generations [1]. This architectural understanding, which is specific to a certain time and place, is based on knowledge that is the result of a long trial and error process. Since it develops depending on the conditions brought by local constraints, it offers excellent techniques that can adapt to these conditions [2].

Examples of civil architecture are works that explain the balance between the climate, available materials, appropriate technology, design techniques, socio-cultural and socio-economic conditions of the region [2]. Among all these factors, the rationalist use of local materials and techniques is an important parameter that makes traditional structures permanent. Because materials and construction techniques play a major role in the effective use of resources and therefore in the preservation of ecological balance. In this respect, local buildings are considered as perfect design models for sustainable environments. In this context, it is very important to ensure the sustainability of these structures.
Zeren (2012) emphasized the importance of an integrated conservation approach in the sustainable preservation of historical buildings. Choosing the right material and using the right techniques are also a part of this conservation approach [3].
Qualified restoration practices suitable for the original texture of the building ensure the sustainability of these structures. In this way, the original qualities of the building are preserved and its document value is preserved and transferred to future generations. For this reason, it is necessary to know the materials and construction techniques used in traditional buildings. This can be achieved by analyzing the material and design features of traditional civil architecture examples.

Traditional Elâzığ houses have an important place among Anatolian houses. Although Elâzığ city center is new in terms of historical settlement, the region has a very old settlement history. According to the excavations and researches, the history of settlement in and around Harput dates back to the Paleolithic period. According to the written history illuminated by Hittite tablets, the region was known as "Işuwa" in 2000 BC [4]. For this reason, examining the examples of civil architecture in Elazig contributes to the documentation of the cultural heritage. Hüseynik, one of the first municipal organizations of Elazig, has important examples of civil architecture. This study deals with the structural system analysis and material properties in traditional Hüseynik houses. The research based on literature review and field studies was supported by detailed drawings and photographs. The research is important in terms of raising awareness about the preservation of traditional Hüseynik houses.

2. GENERAL FEATURES OF THE WORKING AREA

2.1. Geographical and Climatic Features of The Study Area

Elazig is located in the South West of the Eastern Anatolia Region, in the Upper Euphrates Section. Its total surface area is 9151 km² (8,455 km2 of which is land, 826 km2 of dam and natural lake areas). Due to its geographical location, it is located at the junction of the roads connecting the Eastern Anatolia Region to the west. Its height above sea level is 1,067 meters. Elazig consists of mountainous areas, plateaus and plains in terms of landforms [5].

Elazig climate is defined as "Mediterranean climate whose general character is deteriorated by continentality". The reason for this is that, due to some geographical effects, the winter season is milder in Elazig compared to other areas of Eastern Anatolia [4]. In this respect, the Elazig climate is expressed as a temperate-dry climate zone [7]. According to the measurements between 1938-2022, the lowest average temperature in Elazig was measured in January with -3.9° and the highest average temperature was measured in July and August with +34.2°. Elazig receives the least amount of precipitation in summer. In this sense, August is the driest period. The periods with the most precipitation are April and March. Again, according to the data of the General Directorate of Meteorology, according to the average relative humidity measured between 1975 and 2007; The highest relative humidity is observed in January and the lowest relative humidity in August (Url-1).

Figure 2.1. Location of Hüseynik campus in Elazig city plan (Elazig Governorship, 2022)

The study area is the Hüseynik region, which is located in the North East of the city center and 4.5-5 km away from here. The altitude of the inner-village area of Ulukent Mahallesi, as it is known today, is 1200 m on average [6]

2.2. Settlement and Planning Features of Traditional Hüseynik Houses

The history of the settlement in and around Elazig dates back to the Paleolithic period. In the region, which has been home to many cultures since then, the construction history of the houses that preserve their original texture dates back to the 19th century. Harput, which was the first settlement of the city, could not find the opportunity to develop due to its topographic structure, and spread first to Hüseynik and then to the present city center [4]. Although there are original examples of traditional residential architecture in various parts of the city center, Hüseynik is an important residential area where organic texture is preserved.

Hüseynik, where the effect of topography on the settlement can be clearly seen, is located on a cone of accumulation. The region, which has a limestone bedrock, has deep valleys due to the corrosion of limestone blocks [8]. The Huseynik Stream, which has an improved average slope of 10%, divides the region into two. The east side of the stream is more inclined than the west side [9].

Figure 2.2. Satellite image of Huseynik region (Url-2)

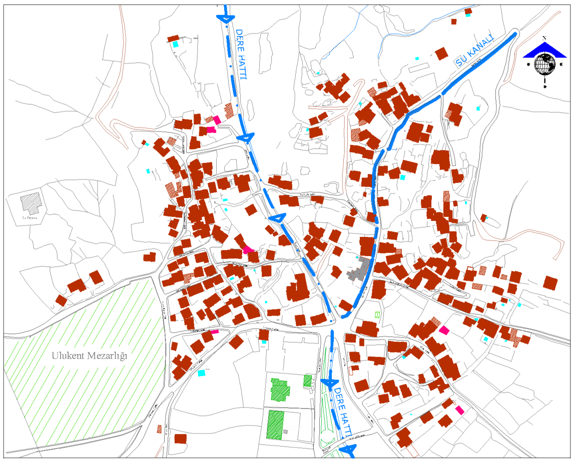


Figure 2.3. Huseynik region site plan (Elazig Municipality, 2022)

All these environmental factors have shown their effect in various ways both in the whole settlement and in the building scale. Housing and agricultural areas are concentrated around the springs. Although the building clusters are scattered on the east side, a more dense settlement is observed on the west side. The sloping land provided access to the buildings from different floors. Most of the houses are positioned to face the Elazig plain, which is located in the southern part of the region. The houses are mostly located adjacent to each other and close to each other. Although a few houses have a garden, they are generally available for back (sometimes side) garden use. Mostly, houses with direct access from the road receive entrances from the south, east, and rarely from the west. There is a compact texture in the settlement as much as the topography allows.

One of the 3 main roads intersecting at the junction point of the region is in the direction of the stream bed and the other is in the direction of the slope. The junction, which is the intersection point of the main roads, preserves the village square feature of the past. Commercial buildings are located here.

Hüseynik houses are planned inwardly with the effect of privacy factor as well as climatic conditions. In some of the houses, which may have one or two floors, basement floors were built by making use of the topography. In some houses, the basement walls are finished with a natural rock surface.

Figure 2.4. Plan scheme of a traditional Hüseynik house

Although the houses in the region are mostly with interior or exterior sofas, there are also plans without sofas. In some houses, the interior sofa is in the form of 'L'. In the planning with an outer sofa, the rooms are arranged in a "U" or "L" shape around the sofa. The ground floor sofa, which is connected to the street, acts as a buffer between the building and the street. On the upper floors, the sofa provides the circulation between the rooms and the floors. Sitting sections called şahnişin were created by making exits on the facades of the sofa that open to the street or the view. In some houses, besides the sofa, there is a şahnişin in other rooms. On the left, a traditional Hüseynik house plan scheme is given. Şahnişin and alcoves are marked on the plan (Fig.2.4)

When the planning organization is examined, it is seen that the service areas are located on the ground floors and the living areas are located on the upper floors. In some houses, there are places on the ground floor that have the characteristics of winter rooms. The winter rooms are mostly oriented south and sometimes west. Some winter rooms have a tandoor and a stove. Due to the long heating periods, the primary spaces that need more heating are located on the south and west facades. Service areas such as the kitchen, cellar, barn, quarry and warehouse are located on the north-facing facades. These areas are buffer spaces that prevent heat transfers. The stove can be used both on the ground floor and on the upper floors. The stoves on the ground floor are mostly located in the kitchen, iwan and courtyard, but some houses have special areas as stoves. On the upper floors, it is possible to come across the use of stoves in the kitchen, rooms and sofas. The windows on the ground floors are small in size and high from the viewpoint of the passers-by in terms of location. On the upper floors, there are larger windows and open to the street or the view. The upper floor spaces are designed more spacious and brighter than the lower floors. The alcoves (şahnişin), especially on the south and west facades, both refresh the primary living areas and serve as a semi-open space with sun-controlled space on these facades.

Hüseynik houses have a very simple facade arrangement. The most striking façade element is the şahnişin. Şahnişin can be built entirely of wood or be surrounded by hımış walls. In addition wooden angle brace elements support the şahnişin from the outer walls. There are examples with 3,5 or 7 windows, depending on the size of the Şahnişin. These sections, which overlook the street or the landscape, function as gathering and resting areas during the day.

Figure 2.5. Traditional Hüseynik houses

3. STRUCTURAL SYSTEMS IN TRADITIONAL HUSEYNIK HOUSES

3.1. Foundations

According to the degree-day zones specified in TS 825, Elazig is located in the 3rd degree climate zone. The frost level varies between 0.99 m and 2.30 m depending on the ground type (Url-4). The basic level of the buildings is as much as the frost level. The foundation systems of the historical buildings that have been able to survive in the region since the past were built as stone foundations with the effect of geological location and ground characteristics.

The sub-basement level is approximately 70 cm. The stone wall thicknesses rising from the foundation to the sub-basement level vary between 70-100 cm. The width of the foundation is still around 70-100 cm and they are split foundations [10]. The foundations were built with rough cut stone and rubble stone, and a mud-based and wood ash added lime mortar was used as the binding material [4].

3.2. Walls

3.2.1. Outer Walls

The outer walls of traditional Hüseynik houses can be mud brick or stone. In addition to the houses built entirely of mud brick in the region, there are also examples of which the ground floor exterior walls are stone and the upper floor exterior walls are mud brick.

The mud brick wall construction technique in Hüseynik houses is similar to the technique commonly used in Elazig houses. The dimensions of the mud brick block are as follows: 10*20*33 cm are full mud brick blocks and 10*15*33 cm are half mud brick blocks [4].

According to this, the outer walls of the ground floor consist of two full and one half mud bricks and are around 70 cm in average with mud plaster. In order to reduce the structural loads on the upper floors, some houses have thinning of the outer wall thicknesses. These floors consist of one full and two half mud bricks and are around 50 cm with mud plaster. In some houses, there is an outer wall thickness of 70 cm, which is a continuation of the ground floor. In some buildings, there are wooden carcass cantilevers on the upper floors. Wooden carcass cantilevers are approximately 20-30 cm thick.

The walls were plastered with mud mortar reinforced with straw. Lime whitewash or lime whitewash + paint process is seen in the houses used in the current situation. In idle houses, the facades are mud plastered.

Rubble stone was used on the outer walls of the ground floor, and mud or lime mortar was preferred as the binder. The average thickness of the stone walls varies between 60-70 cm. While the stone walls of some houses are unplastered, some of them are plastered with mud reinforced with straw. There are also houses with mud plaster + lime whitewashing.

The parts from the foundation to the sub-basement level are rubble and rough cut stones. In addition, rubble and rough cut stone were used in the existing basement walls. In some houses, the outer walls of the basement are finished with a natural rock surface.

In addition to all these, while the ground floor walls are stone, there are also examples of bricks on the upper floors.

Regardless of the type of material used in the construction technique of the masonry wall, wooden intermediate beams are placed. These beams were used at intervals ranging from 60 to 100 cm, without regular intervals.

(a) (b) (c)

Figure 3.1. Types of exterior walls in traditional Hüseynik houses (a: mud brick + mud brick; b: stone + mud brick; c: stone + brick)

3.2.2. interior walls

The interior walls in the region are stone or mud brick. According to the type of material used in the outer wall, the interior wall material is also shaped. In the basement floors, both interior and outer walls are stone. The interior walls on the upper floors are mostly a continuation of the ground floors. However, in some houses, the walls on the upper floor are thinner than on the ground floor. The interior walls were plastered with mud containing straw. Lime whitewash or lime whitewash + paint process is seen on the plaster in the majority of the houses.

It is quite common to use mud bricks with a masonry system or with the hımış technique on the interior walls. As on the outer walls, wooden intermediate beams were placed on the inner walls as they reached certain levels (at intervals of 60 to 100 cm). Wooden lintels are used in the door and window spaces on the interior walls.

Hımış wall construction technique is quite common in the region. Hımış wall is defined as "the technique of making walls by filling the gaps of wooden frames consisting of poles and buttresses with adobe, plaster, brick, etc." (Url-5). This technique is frequently encountered in dividing walls, overhangs and şahnişin. In the region, mud brick blocks are placed between the cavities of the wooden carcass consisting of poles, beams and buttresses. Hımış walls are plastered with mud with added straw, and in some houses there is a process of painting on lime whitewash or lime whitewash.

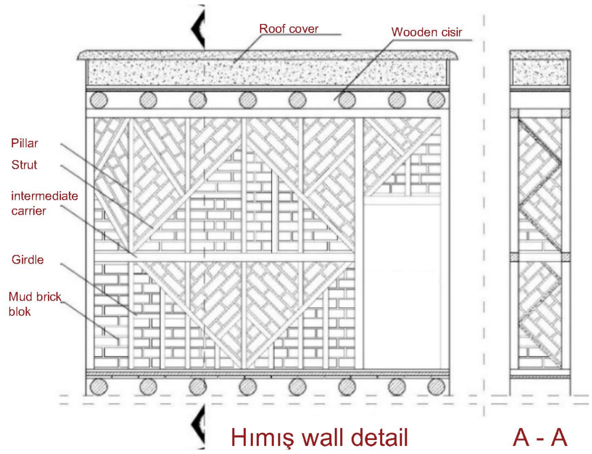


Fig.3.2. Hımış wall detail

Fig.3.3. A şahnişin built with the technique of hımış

3.2.3. Lintels and Beams

Wooden intermediate beams were placed regardless of the type of material used in the masonry wall construction technique in traditional Hüseynik houses. These beams are found at distances ranging from 60 to 100 cm, without regular spacing. There is the use of beams on both interior and exterior walls. It is also observed that wooden lintels are used in the door and window spaces. The use of wooden beams on floor moldings and under windows is quite common in the region.

(a) (b) (c)

Figure 3.4. The use of beams and lintels in traditional Hüseynik houses (a: intermediate beams on the inner wall; b: lintels on the windows; c: beams on the outer wall)

3.3. Slabs

In traditional Elazig houses, the floor of the courtyard is cobbled from the street. However, these floors are found in few houses today [5].
Traditionally, the ground floor floors in Elazig houses are compacted soil and the upper floor floors, which are the main living areas, are characteristically wooden coverings [10].
The floors in Hüseynik houses vary according to the floor and place. It is known that there were similar techniques with the original Elazig houses. However, in the current situation, different flooring types have emerged according to the purpose of use and the needs that have arisen over time.

The floors of the places on the ground floor can be covered with compressed soil, stone coating, screed concrete and wood. This situation is shaped according to the purpose of use of the spaces. The floors of the barn-merek and, if available, the basement floors are usually plastered with soil mortar. While wet areas such as toilets and bathrooms are compacted soil in some houses, they are covered with screed concrete in some houses. The floors of the ground floor rooms, which are arranged as winter rooms, are covered with wooden boards. The floors of some places on the ground floor (usually the courtyard, the iwan and the entrance hall) are paved with slate.

While laying the raft slate, firstly the ground is leveled and leveled with 10 cm thick fine sand by giving the slope direction. 10 cm thick raft stones are placed on the sand and filled with soil between the stones [4].

In the places to be covered with wood on the ground floor, first of all, wooden beams measuring 5*10 cm in line with the short side of the space are laid with an average of 40 cm intervals. Slaked lime is poured between the beams to prevent infestation. The beams are finally covered with 3 cm thick wooden material.

(a) (b)

(c) (d)

Fig.3.5. Ground floor Slabs in Hüseynik houses: (a) a tandoori house with compacted soil; (b) the courtyard with a stone paved floor; (c) a barn with compacted soil flooring; (d) an iwan with a screed floor

Except for the service areas such as the toilet and kitchen on the upper floor of the houses, mostly wooden cladding is used. However, in some houses, it is seen that the floors of the sofas and rooms are only plastered with earthen mortar plaster. There is also a paving stone in the upper floor spaces of large houses. In recent years, tile or screed coating has been used in some houses in line with the needs that have developed over time, in addition to wooden coating, and its originality has been lost.

(a) (b)

Fig.3.6. Upper floor slabs in Hüseynik houses: (a) slate paving; (b) wood veneer

While creating mezzanine floors, first of all, wooden objects (cisir) with an average diameter of 15 cm in the direction of the short side of the space are laid at intervals of approximately 40-50 cm to form a beaming system. After creating a smooth horizontal and vertical beam system, it is covered with a wooden board measuring 3*20 cm.

Fig.3.7. Beaming system (cisir) in Hüseynik houses

3.4. Roof and Eaves

The traditional roof covering of Hüseynik houses is flat roof. However, since this system is easily affected by adverse winter conditions and requires regular maintenance, the houses are covered with cradle, hipped or porch roofs on the existing flat flooring and covered with metal material. While the flat roof is being formed, the mud brick walls are surrounded by 15 cm thick wooden beams.
The roof frame is formed with the help of wooden blocks (cisir) placed in the direction of the short side of the spaces and at intervals of 40-50 cm. The top of the cisir rows is covered with wooden boards of approximately 3*20 cm. Then, a 3-4 cm thick fence made of rafters, reeds or tree branches is placed on it. This fence is covered with 25-30 cm thick brittle barren soil. Then, the top of this soil is plastered with an average of 7 cm thick mud. Afterwards, these layers are compressed with a cylinder made of stone called loğ by inclining in a certain direction. On flat roofs, the slope is mostly directed to the gargoyles placed on the courtyard and street side.
"The plaster used on the roofs is used after resting for a week by adding salt so that the mud does not crack, prevents water seepage and plants do not grow on it. A wooden shovel (sürütme) is used to remove the snow from the roof in a short time" [4].
Some of the traditional Elazig houses with flat earthen roofs do not have eaves. Some have eaves on the front and rear facades, where only the slope is given. The eaves are built as straight eaves to protrude approximately 35 cm [4]. It is very difficult to find original eaves in the region, since the roofs have recently been covered with hipped, gable or porch roofs. While the original eaves are being built, the ceiling beams are removed from the outer walls of the house to the desired extent. The ends are covered with flat face boards. In the Hüseynik campus, non-original eaves are frequently encountered, as the traditional roofs are covered with a roof. The eaves protruding from various facades, depending on the type of roof, are formed by extending the rafters outwards to the desired extent. It is usually covered with sheet metal. With metal gutters, rain and snow waters are discharged.

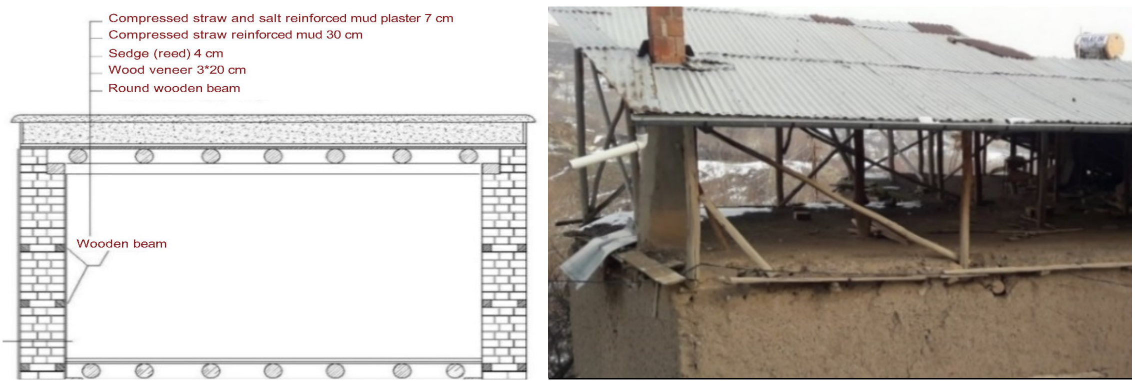


Fig.3.8. (Left) Traditional roof detail; (Right) Traditional roof covering covered with sheet metal cladding

4. Conclusion

In this study, the traditional houses in the Hüseynik campus were evaluated in terms of structural system and material use. The research is based on literature data and fieldwork, supported by photographs and detailed drawings. Stone, mud brick and wood materials are mostly used in the region. These materials have been part of the structural system in various ways. Stone material has been widely used in foundations, interior-exterior walls, arches, door jambs, floor coverings, stairs, courtyard walls, fountains and pools. The mud brick-soil material was preferred for interior-exterior walls, floors, roofs and plastering processes. Wood material has been used frequently in şahnişin, floors, interior-exterior walls, beams, cabinets-loads, roofs, stairs, eaves, doors and windows.

Different shell variations built with the masonry system are very common in the region. In addition to these local materials, bricks, briquettes and metal materials are already used. Brick has been the material of choice for later additions and repairs. Metal material is frequently seen in the şahnişin, window and stair railings, doorknobs and decorations.

As a result of the evaluations, it was concluded that local materials were preferred in Hüseynik houses and design solutions were developed as the material allowed with the effect of environmental conditions. The construction techniques developed specifically for the region have been shaped according to environmental conditions such as climate, topography and available materials. While developing these techniques, flexibility has been gained as much as the material allows. Material selections were made in line with the functional function of the spaces and building elements. The dimensional/formal properties of the structural elements are also arranged in line with the needs, environmental effects and the materials used.

The rationalist use of the material in the building elements and the development of rational construction techniques make these local houses important. It is very important to protect these houses, which are accepted as perfect design models for sustainable environments. At this point, qualified and sustainable conservation with correct restorations comes to the fore. For this, the materials and construction techniques used in these houses should be examined well. Restoration works with the right materials and techniques will preserve the original texture of the buildings and contribute to the sustainable environment.

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Paper Number: 13

Bio-Inspired Design Approach: Earthen Beehive Dome Forms of Harran houses

Pelin Karaçar, Aysun F. Güner
Istanbul Medipol University
pkaracar@medipol.edu.tr
afguner@medipol.edu.tr

ABSTRACT

Studies of natural systems have at all times been inspirational for design. Biomimicry in design is often unfairly associated with the stylistic imitation of natural forms, but Janine Benyus – the researcher who coined the term – believes a biomimetic approach is one that favours ecological performance research and metrics over shape making.
Through an examination of existing biomimetic technologies. It is apparent that there are three levels of mimicry; the organism, behaviour and ecosystem. The organism level refers to a specific organism like a plant or animal and may involve mimicking part of or the whole organism. The second level refers to mimicking behaviour, and may include translating an aspect of how an organism behaves, or relates to a larger context. The third level is the mimicking of whole ecosystems and the common principles that allow them to successfully function
Then these three levels consist of form, material, manufacturing technology, process. Within each of these levels, a further five possible dimensions to the mimicry exist. Within each of these levels, a further five possible dimensions to the mimicry exist. The design may be biomimetic for example in terms of what it looks like (form), what it is made out of (material), how it is made (construction), how it works (process) or what it is able to do (function).
There is a strong temptation to assume that biomimetics is merely a matter of copying a structural idea that is found in nature. However, this overlooks the process of structural design which is much more than creating a certain structural to transfer and adapt the structures, material behaviour and methodologies to bio-inspired technical structures, the geometry model and the material parameters need to be scaled up and adapted to applications in building constructions in a further step.form. Biologically Inspired Design (BID) sometimes shortened in "bio-inspired design", "bioinspiration" and "biodesign" is at least as old as the oldest biomorphic cave paintings, which date back to 40,000 YBP. Bio-inspired technical solutions are the elucidation of movement patterns and of actuation principles and their interplay with the structural set-up of the mechanism because geometrical characteristics and material parameters are inseparably linked and similarly affect the motion behavior of the compliant mechanism.
In the context of bionics and biomimetics, the "evolution" and "adaptation" of traditional architectures is most interesting. By analyzing biomimicry in general terms with natural methods and inspired by these processes taking design. In this context, earthen beehive dome forms of houses in Harran today "inspired by nature", which is widely used in all fields of as the first area where learning/adaptation and/or application technique is implemented can be named. The importance of Traditional and Bio-Inspired architecture of Harran earthen beehive dome as a source of innovation is inadequately identified and used.
The case study on the adaptation of the traditional architecture on the Urfa Harran house. Beehives will present an approach to identify architectural qualities for further application.

Keywords: Earthen Beehive Domes, Traditional architecture, Biomimicry; bio-inspired design; ecology.

1. INTRODUCTION

It is becoming increasingly clear that a shift must be made in how the built environment is created and maintained. Mimicking life, including the complex interactions between living organisms that make up ecosystems is both a readily available example for humans to learn from and an exciting prospect for future human habitats that may be able to be entwined with the habitats of other species in a mutually beneficial way.

We know from Leonardo da Vinci's sketchbooks that he closely studied the forms of skulls and birds' wings: he was, in many ways, a pioneer of biomimicry. We also know that Filippo Brunelleschi referred to the forms of eggshells when designing the Duomo in Florence and it is quite likely that deriving design inspiration from nature goes back even further [1]. It is seen that especially 3 basic factors, climate, culture, environment and local materials are effective in the formation of domed housing structures.

It is becoming increasingly clear that the creation and maintenance of the built environment is the way a change must be made. Houses built in the past appear to mimic life, including the complex interactions between living organisms whose ecosystems are formed. There are houses with these features in Harran.

Harran is a district of Şanlıurfa province in Turkey. It is a town close to the Syrian border. It is 44 km from Şanlıurfa. It is one of the world's first science centers (such as Athens, Mardin, Şanlıurfa). Harran University in Şanlıurfa was named after this district, as the world's first university was located here. Due to the arid climate and low rainfall in the region, green vegetation is not seen much. These natural environmental conditions have been effective in shaping a very different settlement pattern in Harran, which is the closest place to Urfa [2].

Located between the Euphrates and Tigris rivers, and an important ancient city in the Southeastern Anatolia Region, Harran has been influenced and fused with these cultures since it is located between the transition regions of Mesopotamian and Anatolian cultures. "In the old historical inscriptions, the name Harran is referred to as Harranu(m) meaning caravanserai road [3].

Earthen Beehive Dome Forms of houses with its historical past dating back to BC 6000 years, it is understood that it was used by different societies and cultures especially in Mesopotamia, Egypt, Mediterranean and Aegean regions and spread over a wide area. In the process from the use of the earthen beehive dome technique in the houses to the present day, as a result of the interaction of societies with each other and the development of knowledge, domed houses have formed an important architectural form for the settlements where they are located [2].

Today's buildings were built in 1939 and 1300 bricks were used to build a single dome. These bricks were obtained from the remains of structures in the ancient region. Two domed housing structures were built in one day [4].

2. BIO-INSPIRED (BIOMIMICRY) DESIGN APPROACH

Bio-inspiration is a domain with a proliferation of terms. It is therefore interesting to take a closer look at them. The first term to appear in modern literature is "biomimetic" which according to the Oxford English Dictionary is indexed in the volume 132 of Science, published in December 1960 [5].

Biomimicry emerged much later, in 1997 [6] as the eco-design part of bio-inspiration. Nowadays, as acknowledged by Vincent [7], biomimetics tends to become a synonym of biomimicry, biomimesis or even biognosis, whereas they are all equivalent to bio-inspiration.

A cross analysis of the literature, partially carried out within a standardization committee, leads us to propose the following new definitions:

Biomimetics: Interdisciplinary creative process between biology and technology, aiming at solving antrophospheric problems through abstraction, transfer and application of knowledge from biological models.

Biomimicry/Biomimesis: philosophy that takes-up challenges related to resilience (social, environmental and economic ones), by being inspired from living organisms, particularly on an organizational level.

Bionics: technical discipline that seeks to replicate, increase or replace biological functions by their electronic and/or mechanical equivalents.

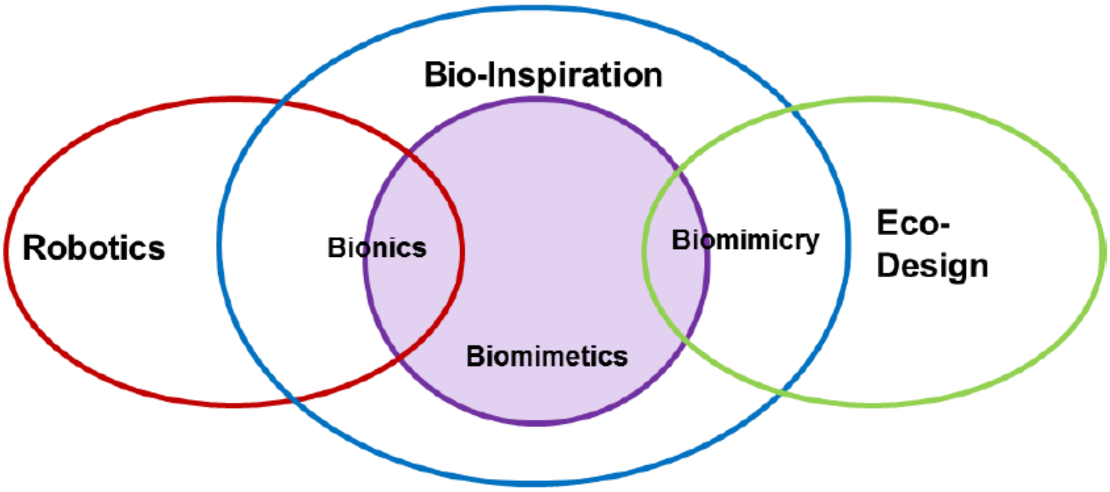

Figure 1. Bio-inspiration and linked concepts boundaries map [8]

These new definitions, in a more precise way, define the conceptual boundaries of each term, as shown in figure 1. However, they do not allow to overcome interpretation issues, even if they are reducing them, with the areas in which they apply [8]

Although various forms of biomimicry or bio-inspired design are discussed by researchers and professionals in the field of sustainable architecture [9, 10].

The point being asserted in adopting a new term is that both 'biomimicry' and 'biomimetic' imply copying, whereas 'bio-inspired' is intended to include the potential for developing something beyond what exists in biology.

Approaches to Bio- Inspired (biomimicry) as a design process typically fall into two categories: Defining a human need or design problem and looking to the ways other organisms or ecosystems solve this, termed here design looking to biology, or identifying a particular characteristic, behaviour or function in an organism or ecosystem and translating that into human designs, referred to as biology influencing design [11].

The approach where designers look to the living world for solutions, requires designers to identify problems and biologists to then match these to organisms that have solved similar issues. This approach is effectively led by designers identifying initial goals and parameters for the design.

Biologically inspired design is gaining importance as a wide-spread movement in design for environmentally conscious sustainable development [6]. Within the two approaches discussed, three levels of biomimicry that may be applied to a design problem are typically given as form, process and ecosystem [11].

In studying an organism or Ecosystem, form and process are aspects of an organism or ecosystem that could be mimicked. The framework that will be described here is applicable to both approaches (design looking to biology, and biology influencing design).

The first part of the framework determines which aspect of 'bio' has been 'mimicked'. This is referred to here as a level. Through an examination of existing biomimetic technologies it is apparent that there are three levels of mimicry; the organism, behaviour and ecosystem. The organism level refers to a specific organism like a plant or animal and may involve mimicking part of or the whole organism. The second level refers to mimicking behaviour, and may include translating an aspect of how an organism behaves, or relates to a larger context. The third level is the mimicking of whole ecosystems and the common principles that allow them to successfully function. Ecosysytem however is what could be studied to look for specific aspects to mimic [12].

Within each of these levels, a further five possible dimensions to the mimicry exist. The design may be biomimetic for example in terms of what it looks like (form), what it is made out of (material), how it is made (construction), how it works (process) or what it is able to do (function). The differences between each kind of biomimicry are described in Table 1 and are exemplified by looking at how different aspects ecosystem a termite is part of could be mimicked [12].

Table 1. A Framework for the Application of Biomimicry of Ecosystem Level [12]

Level of Biomimicry		*Example - A building that mimics termites:*
Ecosystem level (Mimicry of an ecosystem)	*form*	The building looks like an ecosystem (a termite would live in).
	material	The building is made from the same kind of materials that (a termite) ecosystem is made of; it uses naturally occurring common compounds, and water as the primary chemical medium for example.
	construction	The building is assembled in the same way as a (termite) ecosystem; principles of succession and increasing complexity over time are used for example.
	process	The building works in the same way as a (termite) ecosystem; it captures and converts energy from the sun, and stores water for example.
	function	The building is able to function in the same way that a (termite) ecosystem would and forms part of a complex system by utilising the relationships between processes; it is able to participate in the hydrological, carbon, nitrogen cycles etc in a similar way to an ecosystem for example.

An advantage of designing at this level of biomimicry is that it can be used in conjunction with other levels of biomimicry (organism and behaviour). It is also possible to incorporate existing established sustainable building methods that are not specifically biomimetic such as interfaced or bio-assisted systems, where human and non-human systems are merged to the mutual benefit of both. A further advantage of an ecosystem based biomimetic design approach is that it is applicable to a range of temporal and spatial scales [13].

Ecosystem biomimicry at the process level provides a clear and logical framework to apply existing technology or design strategies for a more thorough approach to increasing sustainability. It has also been demonstrated that ecosystem biomimicry is a way of giving order and coherence to the myriad of methods used in the creation of sustainable architecture [14].

Building mimics the natural process and cycle of the greater environment. Ecosystem principles follow that ecosystems [14];

(1) are dependent on contemporary sunlight;

(2) optimize the system rather than its components;

(3) are attuned to and dependent on local conditions;

(4) are diverse in components, relationships and information;

(5) create conditions favorable to sustained life; and

(6) adapt and evolve at different levels and at different rates.

Essentially, this means that a number of components and processes make up an ecosystem and they must work with each other rather than against in order for the ecosystem to run smoothly [14].

Harran houses mimic these natural process and cycle of the greater environment. Harran houses are generally in the form of beehives made entirely of bricks and plastered with adobe plaster. It resembles the habitats that bees produce for themselves in nature. There is an ecosystem approach in biomimicry. For this reason, Harran houses are given as an example as this approach inspired by nature.

3. EARTHEN BEEHIVE DOME FORMS OF HARRAN HOUSES

There are a limited number of official studies on Earthen Beehive dome forms of houses and their structures in the Harran Region. These houses are made of stone and brick material obtained in the surrounding area and covered with earthen plaster. Especially with the opening left at the top of the roof area, air circulation is provided to a great extent. The main material of the domed housing structures in the Harran region consists of brick, earth plaster and limestone blocks obtained from the ruins of the ancient Roman city [15].

The most important reason why the housing units are adjacent and side by side is that the people are related to each other. "Discipline in the house plan is not very common in the village settlement. The random layout of the Harran houses creates a natural-looking environment that does not stress people" [16]. The domed housing structures in Harran were built with materials such as stone, brick and soil that people can easily find in the environment due to the scarcity of wood in the region. These structures are very suitable for nomadic societies, can be built quickly and are suitable for hot climates [17]. In addition, domed units are positioned around a courtyard in hot climate regions.

Figure 2. Harran houses which consist of a conical con shape like beehives (Photo by authors)

Harran houses are covered with domes, which consist of a conical cone shape by gradually narrowing the bricks laid on a square or nearly square prismatic infrastructure (Figure 2). The transition to the domes is made with simple squinches and pendentives (bingi). The domes, with a height of up to 5 m from the inside, were built with 30-40 bricks on top of each other.

With the expansion of the family over time, the new units were added organically, without the concern of a particular module, entirely within the framework of the terrain and materials. It is possible to distinguish the settlement typology of the houses in the region as closed, surrounded by domed cells and walls around a courtyard, and an open, unenclosed, building settlement with a passage from the outside to the courtyard (Figure 3).

Figure 3. The settlement typology of the houses in the region as closed, surrounded by domed cells and walls around a courtyard (Photo by authors)

The domes used in Harran houses were developed and applied in parabolic form. The reason for the formation of this form is the overlapping dome technique, while it rises circularly from the center, a large part of the load on the dome is transferred to the load-bearing walls as a pressure load. For this reason, the longitudinal section of the dome has developed in a parabolic/conical shape, not a semicircle (Figure 4).

Figure 4. The longitudinal section of the dome has developed in a parabolic/conical shape (Photo by authors)

While the domes were being built, brick projections were placed on the sides at regular intervals and the top of the dome was left open. The protrusions were made to repair the dome and to reach the top of the domes in order to partially or completely close the hole in the top in rainy-cold weather when necessary.

The openings used for ventilation, lighting and passage are used as small and few as possible in the structure. Window openings used for ventilation are made in a way that increases the ventilation circulation. The opening at the top of the dome provides a chimney function and natural ventilation for the smoke to escape (Figure 5).

Figure 5. The openings used for ventilation, lighting and passage (Photo by authors)

It is seen that the life style of the building users and the way they use the domed structures are effective on the form of the building. The size of the family structure, how the individuals share the spaces, how the food preparation, cooking and eating functions take place, and the culture of washing and cleaning have affected the shaping of the structure.

Stone walls are usually protected with earthen plaster. Sometimes it is whitewashed with white lime on plaster. Stone walls generally consist of double-skinned parallel walls. These walls gain the feature of acting together with the occasional binding stones. The space between the two walls is filled with soil, stone and filling material. Thanks to the dome form, the stones rising slightly upwards, rain water on the structure is removed from the structure. The environment and construction materials of the building have been effective in the form of the building. The fact that the society living in Harran lives in the form of extended families has been seen as a major factor in the increase in the number of domes.

4. CONCLUSION

Biological systems teach us to see waste as an opportunity: a vital lesson. This applies equally to the resources that flow through our cities, as well as the materials from which they are made. When using biomimicry, in a given situation some biological models are more appropriate than others for the function or system that you intend to re-imagine.

The domed housing structures in Harran, in this context, the building culture in the region and their sensitivity to the environment and climate make these structures important.The existing structures in Harran were used until the 1980s. However, a few buildings today are used as warehouses and barns by changing their functions, other than for touristic purposes. Most of the people living in Harran live in the newly established area 2 km away from the ancient site.

Biologically inspired design is a nascent but rapidly growing area of design research. In this paper, we have analyzed the biologically inspired design process in terms of the practices of the Harran Houses. The beehive shape of these abodes allows them to withstand earthquakes, violent wind storms, and seasonal heavy rains, which explains why they are still in use these days, thousands of years later. What's more, it is relatively easy to expand the size of a beehive house by simply erecting another hive next to it and knocking an archway through.

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Paper Number:15

A Sample for The Use of Adobe in The Experimental Archaeology In Turkey: Kültepe


Prof.Dr.Nur Urfalıoğlu, Akgül Zor(M.Sc.)
Yildiz Technical University,
Kayseri Municipality
nururfalioglu@msn.com
azor@kayseri.bel.tr

ABSTRACT

Experimental Archaeology is a method used over all globe in recent years for both explanation of undiscovered parts and ease of perception of periods and objects for guests. For example, Roman boat was reconstructed in 2022 with materials of its original era and sailed on shores of Danube and similar method was used on boat remains from the Yenikapı Excavations which were sailed on Bosphorus. The in-situ reconstructions of city wall of the Hittite capital Hattusa and Neolithic adobe residences of Aşıklı Höyük, both again with material and technique of the era, are other important examples.

Another important recent project is "Neighborhood of Assyrian Merchants" which is being reconstructed and expected to resurrect the commercial hub of the era, Kültepe, which was the center of the Kanesh Kingdom and the capital of the Assyrian Trade Colonies.

Kültepe dates back to 4000 BC. Excavations began in 1948 by Prof. Dr. Tahsin Özgüç. The "Archaeological Site of Kültepe-Kanesh" was accepted into UNESCO World Heritage Tentative List in 2014. Currently, the excavation project is operated by Prof. Dr. Fikri Kulakoğlu from Ankara University.

Similar to the once applied for single residences in Aşıklı Höyük, a new reconstruction is going to be built on neighborhood pattern scale in Kültepe. According to the project report, this application aims to "Re-tell the story of the residences and the neighborhood of both Assyrian and local merchants settled in Karum, which is unavailable over the current architectural remains". The chosen place for this project is the site excavated between 1948-1958, for which Mahmut Akok also prepared restitutions. Adobe was named as main construction material of the site and even measurements of blocks were explained in many sources.

This proceeding will examine use of adobe in experimental archaeology in Turkey and focus on "Neighborhood of Assyrian Merchants Project" of Kültepe in detail.

Keywords: Adobe Architecture, Kültepe, Experimental Archaeology, Assyrian Merchants, Aşıklı Höyük

1. INTRODUCTION

Turkey can be considered as an archaeologically enriched country for its numerous historic sites. Therefore, local archaeologists are thought to be lucky in terms of study areas. Kayseri, as one of these spots, hosted many civilizations from prehistory to the current era and still holds their cultural heritage.

The recent popular term "experimental archaeology" is defined by many local and foreign scientists. According to Güneş Duru, who refers to Flores, it is "a tool for varying the archaeological data from the excavations, for the correct interpretation of the knowledge, and for the enrichment of the study with new questions". He also thinks that experimental archaeology began to be used in the 1960s, during the new fluctuations in the field [1]. Christopher Busuttill thinks it is on the experiments, as the name implies. He also says it is multidisciplinary on a large scale from zooarchaeology to landscape, it includes all archaeological periods and is of the hypotheses put forward by the experts [2]. Almost all scientists studying experimental archaeology agree that the pioneering name is J. Coles. Coles, in his 1973 book *Archaeology by Experiment* and 1979 book *Experimental Archaeology*, defines the field as covering all experiments of the archaeology field while defining a point in the archaeology. This is the most referenced definition [3]. Ülkü Türkoğlu, referring to Mathieu, defines the field as "a science that creates analogies for explanations and hypotheses for improvements via experiences or repeats of the events with controllable experiments" [4]. According to Peterson, who refers to the same source and thinks he makes the 21st-century definition of the field, it is the sub-branch of archaeology, uses different methods, techniques, analyses, and controllable experiments, and creates analogies and tests hypotheses for archaeological studies [5].

As understood over these definitions, experimental archaeology is an important tool for delivering cultural wealth to new generations. Foreign universities, who discovered this early, developed "Experimental Archaeology" courses and told about its definitions, old technologies, activities, rebuilding of structures and toponomy, its value for archaeological research, and the importance of public access. And for their practical hours, students had the opportunity to join local projects (such as the "Archeologie Telt" project), rebuild the Late-Neolithic residences, experiment the local crafts as agriculture, and to analyze the building materials (as open-air educational field of Vlaardingen Broekpolder) [6].

There also are experimental archaeology centers in some Turkish universities, such as Manisa Celal Bayar University Experimental Archaeology Application and Research Center. This hub aims to operate surrounding archaeological and ethnoarchaeological excavations, to promote the importance of national cultural heritage, to reconstruct almost all findings, to make experimental studies by collecting local and foreign scientists, to organize certificated conferences and workshops, to promote experimental archaeology in education, to educate much-needed experts, to create infrastructure, and to provide advice service [7]. In 2014, a set of studies in experimental archaeology and archaic metallurgy were operated at İTÜ Science Center. One of these studies was for children 8-10 and another was for the experts of copper, lead, and bronze. Both studies aimed to resurrect the use of archaic bronze kilns discovered in excavations. This education helped students to discover a new world and to express themselves via specific material culture products [8].

2. EXPERIMENTAL ARCHAEOLOGY SAMPLES FROM THE WORLD AND TURKEY AND THE USE OF ADOBE IN THEM

Some scientists think that experimental archaeology can date back as old as the 18th century when the bronze musical instruments of the era were made as the resurrections of the ancient ones [9]. And some think that the roots of experimental archaeology date back to the antique dealers of the early 19th century [10]. There are two main approaches to reconstructing the buildings or findings. First is the additional archaeological interpretation and the other is sharing the finding with a larger audience. Both methods are criticized for being mimics of the historical ones [11].

Some samples for experimental archaeology from the world and Turkey are listed. Norwegian discoverer Thor Heyerdahl's self-built boat, which was named after the Inka sun and storm god Kon-Tiki and sailed on the Pacific Ocean for three months, can be considered the very first and one of the very interesting samples of experimental archaeology [12]. A similar approach in Turkey reconstructed boats from the Yenikapı Excavations in İstanbul, which also sailed on the Bosphorus can be considered as another example. Here, the same material and measurements from archaeological findings were used.

Yet another boat reconstruction from the Roman period was built and sailed on the Danube, in recent years. In many studies, ancient findings were copied, and lifestyle was resurrected via mannequins. As the researchers put forward, experimental archaeology is a multidisciplinary field in connection with archaeology, architectural history, art history, museology, and many other areas.

These applications come out also important architectural results. Since the structures are discovered only on foundation levels in excavations in Turkey, experimental archaeology helps visitors in understanding them in detail, in recent years. For example, the city wall of the Hittite capital Hattusa was partly reconstructed with adobe via experimental archaeology. When the 65-meter long, 7 or 8-meter tall (along with 12 or 13-meter long twin towers) reconstruction of the adobe brick wall part finished, people figured out how well the city was protected and how a visitor feels when he comes closer to the city. Similar projects in Turkey are quite a few. For the project, the lower city was selected. The original wall was in use during the Empire period (14^{th}-13^{th} century BC). The main deciders during the project were ease of access and the dramatic effect. Hattusa visitors generally use the route in the urban field. Since the gate of the ruins is next to the newly reconstructed wall, visitors will experience its existence at both entrance and the exit [13]. (Fig.1).

Figure 1. General view of the Hattusa city walls and views from the construction phase [14]

Yet another example in Turkey is the reconstruction of the Aşıklı Höyük residences. Once again constructed with the material of the era, the adobe, here the original roof entrances of the houses were converted to a side entrance for safety reasons [15]. Güneş Duru, who also was in the Aşıklı Höyük excavation team, once told about the reconstruction of these Neolithic houses and the use of adobe here as follows: "People today do not use adobe here. It is difficult to determine the different techniques of the material, its ingredients (ratios, branches) and density, the tools, the original production place, and transportation. It is also difficult to determine the inner and the outer plaster, the frequency of its reapplication, its ingredients, and its durability. And also the roof covering was difficult, and its materials (branches and wood), the opening (entrance), and the ladder. Overall, it is difficult if these structures required a pre-design. Mentioned Aşıklı Höyük Experimental Project is the reconstruction part of the protection and exhibition process ongoing since 2009. As of 2014, three adobe buildings from 9000 BC and ten adobe buildings and an adjacent street (displaying the urban pattern) from 8000 BC were reconstructed, all in correct plan, orientation, and scale with the original ones [16]. Thanks to micromorphology analysis results, we now know that animal dung was used along with the botanic material inside the adobe [17]. Here, during the reconstructions, 15 different adobe types were designed and used on walls to measure their climate responses (Fig.2). Mould, wet, and hand-shaped methods were used in adobe production since the adobe was used in different techniques from the earliest periods of the Aşıklı Höyük. New constructed typical one-room Aşıklı Residence is the true copy of its predecessor in terms of type and scale [18].

Figure 2. Aşıklı houses built by experimental archeology at Aşıklı Höyük [19]

3. EXPERIMENTAL ARCHAEOLOGY SAMPLE FROM KÜLTEPE

Kültepe-Kanesh Ruins, in the modern-day Kocasinan district of the Kayseri province, are the center of the Kanesh Kingdom and the capital of the Assyrian Trade Colonies in Anatolia. Assyrian merchants who came to Anatolia in the middle 2nd millennium BC, built almost 40 trade colonies in central and southeastern Anatolia (named "karum" and "wabartum" in cuneiform tablets) with permission of the Anatolian city-kings. Their period lasted 250 years. In terms of management, all "karum"s were connected to Kanesh, and Kanesh was to Assur. We learn the most important knowledge of this period from the clay tablets discovered during Kültepe Kanesh excavations [20]. Kültepe is of two parts: the "hill" or "mound" (old name "Kanesh") and the "Lower City" (old name "Karum") placed around the hill (Fig.3).

The first systematic excavations in Kültepe were started by Prof. Dr. Tahsin Özgüç from the Turkish Historical Society in 1948. Recently, Prof. Dr. Fikri Kluakoğlu from Ankara University operates the studies. Until today, a total of 23500 tablets were discovered and these were the oldest written documents of Anatolia. Their context were laws, interpersonal relationships, and international relationships [21].

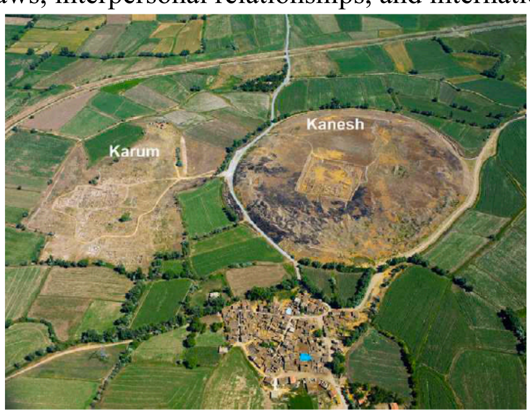

Figure 3. Aerial view of Kanesh and Karum [22]

There are adjacent houses on both sides of a street in Lower city ruins. Larsen tells the city pattern and the residences as follows: "Some streets are paved with large stones, and under some of these stones there are sewer canals. You can roam around these streets and through the gate openings you can see the left rooms filled with big earthen utensils, kilns, firepits, and carefully painted ceramics. Homes face each other and from the streets, only the door openings are visible. Most residences had an upper floor of living rooms and bedrooms. On the entrance floor, there were firepits and kilns and one or two small rooms of archives. These archives were full of clay tablets. Archaeologists usually were surprised that these were very detailed in terms of the daily life of the family. They discovered 2000 of them." [23]. One of these residences belongs to the Shalim-Ashur's family, who was an important merchant according to the 1200 files found here [24]. Many houses were belonging to the Assyrian and local merchants.

In the excavated parts of the city, especially for the residences, the main construction material was adobe. Since adobe deforms easily in time, architectural details are challenging to be figured out. Kültepe excavations show that there were different techniques and measurements within the adobe method. For example, wooden beams were placed within the adobe walls. Another sample shows wooden posts on one side or both sides of the adobe wall built on the stone floor [25](Fig.4).

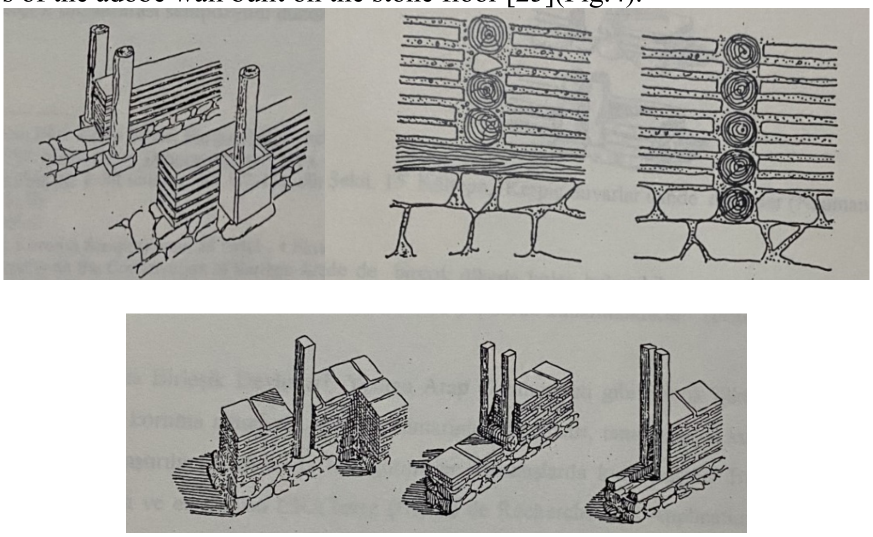

Figure 4. Details given by Rudolf Nauman for Kültepe Kanesh [25]

Kültepe joined the list of archaeological sites using the experimental archaeology method for reputation and tourist attraction. So, the excavation president led the preparations for the "Neighborhood of Assyrian Merchants" project. The site excavated by Prof. Dr. Tahsin Özgüç in 1948-1958 was chosen for the project. The area was once rented, excavated, documented, given back to its owner, and later expropriated. Architect Mahmut Akok prepared restitutions for the site, which became very useful during the project phase. Also, the diary of Akok, which was in Ottoman Turkish is preserved in the excavation archive (Fig.5).

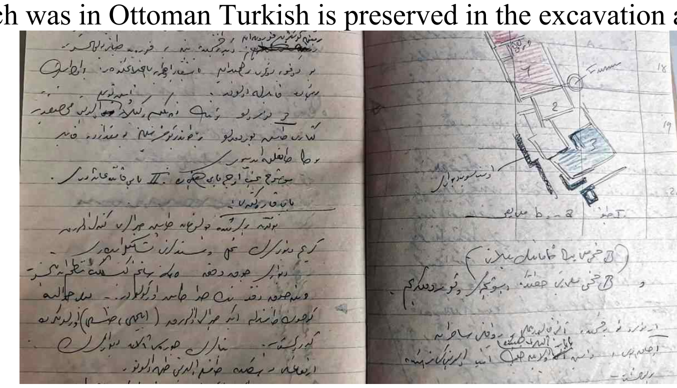

Figure 5. Mahmut Akok's diary found in Kültepe Excavation Archive [26]

These restitutions of Akok are significant. They display adobe and wood details and usage instructions.

For the "Neighborhood of Assyrian Merchants", which was considered in the context of experimental archaeology, the original Kültepe construction materials of adobe and wood were used, as done the Aşıklı Höyük reconstructions [27] (Fig.6).

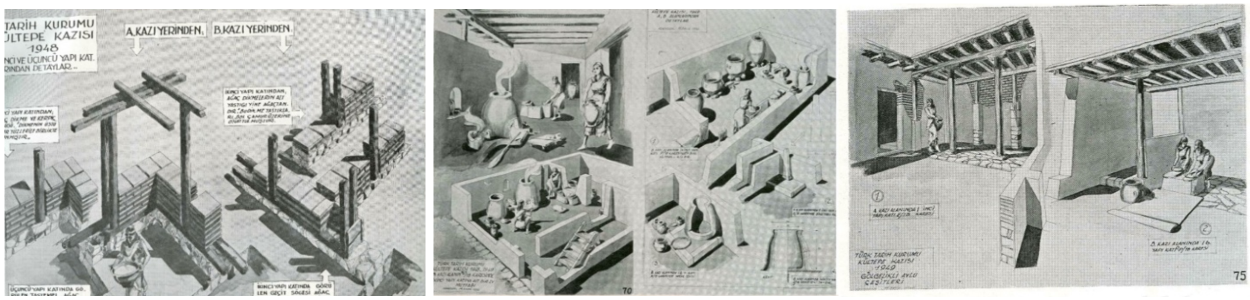

Figure.6. Mahmut Akok's restitutions on Kültepe[27]

The project was designed by the architect Hakan Şahan, with the advice of the excavation president Prof. Dr. Fikri Kulakoğlu. The project began in 2022. The adobe blocks used for wall construction are in 30x40x8 cm measurements. 30x40x8 (or 10) cm bricks were used in running bond patterns on the supports. For each 1,5 or 2-meter, one or two wooden posts are used as supports (Fig.27). Residence floors are of earth and workshop floors are of stone [28]. Using both architect Akok's drawings and techniques from the surrounding village residences, the project, which started in 2022, is now close to the final. Similar to Hattusa city walls and Aşıklı Höyük residences, the Kültepe-Kanesh "Neighborhood of Assyrian Merchants" experimental archaeology project is also placed close to the ruins entrance.

Figure 7. Views from the construction phase of the Neighborhood of Assyrian Merchants Project [29]

4. ACKNOWLEDGEMENTS

Finally, the "experimental archaeology" project is one of the best methods for displaying the lifestyle and the structures of the era. And it is widely preferred in the world and Turkey. In Turkey, after the Aşıklı Höyük, reconstructions of the structures were also used in the Kültepe-Kanish Ruins. Thanks to the knowledge from the excavations (since 1948), drawn restitutions and restorations, and other methods of archaeology, both Kültepe-Kanesh merchant residences and their material, details, and different function rooms are now easily perceivable for visitors. Projects of this kind will also help to promote adobe as a healthy and trustable construction material for modern-day usage.

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Paper Number: 16

Adaptable Reuse and Restoratıon of Florya, Senlikkoy Old Church – Mosque

Fatma Sedes
Istanbul Aydin University
fatmasedes@aydin.edu.tr

ABSTRACT

The church, at Şenlikköy, (a small Rum village in the 1800's), was built in the 1900's.The decrease of the Anatolian Rum population in years and even the extinction due to migration,the church was converted into a mosque as Muslim families settled in the village. In the oral history interviews with the elders and the headman (muhtar) of Şenlikköy, it was used as a mosque.It was learned that a timber minaret was added to the structure , but any visual material could not be obtained about it.

Due to the decrease or even disappearance of the Christian community, minarets were added to some churches. Such Greek, Rum and Armenian churches in Anatolia and some districts of Istanbul were converted into a mosque (Fig.1,2,3,4). It is mostly seen similar examples in Fatih District, İstanbul. Imrahor Mosque is the most well-known example of the basilica church type in Turkey (Church of Yoharines Studios).Over time Basilicas in Anatolia, a development has occurred that will affect the form.The best-known examples in Istanbul can be listed as follows:

- Acem Ağa Masjid (1484) (Chelkopratia Church) (5th century)
- Atik Mustafa Pasha Mosque (16th century) (St. Peter's Church) (11th century)
- Kefeli Masjid (1935) (St.Nikolaus Church) (16th century)
- Monastery Masjid (15th century) (Monastery Church) (11th century)
- Sekbanbaşı Masjid (15th century) (Name not known) (?)
- Sinan Pasha Masjid (16th century) (Red Church) (14th century)

The political and religious aspects of the conversion of small-scale churches into mosques are not discussed in this report, it is not the subject.
A new function as a library and cultural center is aimed to be given this historic building as mentioned (FLORYA, SENLIKKOY OLD CHURCH MOSQUE) with a revitalization project.

Keywords: The church in Şenlikköy, revitalization project, new use, adaptable reuse, Florya, restoration.

1. INTRODUCTION

It was built on a plot of **688.48 square meters** located on Area 80, Block 285, Plot 9 in Florya District, Şenlikköy, Bakırköy,Istanbul.By the decision of Istanbul Cultural and Natural Assets Conservation Board **No. 7**, it was registered as an immovable cultural property to be protected by the decision dated 2008 and numbered 811.It was determined as the **1'st** group as the protection group with the decision of the same board (Fig.5,6). Analytical survey, the restitution proposal and the restoration project of the historic asset was approved,in question by Bakırköy Mufti.Since eight years have passed since the approval date of the restoration project, the Board's opinion was requested on whether it should be revised and updated for the implementation of the project. Istanbul No. 1 Cultural Heritage Preservation Regional Board has decided that the approved project can be implemented (Fig.7,8,9,10,13).

2. HISTORY ABOUT THE SURROUNDINGS OF THE ŞENLİKKÖY CHURCH/ MOSQUE

At the end of the Ottoman-Russian war (1877-1878), the Russians wanted to erect a victory monument in Yeşilköy, which was the most advanced point they had reached towards Istanbul, in memory of this event. For this reason, the construction of the monument caused long conflicts and discussions between the two states, and then a compromise was reached. Thereupon, the Russian government took action, bought a part of the land belonging to Barutçubaşılar in Şenlikköy (formerly Kalkiratya) near Florya, around today's Yeşilköy, and immediately started construction preparations. The monument was designed and built by the Russian architect Bozarov, within the framework of the principles set by Colonel Pechkov, the military attaché of Russia in Istanbul. The Ayastefanos (Yeşilköy) Russian Monument was designed as a structure with three symmetrically schematic platforms on a square plan and completed with an onion-domed pyramidal tower on the last platform, supported by columns. On the second platform, which is reached by stairs rising from both sides of the entrance, there was another section with a semicircular arch and metal decoration in the middle. The first part of these platforms was a massive and Romanesque-Byzantine mix, even a fortress-like military-looking design. The upper part, carried by the columns and separated from the bottom, had a distinctive neo-Slavic character. This section, which also functions as a bell tower, was built with a bright green material.At that time there was an orthodox community in Florya ,Galateria-Kalkiratya (now named Şenlikköy). This congregation built a small church for themselves. They built a rectangular basilical masonry church. The tile roof of Marseille probably belongs to the years it was first built. The apse niche is in the south direction. After the church was converted into a mosque, an artificial mihrab niche was created, but this mihrab disappeared over time. At the same time, the wooden minaret built by the Muslim community was destroyed and disappeared. The women's mahfili, which is thought to have been built in the 1930s, was a wooden structure. Today it is in ruins. The trees in the garden are in a neglected condition. They are all covered with weeds. The front façade is covered with ivy, which will erode and damage the stones and joints of the historical building (Fig7,8). However, with the finalization of the Ottoman state's siding with the Central Powers, the demolition of the Ayastefanos Russian Monument came to the fore. The monument was dynamited and blown up by Lieutenant Bahri Doğanay in front of a large crowd on 14 November 1914, thirteen days after the official declaration of war. The Christian community continued to live in Florya until 1925.

3. ADAPTABLE REUSE and RESTORATION

Adaptive reuse of heritage buildings is a way to preserve and protect the historical and cultural value of old structures while giving them new functions and uses. It can be a sustainable and creative way to revitalize urban areas and enhance their identity and diversity.In the continuity of time, the change seen in societies changing their needs, shaped according to the time and context they belong to.It changes the spaces and therefore the structures. In the continuity of time, the change seen in societies changing their needs, shaped according to the time and context they belong to.It changes the spaces and therefore the structures. As a result of the above-mentioned change, the structural life of buildings reasons for the completion of their functional life before they are completed can be grouped as follows;

- **Loss of Original Function of Buildings**
- Functional Aging of Buildings
- Impact of Urban Environment and Zoning Legislation Changes
- Economic Reasons
- Other Reasons

Today the continuous increase in the pace of development and change we live in, about our predictions, while causing us to expect more. As societies change, new needs new structures are produced in accordance with these needs. Even in structures shaped according to the needs program, with the speed of change,more complex after a while, or simpler with the contribution of technology spatial requirements arise. This situation makes the current affects the way of use, and as a result, all the building-related challenges the architectural and engineering disciplines. response to need structures that cannot function or maintain their original function until today, by demolishing them before completing their structural life and constructing a new structure in their place result is lost.structures that lose their original Building Reuse, existing building stock. Both in the world and in Turkey in terms of the evaluation of each time has been the subject of controversy. Functionally obsolete but structurally buildings that have not completed their life are not given due importance and new destroyed to fit the currents; sometimes they were first made tried to be brought back to their state and unfortunately most of the time left alone or left to rot.function, even if they lose their functions, preserves its properties, therefore it is suitable for reuse.

Especially with the economic and social developments at the end of the 19th century.together with changes in lifestyles and needs has arrived. With this change, many types of structures are no longer needed. These building types, which have lost their function, have not completed their structural life and appear as structures suitable for re-functioning.As a result of the post-Republican revolutions in our country, many Ottoman structure has completely lost its function. Palaces, defensive structures,many building types such as madrasas and inns are not used today.For example, Rumeli Fortress, which is a defensive structure, does not need this function.Today, recreation and open-air museum take place. Changes while continuing to function there are also building groups that are not used depending on the conditions. Buildings such as inns, baths, and caravanserais continue to function today.However, there have been some changes in needs. This changes to a dimension that cannot be eliminated by spatial and structural interventions.As a result of the construction, many bath structures have undergone functional changes.

On the other hand the new building requires an "energy intensive" effort, requires "labor intensive" work. It is a production process that requires intense energy and machine power. To build a new building, from infrastructure works to excavation works,from the structural system to finishing work and even pre-use cleaning.Petroleum fuel is used too much for the operation of the machines and there is a great need for such tools. Likewise, excavation…In the evaluation process, by giving a new function to an old structure, energy is saved.

4. TECHNICAL PROPOSE of RESTORATION PROCESS

Today, many historical buildings are protected and registered.Thus, the needs of such structures such as periodic maintenance and cleaning carried out by a central institution. The most realistic work to be done for such structures that have been forgotten and left to their fate.The solution is to reopen it for human use and thus the use of the building,to ensure their maintenance and cleaning.

Structures that do not interact with people are forgotten or they turn into a structure that is watched as "spectacular". As a result of this,through a number of tenders made by the central institution or to a temporary structure.They are maintained by the personnel providing service, which is a financial resource. By re-functioning such structures,regular maintenance by the operator as a result of being put into use .Continuation of the structural life of the building will be ensured, structure helps many more people connect with the past. It is necessary to carry out the healthy restoration process by adhering to national and international rules. Attention must be taken to the quality of the material to be used during the restoration of the historic building and their suitability with the building.The physical interventions to be mad,e below are summarized as a short specification:

The tiles to be used in the building are well-molded, well-cooked, uniform in color. The reddish surface is smooth and free of any cracks, burrs and holes. The cross-section will be void-free and homogeneous.

Laying the tile: The tiles must fit together exactly while being laid.

The piece of tiles will be cut properly according to their location and additionally small parts will not be used. Marseille type tiles are placed with galvanized wire in one row. It will be attached to the roof or under-tile board. Tiles to be used on an inclined surface It will be the same factory production. An additional lath under the tiles coming to the eaves ends should be placed. The ridge tiles are placed in their places to be completely filled with mortar. Tiles missing a part will be replaced with new onesa). Cleaning surfaces made of similar materials from oil, dust and dirt, washing extremely alkaline surfaces with 1% hydrochloric acid, removing alkalinity and should be washed with clean water. before application; wood, metal, plaster, plastic, bitumen

Scaffolds will be constructed in accordance with their projects (Fig .14,15,16,17,18,19,20).Before starting the masonry construction, the scaffolds must be seen and approved.

Scaffolding can be steel or wood. Scaffolding timbers will generally be in square cross section. In the round section of the props there is nothing wrong with it.

Roof; it is a system that covers the structures and protects them from external influences. influencing on higher in the special specification on the roofs that transport snow, wind, etc. to the building parts (Fig 22).

The project arrangement, provided that the wood stresses are not more than the following values will be. In the construction deemed necessary by the administration, under the loads that the scaffold will be exposed to,deformation of the structure under its own weight after the scaffold is taken.

Parts to be used in important scaffoldings such as trusses, trusses, beams, etc. cut according to the drawn full size pictures, with all the details in full It will be put in place after it is ready. These are aggregates formed by natural or artificial fragmentation of stones

Natural stones to be used in coating works are fine-cut construction stones.
1) The lower faces are roughly chiseled or hammered,
2) The lower faces are finely carved. The floor covering is done in two ways with chipped stones.
To be used as floor covering, in the special specification or project of the stones (Fig 14,15).

The thickness of the covering stones is maximum 20 cm. will be. The surface to be coated will be thoroughly cleaned and washed with plenty of water. this surface stones on it, 400 kg, with a dosed base mortar, the joints should be in accordance with the detail drawing and 1 cm. will be placed to pass. Skirting will not be made with this type of stone. The stones are in a way that their upper faces will not protrude from each other, in accordance with the project. Stone faces will be cleaned so that no mortar dishes and no dirt remain.

Natural stone, was used . Stones will be placed by ramming. During placement cracked, broken stones will be replaced. Frames to make the gaps even will be used. The joints of the stones to be laid continuously, 3 cm from the upper face.The stone pavement surface is flat and uniformly indented and protruding from each other. Recessed, corrugated and relief joints are made on the wall surfaces upon request. Joint surfaces 3-5 cm. will be scraped and cleaned to the depth and before starting the joint work. Before grouting, the gaps to be grouted will be wetted with a brush and the thin joint mortar should be filled with little water.

It will be filled in the gaps and compacted strongly and all mortar residues will be cleaned. When the mortar absorbs enough water and gains hardness, the direction of the stones (facade) 1 cm from the sharp corners of the stones. It will be well compressed by pulling along the joint with an iron suitable for the profile of the joint and this compaction work several times until the joint mortar cracks and hardens well.

The consistency to withstand light pressure to be gauged so that the surface becomes smooth. When they come, they will be polished with a metal trowel without leaving any traces.

Screed surface to protect from sun, rain and frost in open screed works should be covered with paper, straw, sand, sawdust and similar materials. In order to complete the screed set and to prevent cracking, it should be sufficient according to the season. It will be watered and kept moist for the required time.

In wide screed coatings, partitions will be made in accordance with the request or detail drawing. It does not damage any structure, facility or cause any interference between the public and workers.

Necessary safety and equipment will be taken to prevent an accident and the relevant relevant regulations will be followed. During the dismantling, the round trip will not be interrupted, the road or pavement head of that part will not be interrupted.

Signs, barriers and guards will be placed to show whether there is a passage or not, and these parts will also be placed. It will be illuminated at night. The useful material that comes out during the dismantling is properly stacked to the desired place by the administration, shall be submitted to the administration with a mutual report.

5. CONCLUSION

The voluntarily people of the Şenlikköy, who knew and saw, that the old church/ mosque was in a dilapidated and neglected condition, gathered signatures and wanted to raise a voice that the Mufti and the district governor's office were responsible for restoring this work. This restoration is required in accordance with the law on the protection of cultural assets (2863 law number). It is expected to be brought to a location where the children of the neighborhood can do sports, play games, set up libraries and open exhibitions in its garden during the summer months.

Because a new mosque was built ten meters away for the people of the environment. Besides there is no Christian population to go to the church in this area.

Therefore, it is necessary to save the historical building from demolition, to restore it under appropriate conditions, and give new life with its new function by putting the necessary equipment in the interior. As can be seen, the economy and good use of resources, while it is one of the advantages of the functionalization process,especially for developing countries like Türkiye, which cannot be wasted the effective use of the resource. The structure produced in our country every year

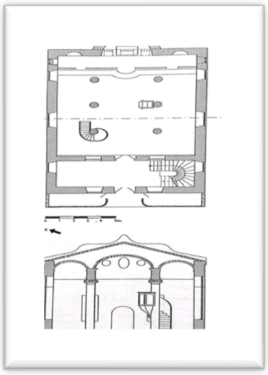
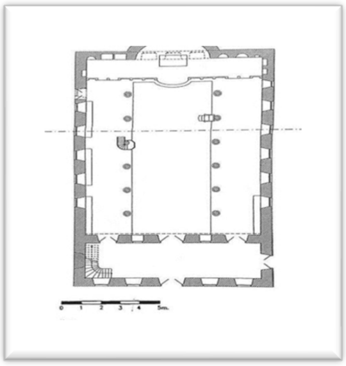
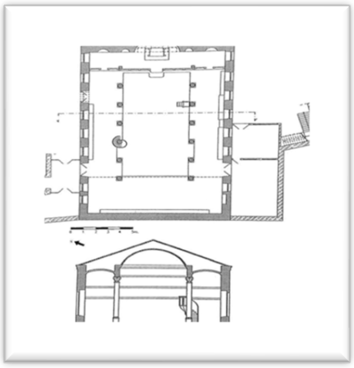
it is seen as a building production technique. Cultural continuity, without losing the identity and essence of the society, can be defined as changing by adapting to the requirements. Identity, qualities that distinguish or common an individual or society from others, a body of subjective values and relations, in other words, an identity or The identification of difference is a problem of belonging.

Culture is the "things left over from previous periods and passed on to new generations,defines it as "the reality of heritage". With this approach, cultural experience, social identity by transferring social values from generation to generation, presumably to ensure its continuity.

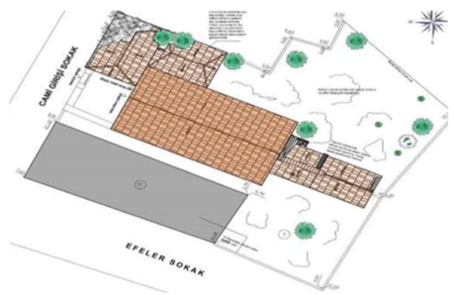
Places, which are a cultural identity identification element, are in memory. Objects that are shaped according to the stored information. Space, with its physical features, an arrangement that determines the boundaries of belonging and at the same time sociological three-dimensional, on which the values that make up the association system are coded.With this approach, architectural structures historical documents containing data about the period.

Experiencing the space means belonging to that culture rather than architectural knowledge.. Monuments are the spatial traces of shared experiences. its understanding and continuity depends on shared experience; physical in our memory. It is the objectification of environmental information. those stored on the monument.

The main values that make up the institutional structure of the society are the essences of identity.
PROJECT AUTHOR: Dr. Faculty Member Fatma SEDES (ITU-IAU)
FIGURES 1-24.

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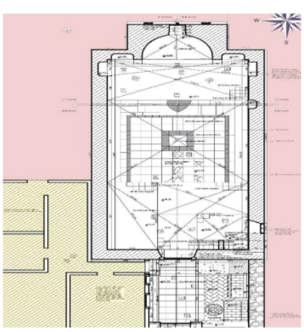

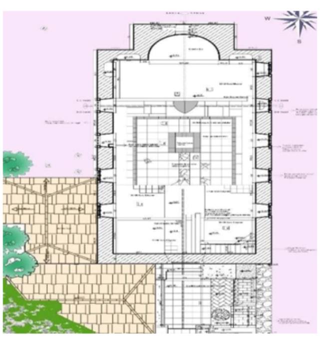

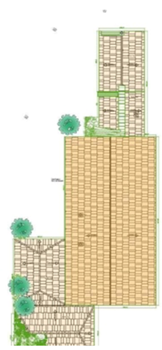

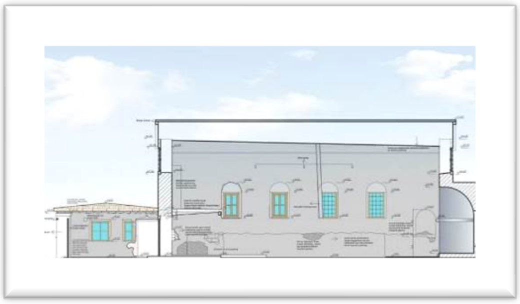
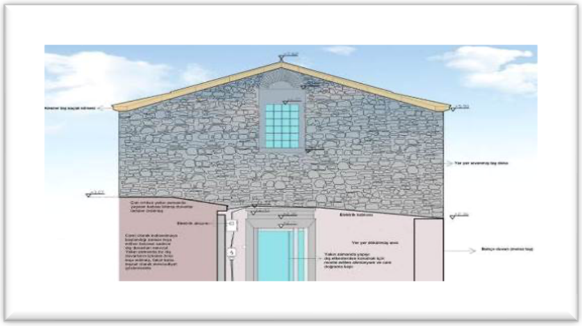

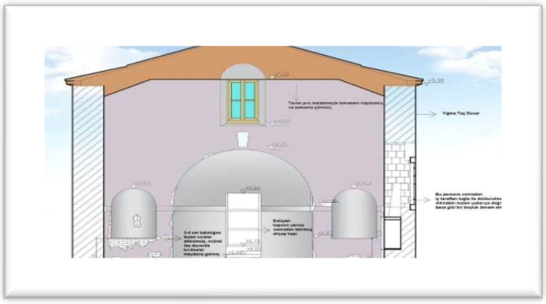
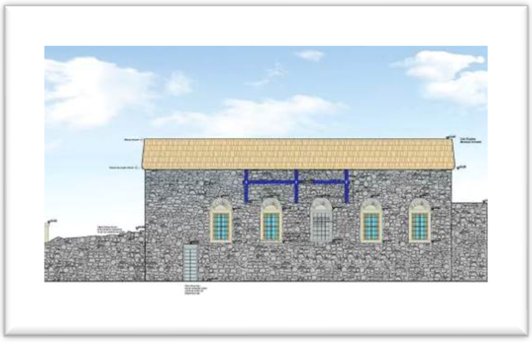
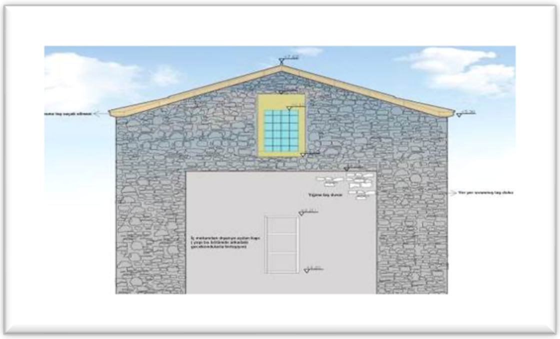
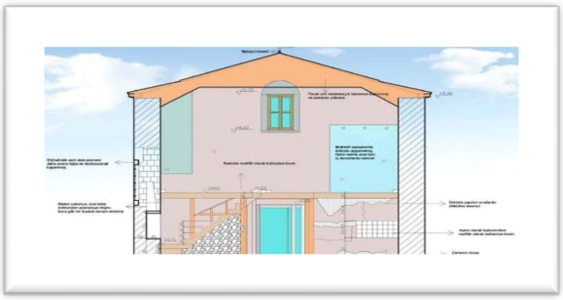
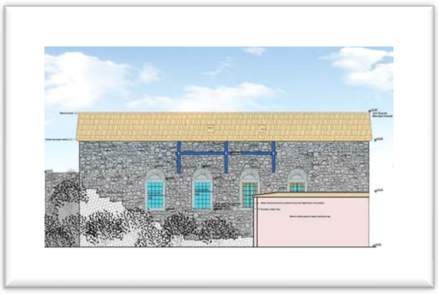

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Özgen, Ö., TC. Kültür ve Turizm Bakanlığı İstanbul Rölöve ve Anıtlar Müdürlüğü Horasan Harcı Üzerine Deneysel Çalışmalar TC. Kültür ve Turizm Bakanlığı İstanbul Rölöve ve Anıtlar Müdürlüğü Horasan Harcı Üzerine Deneysel Çalışmalar Uzmanlık Tezi

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Material Waste Management in the Construction Industry: Brick Waste



Gizem Can, Saniye Karaman Öztaş, Elçin Filiz Taş
Istanbul Medipol University
Gebze Technical University
İstanbul Technical University
gizem.can@medipol.edu.tr
saniyekaraman@gtu.edu.tr
tase@itu.edu.tr

ABSTRACT

Waste is a critical and worldwide problem that should be dealt with to manage the sources well. Construction wastes are the results of evitable and inevitable activities that do not create value, originate from different reasons such as stakeholders, building production processes, force majeure and occur in physical forms such as materials, labor, equipment or in non-physical forms such as cost, time, quality. Construction wastes have been known to generate large and diverse quantities of waste with 37.5% [1]. In many countries, material wastes, one of the physical wastes, generation increased by 342% in the last years [2]. Transparency Market Research [3], states that annual construction waste is expected to reach 2.2 billion tons globally by 2025. This amount is expected to generate 2.59 billion tons of construction material waste (CMW) annually by 2030 and to rise further to 3.40 billion tons by 2050. These statistics show the importance of CMW management in the construction industry to manage the sources for circular economy and sustainability. Material waste management encompasses collection, transporting, storage, treatment, recovery, and disposal of waste, and is defined as a comprehensive, integrated, and rational system approach towards achievement and maintenance of acceptable environmental quality and support of sustainable development. Well organized and implemented CMW management in the construction industry provides reduced demand for landfill spaces, improved resource management, productivity, and quality improvement as well as economic benefits. As a result of this, waste management in the construction industry needs a holistic perspective that should be cared both material and building life cycle. 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. EPA [2]'s report emphasizes that more than 75% of all construction waste from wood, drywall, asphalt shingles, bricks and clay tiles ends up in landfills. As a result of this, it is thought that material and building life cycle should be evaluated with a circular perspective in terms of zero-material waste idea.

Brick, one of most used material in the construction and demolition processes, is a natural material which has been used for many years and could be evaluated sustainable material in terms of zero-waste circular economy. In this study, clay brick is evaluated as a commonly used construction material from an environmental and waste perspectives. There are several common waste management scenarios such as reuse, recycling, and landfill for the brick life cycle as the common CMW management strategies. The typical process of clay brick production involves clay mining, transportation to the factory, clay preparation, manufacturing, drying, firing, and packaging. Construction, use, and end-of-life stages follow the brick production. Brickwork can be separated, cleaned, reused, or demolished, broken down to a smaller size, and used for a variety of purposes, such as foundation construction, hardcore for below slab support, etc. Even though the brick wastes are of great importance for the circular economy, Environmental Product Declarations (EPDs) usually lack waste data for the construction-installation information module (A5) in the construction process and waste processing module (C3) in the end-of-life process. Several EPDs include information in the reuse, recovery, and recycling potential module (D). In this context, this study will question the potential of brick waste by evaluating the waste scenarios reported in the brick EPDs and the research in the literature with the Life Cycle Assessment (LCA) approach. Resource efficiency, energy efficiency, and carbon emissions will be assessed by developing a waste management flow diagram. It is thought that the findings of this study will contribute to the identification of various waste-minimizing strategies and the development of waste management during the brick life cycle.

Keywords: Construction material waste, waste management, brick, circular economy, life cycle assessment

1. INTRODUCTION

Construction industry, evaluated as a locomotive industry for many countries, generally symbolizes the level of development of a country. Above of 200 sub-sectors present their goods and labor to the construction industry. It means that there is a huge production and collaboration for construction industry in terms of economic issues. As a result of playing a key role for economic growth, construction industry needs to be improved in terms of sustainability and managerial issues to control the building life cycle processes for circular economy which is a contemporary solution for today's world.

Linear economy model assumes that natural resources are available, abundant, easy to source and cheap to dispose which is not sustainable [4]. However, limited sources and climate problems have come up with the need of new solutions to manage the world and economies. Circular economy aims to manage all natural resources efficiently and, above all, sustainably, represents a fundamental alternative to the linear take-make-consume-dispose economic model that currently predominates [5]. The transition to a circular economy will be multifaceted and will need to involve many industries and their stakeholders. Therefore, the construction industry needs all stakeholders such as main contractors, sub-contractors, and suppliers' movement towards to this new economy model.

The circular economy minimizes the need for new inputs of virgin materials and energy, while reducing environmental pressures linked to resource extraction, emissions, and waste management as seen Figure 1 [5]. To support and promote circular economy, which focuses waste management, waste prevention and resource efficiency, in December 2015, the European Commission (EC) adopted the first "Circular Economy Action Plan (CEAP)" [6]. In this context, EC has developed sustainable built environment strategy, in the new circular economy action plan and in the new industrial strategy for Europe. Accordingly, EC published a second CEAP in March 2020 as part of the European Green Deal. This latest CEAP reveals that the construction industry requires vast amounts of resources and accounts for about 50% of all extracted material. According to [7]'s updated report, the construction industry is responsible for over 35% of the European Union (EU)'s total waste generation and Greenhouse Gas Emissions (GHGe) from material extraction, manufacturing of construction products, construction and renovation of buildings are estimated at 5–12% of total national GHGe. The EC's strategy aims increasing material efficiency and reducing climate impacts of the built environment, particularly promoting circularity principles throughout the life cycle of buildings [8]. This strategy also aims ensure coherence across different areas related, to illustrate, to climate, energy, management of construction and demolition waste, digitalization, or skills. The EC has also pointed out some imported topics such as the sustainability performance of construction products, possibly introducing recycled content requirements for certain construction products, framework for sustainable buildings, to integrate life cycle assessment in public procurement, waste legislation, focusing on material recovery targets for construction and demolition waste, and its material-specific waste streams [8].

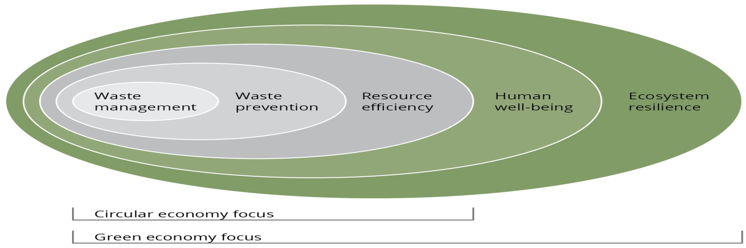

Figure 1. Circular Economy and Green Economy [5].

The green building certificate systems also care the importance of waste management in the construction industry. Leadership in Energy and Environmental Design (LEED), requests 13 credits from materials and resources category for new constructions in scope of LEED v4.1 for BD+C [9]. This category requires storage and collection of recyclables, building life cycle impact reduction, building product declarations, sourcing of raw materials, material ingredients, construction, and demolition waste management. Building Research Establishment Environmental Assessment Method (BREEAM), also requests some assessments for CMW in the latest version 6.0 (INC V6) [10]. While the materials category contains environmental impacts from construction products-LCA, Environmental impacts from construction products-EPD, responsible sourcing of construction products, designing for durability and resilience, material efficiency the waste category contains construction waste management plan, use of recycled and sustainably sourced aggregates, operational waste, speculative finishes, adaptation to climate change, design for disassembly and adaptability. It is obviously seemed that the awareness of waste management in terms of resources and circular economy is crucial step for all over the world. Because of having an important role in the economy and despite this generating large and diverse quantities of waste, the construction industry has become one of the focused industries in the world in terms of circular economy. So, to contribute to sustainable world, the construction industry needs to analyze the sustainable materials, and manage the implementation processes and whole production processes of materials, from cradle to grave, in terms of sustainability. This paper aims to conduct the CMW and CMW management that focuses on natural materials with a brick case. This study will reveal the current CMW situation and question the potential of brick waste by evaluating the waste scenarios reported in the brick EPDs and the research in the literature with the Life Cycle Assessment (LCA) approach.

2. CMW AND CMW MANAGEMENT

Construction wastes have been known to generate large and diverse quantities of waste with 37.5% [1]. CMWs, which is one of the types of physical wastes, are mostly occurred during construction and demolition (C&D) sites of building and civil engineering structures [11]. According to BigRentz's Research [12], C&D material wastes such as concrete, asphalt, brick, wood, and other building wastes are estimated to be nearly one-quarter of national waste stream, which is the total material waste generated in the United States in one year. The research emphasizes that CMW generation is on the rise, and it is expected to skyrocket soon. In just United States, C&D waste generation increased by 342% from 1990 to 2018 and between 2005-2018, C&D waste generation levels grew more than 10 times faster than from 1990 to 2005 [2]. The United Kingdom generated 67.8 million tons of C&D material waste in 2018. In 2018, the Netherlands produced 25.12 million tons C&D material waste in 2018. Similarly, Germany generated 218.8 million tons material wastes in 2018 and this amount reached to 230.85 million tons in 2019. On the other hand, European Union are responsible for generating 850 million tons of C&D waste per year [13]. Furthermore, Transparency Market Research [3] states that annual construction waste is expected to reach 2.2 billion tons globally by 2025. This amount is expected to generate 2.59 billion tons of material waste annually by 2030 and to rise further to 3.40 billion tons by 2050 [13]. Concrete and metals, relatively cost-effective to recycle, and brick, clay, gypsum boards, much less reusable, are the basic material wastes which ends up in landfills in plenty of quantities [12]. EPA's report [2] emphasizes that more than 75% of all construction waste from wood, drywall, asphalt shingles, bricks and clay tiles end up in landfills. In the Nigerian construction industry, material waste types are determined with their percentage composition as concrete (16.5%), wood (14.5%), reinforcement (12.1%), asbestos (10.5%), glass (9.4%), asphalt (7.3%), tile ceramics (6.1%), soil and stone (5.4%), plastic and packaging (5.2%), rubbles (4.4%), drywall (3.7%) and bitumen (2.8%) [14]. Similarly, in the Malaysian construction industry, the material wastes and ratio are as soil and aggregates, sand (44.3%), wood (12%), ceiling insulation materials (9.3%), concrete (7.2%), bricks (6.2%), tiles and ceramics (5.8%), lime (5.5%), cement (3.3%), metal (2.8%), glass (2.3%), gypsum board (1.2%) [15]. Although material wastes are generally generated during the construction and post construction processes of building life cycle named as construction and demolition wastes, it should be considered that building life cycle contains many stakeholders such as project team, main and sub-contractors, and suppliers. Because managing the material waste is not only relevant generation processes of waste but also relevant other related processes such as pre-construction and stakeholder processes like suppliers. For instance, in the pre-construction process, if designs are prepared according to the needs of the owner and the end user regarding the contribution of the circular economy and environmental sustainability, it effects the C&D wastes directly. On the other hand, improving point of view to the waste management of not only main contractors but also suppliers and sub-contractors could affect all the building life cycle process's contribution to the circular economy.

The management of material waste is becoming more important with the necessity of effective use of limited resources in the world. Implementation of construction waste management can be one of the apparent solutions for the industry to minimize waste and waste disposal, ultimately reducing costs incurred during the process and contributing to the global "environmental-friendly" movement [16]. In recent years, because of limited resources and large volume of material waste production such as woods, steel, glass, brick companies in many countries, which one of them Türkiye have started to explore new waste management strategies to manage construction wastes to contribute circular economy and environment. As a result of this managing the material wastes is becoming vital requirement for sustainability.

3. CMW IN BRICK SAMPLE

Clay-based brick is one of the most widely used materials with low embodied energy. The typical process of brick production involves clay mining, raw material storage, transportation to the factory, size reduction, screening, forming, cutting, coating, glazing, drying, firing, cooling, storage, and packaging. Construction, use, and end-of-life stages follow the brick production. Brickwork can generate a large amount of waste each year [17]. A significant initiative of the brick companies of Brickworks Building Products is to return all production waste to the clay mix in Australia. The new Austral Bricks plant has remarkably reduced the instance of malformed or off-specification of unfired bricks. The lost bricks are automatically recycled into the mix rather than going to a landfill [18]. A model called brick- LoWMoR (Low of Waste, More of Resources) is developed to reduce waste brick (WB) from manufacturing to end-of-life stages. The production of half bricks that is necessary for some parts of the buildings [19] and the application of lean and parallel-line manufacturing [20] are the strategies proposed in the model.

Correct estimation of the needed bricks in the construction stage can save a significant quantity of unwanted materials that might have otherwise been landfilled. More flexible last-pack sizes can minimize waste because of over-ordering [19]. The main source of waste brick comes from inaccurate brick cutting, which is primarily done by chopping at bricks with a trowel at the site [21]. Proper storage of bricks at the site can also reduce WB during construction activities. If the construction site has enough space, bricks arriving at the site can be adequately stored away from the main traffic flow onsite [22]. In the end-of-life stages, reusing old bricks is also effective in reducing WB. REBRICK-process has been developed in Denmark to reuse old bricks that are cleaned by vibrational technology, manually sorted, and stabled by a robot [23]. There are several common waste management scenarios, such as reuse, recycling, and landfill for brick as the common CMW management strategies. Brick waste almost always comes in a mix with other C&D waste. Brick waste can be processed and further used in the construction industry (recycling) or in other industries (upcycling). Replacement of natural aggregate is the most often used method for recycling of WB in Europe. The processed WB is frequently used in road construction as a fine or coarse aggregate [24]. WB aggregates also were used for preparing of recycled concrete [25] and lightweight concrete [26].

Table 1. Product description of seven brick EPDs

product	product applications	contents	data sources
generic brick [29]	cavity walls, outside face of the wall, free standing walls, and civil engineering structures	clay 86%, sand 12%, other additives and pigments 2%	production process data is based on around 70% of UK brick production
clay brick [30]	cavity walls, outside face of the wall, free standing walls, and civil engineering structures	clay and shales 92 %, sand 6%, other additives and pigments 2%	sector UK average production process and is based on data representative of 99% brick production by BDA member companies.
facing bricks, clay pavers and brick slips [31]	facing bricks for double wall const in exterior areas, clay pavers for paving in road const and interior floorings, brick slips for exterior and interior cladding on wall const.	clay/loam around 85%, and sand around 8%, other additives and pigments	production process data is based on approx. 95% of the German market.
grey brick [32]	build walls, pillars, and partitions	grey-firing clay 70,1%, yellow-firing clay 12,7%, red-firing clay 4,8%, sand 3,6 %, water 7,5% additives and pigments	one production site in Denmark
red bricks [33]	build walls, pillars, and partitions	red clay 87%, sand 9%, water, other additives, and pigments 2%	one production site in Denmark
red clay brick [34]	facade and frame construction and for chimneys and fireplaces.	clay 79%, sand 19,9, sawdust 1,1%	production sites in two cities in Finland
hand-made brick [35]	wedge bricks, facing bricks, build walls, floor tiles	clay >90%, minor additives <1%	one production site in Türkiye

There is a lack of data on the waste properties and cycles during the brick life cycle, even though brickwork can generate a large amount of waste. Therefore, this study questioned the potential of brick waste by evaluating the waste scenarios reported in the brick EPDs. Type III EPDs provide quantified environmental data on the life cycle of a product using predetermined parameters, allows comparisons between products fulfilling the same function [27]. EPDs are expressed in information modules which allow easy organization and expression of data packages throughout the life cycle of the product. The product stage includes A1 (extraction and processing of raw materials), A2 (transport to the production site), A3 (manufacturing processes) modules. Construction process stage includes A4 (transport to the building site) and A5 (installation into the building) modules. Use stage includes B1 (use or application of the installed product), B2 (maintenance), B3 (repair), B4 (replacement), B5 (refurbishment), B6 (operational energy use) and B7 (operational water use) modules. End-of-life stage includes C1 (de-construction, demolition), C2 (transport to waste processing), C3 (waste processing for reuse, recovery and/or recycling) and C4 (disposal) modules. D module comprises reuse, recovery and/or recycling potential [28]. In this study, seven brick EPDs that geographical scopes are the UK, Germany, Denmark, Finland, and Türkiye were examined particularly according to waste scenarios in production, construction, and end-of-life processes. These EPDs are developed according to product category rules of construction products in EN 15804, ISO 14025 / ISO 21930. These bricks are used as build walls, pillars, partitions, facing bricks, wedge bricks, clay pavers, and brick slips and contains clay, sand, additives, and pigments (Table 1). Two scenarios were assumed for the facing bricks, clay pavers, and brick slips in Germany. Scenario 1 refers to material utilization as aggregate in the construction industry (C3), and scenario 2 outlines disposal at a building rubble landfill(C4). Sorted bricks from de-constructed sites can be taken back by brick manufacturers and recycled in ground form as shortening material in production. It is indicated that the possibilities of further use involve as aggregate for crushed brick concrete, as filling or bulk material in road construction and civil engineering, as substrate in garden design and landscape gardening, as material for refilling mines and quarries, when building sound barriers and as tennis powder and tennis sand.

Table 2. LCA information and waste scenarios of brick EPDs

	program operator	functional unit	system boundary	production	construction	end of life	re-use/recovery/recycling
generic brick	Bre	1 ton	A1-5, C 4, D	-	-	waste for re-use 400 kg, waste for recycling 500 kg, waste for final disposal 100 kg	crushed brick is re-used as a replacement for virgin aggregate in roadwork or used as a replacement for normal weight coarse aggregate in the manufacture of concrete blockwork.
clay brick	Bre	1 ton	A1-5, C2-4 and D	-	installation wastage to reuse brick; 5%	crushed brick leaving system as recycled aggregate: 900 kg, crushed brick going to landfill: 100 kg	recycled secondary aggregate can in turn replace 900 kg of virgin aggregate.
facing bricks, clay pavers and brick slips	IBU	1 ton	A1-5, C1-4, D	approx. one-third of brick residue can be ground and re-used.	-	material utilization as aggregate in the construction industry (C3), disposal at a building rubble landfill (C4).	aggregate for crushed brick concrete, filling or bulk material in road construction and civil engineering, substrate in garden design and landscape gardening, material for refilling mines and quarries, tennis powder and tennis sand.
grey brick	EPD Denmark	1 ton	A1-5, C2-4, D	-	the waste bricks are landfilled30 kg (3%)	1 % of bricks landfilled. collected separately: 970 kg	for recycling: 960,3 kg, for landfilling: 9,7 kg (substitution of gravel from the recycling of crushed bricks.)
red bricks	EPD Denmark	1 ton	A1-5, C2-4, D	-	waste bricks are landfilled30 kg (3%)	1 % of bricks landfilled. collected separately: 970	for recycling: 960,3 kg, for landfilling: 9,7 kg all the clay material will substitute clay used for clay bricks production. The rest mitigates gravel in road construction.
red clay brick	The Building Information Foundation RTS	1 ton	A1-5, C2-4, D	-	-	collected separately 580 kg, collected with mixed waste 420 kg, kg for recycling 580 kg, disposal 420 kg	crushed bricks can be used as sand and gravel, also be used in brick manufacturing as a secondary raw material.
handmade brick	The international EPD system	1 sqm	A1-4, C2-4, D	-	waste bricks are landfilled.	95% of crushed bricks are reused, the remaining 5% of the waste bricks are sent to landfill.	per functional unit, 119.7 kg of crushed bricks are used as infill at the construction site.

In Finland, it's assumed that 58% of all waste bricks will be recycled and the rest are sent to the landfill. Collected separately brick wastes (580kg) are recycled, while collected with mixed waste (420kg) are disposed. It is indicated that crushed bricks can be used as sand and gravel in, for example, road constructions. Crushed bricks can also be used in brick manufacturing as a secondary raw material. For handmade brick, it is assumed that bricks are crushed on site and 95% are reused on the site as infill and the rest is sent to a landfill. The remaining 5% of the waste bricks are sent to landfill in Türkiye. Per functional unit, 119.7kg of crushed bricks is used as an infill at the construction site (Table 2).

4. CONCLUSION

Effective material waste management provides cost saving, reduced demand for landfill, improved resource management, profit and quality maximisation. As a result of the today's limited resources and sustainable development, it is believed that waste management in the construction industry should has needed priority. Waste management closely associate with almost whole project life cycle considering material life cycle, too. In this study, it is emphasised the importance of CMW management in terms of life cycle of brick as a sample.

The reuse of brick production waste in the production mix is not considered in any brick EPDs. On the other hand, production wastes are recycled into the process by some brick manufacturers in Australia. Although the amount of waste is small (approx. 5%) for a declared unit, it can contribute significantly to resource efficiency in large amounts of production. In this context, it is significant to include brick waste at different rates as raw material by crushing and to evaluate resource efficiency and the properties of the final product with experimental and field studies. Installation brick wastes (3-5%) were landfilled for all EPDs. Brick wastes incurred on the building site should be collected separately. Sorted brick residue can be taken back by the manufacturers and used as a raw material or otherwise. For end-of-life stages, the EPDs show that wastes between 500- 960 kg are recycled for one ton brick. Crushed bricks are reused in roadwork, used as a replacement for typical weight coarse aggregate in the manufacture of concrete block work, used as substrate in garden design and landscape gardening, used as material for refilling mines and quarries. The recycled bricks avoid use of primary materials. These waste scenarios include WB that are collected separately. At the end of building life, bricks are obtained together with other material mixtures. Therefore, methods should be developed for the separation and processing of brick wastes and should be considered within the scope of waste management and circular economy. This paper can be a vital paper to start the manage CMWs with the natural materials like brick in terms of analyzing the steps of material production process as emphasised by green building certificate systems regarding circular economy issues.

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Paper Number: 18

The Earthen Architecture Example In Nature Conservation Area: Sindelhöyük

Akgül Zor, Nimet Gönenç Çınaroğlu
Kayseri Municipality
azor@kayseri.bel.tr
nimet85.cinaroglu@gmail.com

ABSTRACT

This study focuses on the Sindelhöyük Neighborhood, situated in the Develi district of Kayseri province, Turkey, which encompasses a collection of structures that have survived over time and were constructed employing the earliest known earthen construction technique.

Sindelhöyük is situated on the outskirts of Sultan Marshes, a significant natural site known as both a national park and a Ramsar area. This area is a crucial habitat for Anatolian wildlife, especially birds, and is home to numerous endemic plant species. The local community relies on these resources for sustenance. The unique construction method used in the settlement's buildings involves load-bearing walls made of clamped blocks, adorned with clay resin. The roofs are covered with straw and soil, reminiscent of ancient carpet structures.

Additionally, the use of peat in the region involves a rare method of cutting and drying pebble soil, which distinguishes it from more commonly known construction techniques. This distinctive approach underscores the importance of preserving this knowledge and communicating it to future generations, especially considering the protective environment in which it operates.

The earthen structures found in the tombs are examples of rural cultural heritage and were built by the local community. Our documentation work involved a blend of written research and oral and visual information obtained directly from the local people, who possess invaluable knowledge of this architectural tradition. Through this approach, we strive to both embrace and transmit our cultural heritage to future generations.

Keywords: Earthen Architecture, Sindelhöyük, Sultan Marshes, Vernacular Construction, Traditional Adobe.

1. INTRODUCTION

Earthen, an ancient building material, has been extensively utilized in Middle Anatolia and has evolved to meet the evolving needs for shelter (Figure 1). Presently, earthen persist as a traditional construction material in rural regions of Anatolia.

Our research focuses on the Sindelhöyük district, specifically Çarıklı and Devetepesi village, situated in Kayseri's Develi district. These traditional structures, still in use and constructed with the oldest known earthen technology, exemplify the historical significance of the region. The buildings within the settlements are constructed using the stacking technique, where walls are formed by the arrangement of compressed blocks, making them exceptionally rare examples within the context of Kayseri.

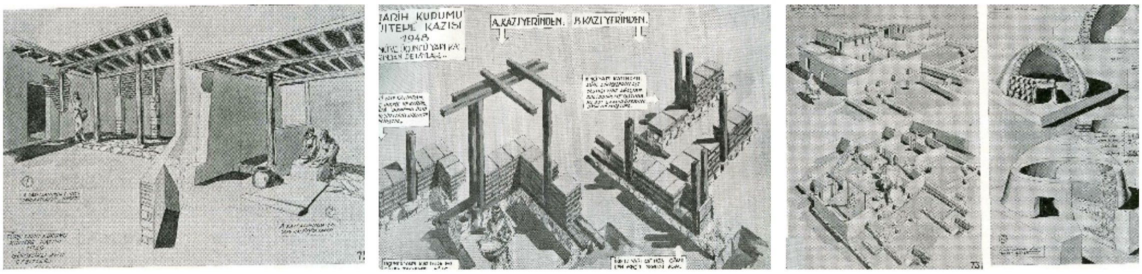

Figure 1. Earthen building drawings of Kültepe (Kaniş-Karum). (M. Akok)

Sindelhöyük is a town in Develi Plain that is along the shore of the Sultan Marshes (Figure 2). A marshland is generally a wetland area characterized by marshes, ponds, and small islands. It is a natural, protected area. Small settlements have formed on the local land inside the cities of Sindelhöyük, especially Çarıklı and Devetepesi. Notably, these villages are built with earthen structures created from the muddy soil of the pebble, which serve a variety of functions such as furnaces, pebble storage, barracks, garden walls and homes. Because the region is designated as a natural site, new building development is prohibited, necessitating the reuse of existing structures.

Figure 2. Sultan Marshes, 2022. (The Archive of Kayseri Metropolitan Municipality)

Sultan Marshes property, Kayseri Cultural and Natural Assets Protection Regional Council of 26.06.1993 date and Decision No.1493 were declared the I-degree natural site area. On January 2, 2008, the Ministry of Environment and Forestry of Mülga prepared a Long-term Development Plan for the Sultan Marshes National Park and the Ramsar Area. The area, which houses thousands of bird species on natural migratory routes, is also called "Bird Paradise." There are dozens of different kinds of plants and shrimp grown in Sultan Marshes (Figure 2) [1].

In the buildings where the earth is used as the main construction material in Sindelhöyük, the upper covering is created by gathering reeds from the marshes and covering them with soil. This feature represents the oldest known characteristic of earthen construction (Figure 3).

It has been determined that earthen structures in the area are gradually decreasing due to factors such as collapse, lack of renewal, inadequate maintenance, and the inability to produce materials. To preserve these structures, it is necessary to first understand them, learn how they were created, and find solutions to their problems to make them sustainable. The earthen construction technique practiced here should be included among the intangible cultural heritage of traditional crafts recognized by UNESCO. Additionally, for preserving and transmitting earthen structures, which have entirely forgotten their construction techniques and are also considered environmentally friendly materials, written and oral sources should be researched, information should be updated, and publications should be expanded.

Figure 3. Traditional earthen buildings in Sindelhöyük, 2023

2. EARTHEN BUILDING ARCHITECTURE AND CONSTRUCTION TECHNIQUES IN SİNDELHÖYÜK

Sindelhöyük is an old settlement located on the outskirts of Sultan Marshes, situated on the Develi Plain, approximately 55 km away from the city of Kayseri in Turkey. It is a small village with a population of around four thousand, belonging to the Develi district. Due to its location along migration routes, Sindelhöyük has been inhabited by various cultures throughout history.

Sultan Marshes, which is the main source of sustenance for Sindelhöyük, is an important ecosystem in Central Anatolia. It derived its name from the fact that during the Revan Campaign carried out by Sultan Murad IV in 1636, the Ottoman sultan stayed in this area [7].

Sultan Marshes National Park is one of the rare wetland areas in Anatolia that combines freshwater and saltwater ecosystems, located within the boundaries of Kayseri Province, between the districts of Yeşilhisar, Yahyalı, and Develi. Its location at the intersection of the bird migration route between Africa and Europe further enhances its natural significance. Due to hosting approximately 301 bird species, it is known as "Bird Paradise" or "Bird Heaven." With these unique features, Sultan Marshes was declared a "1st Degree Natural Site" by the Kayseri Cultural and Natural Heritage Conservation Board on June 26, 1993. In 1994, an area of 17,200 hectares was designated as a Ramsar site [9]. The term "Ramsar site" refers to an area protected under the Ramsar Convention. The Convention was initially signed in Ramsar, a city in Iran, in 1971, hence the name. The Ramsar Convention is officially known as the "Convention on Wetlands of International Importance, Especially as Waterfowl Habitat." In total, 1,911 wetland areas worldwide are included under the Ramsar Convention. Countries that are party to the Convention commit to preparing national inventories of wetlands, identifying wetlands that will be included in the list of internationally important wetlands, planning and implementing methods to protect and sustainably use these wetlands, and reporting any changes occurring in listed wetlands to the "International Union for Conservation of Nature." In 2006, the protection status of Sultan Marshes was further reinforced by being designated as a National Park Area, covering an area of 24,523 hectares, under the protection of National Parks Law No. 2873 [13].

Sultan Marshes serve as a habitat for diverse bird and animal species, as well as a nesting ground for numerous varieties of native plants. Among these plants, the most widely recognized and extensively utilized is the reed or bulrush, which also plays a significant role in local construction practices (Figure 4).

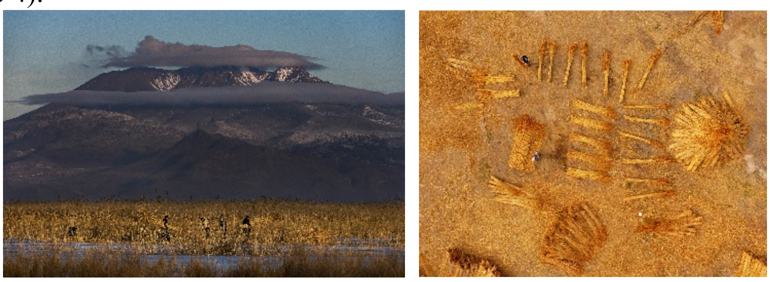

Figure 4. The harvesting of reeds and rushes in Sindelhöyük, 2023. (The Archive of Kayseri

Metropolitan Municipality)

Reed, also known as bulrush, is a construction material used for covering the walls of earthen structures, especially in rural areas of Central Anatolia and eastern regions of Turkey. Typically, wooden beams made from poplar trees are placed at regular intervals on the walls, and reeds are tightly woven between them, creating a layer of approximately 10 cm in thickness. Finally, a layer of soil is added on top of the accumulated reeds. The choice of reed in construction is due to its easy availability and suitability for local conditions.

Even in modern construction using different wall materials, there are still buildings today where reeds are used for roofing and flooring.

In Sindelhöyük, located on the eastern coast of Sultan Marshes, the trees, reeds, and marsh soil from the marshland were utilized as the primary building materials. There are two well-known construction techniques for earthen materials.

The first technique involves mixing suitable soil and additives with water, pouring the mixture into molds, and allowing it to dry in the sun. This method is the most commonly used (Figure 5).

The second technique involves mixing suitable soil and additives with water, pouring the mixture into molds that shape the walls of the structure, and compacting it to form earthen bricks (Figure 5).

Figure 5. Earthen Construction Techniques [11].

Earthen construction systems, using mud bricks as the main building material, are divided into three types: solid, lightweight, and mixed brick construction systems[12].

Solid brick construction systems involve stacking mud bricks on top of each other and bonding them together with a binder, without the use of an external load-bearing system. This is the oldest brick construction technique (Figure 6).

Lightweight brick construction systems are created by filling the voids between horizontally, vertically, and diagonally placed wooden elements in a structural framework with mud bricks.

Mixed brick construction systems combine both solid and lightweight techniques in their construction.

Figure 6. Different traditional earthen construction systems, 2023.

The places where earthen is used in construction include the main material for walls, roof covering, exterior and interior plaster, and mortar for bonding the walls.

The traditional earthen structures we examined at Sindelhöyük have some minor variations but share the following general features (Figure 7):

- They are single-story buildings.
- They have small, square windows.
- They are constructed using the cob construction system.
- The walls are built with earthen blocks.
- The roof is constructed using wooden beams covered with reeds, soil, and earth.
- The exterior walls and interior surfaces are plastered.
- They are built on a stone foundation.
- The flooring is made of compacted soil.

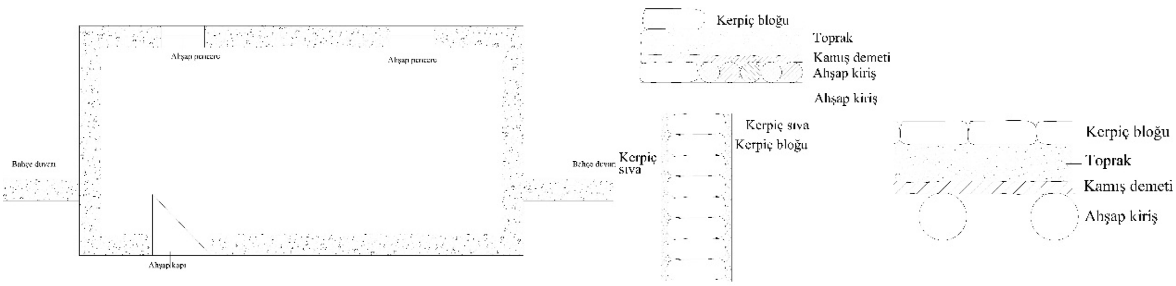

Figure 7. Vernacular earthen building plan, section, and detail drawing in Sindelhöyük, 2023.

However, the earth material used in these structures is a type of earth that is produced differently from the conventional method of cutting and drying clay soil manually. Therefore, the local community has described and documented how it is made through practical applications.

Figure 8. Use of vernacular earthen in Sindelhöyük, 2023

The earthen buildings we examined in the region were constructed using the cob construction system. The foundation of the structures is made of rubble stones bonded with earthen mortar, while the walls are constructed by stacking earthen blocks with earthen mortar. The window and door openings, bordered by thin wooden beams, are generally kept small. Wooden beams, often made of poplar, are laid across the walls at intervals to create the ceiling structure. These wooden beams are then covered with tightly packed reeds to form a roofing layer. To reinforce the roof's stability, it is covered with soil, mud, or earthen blocks over the reeds. The interior and exterior of the buildings are mostly plastered with earth plaster, and in some cases, lime plaster is also used. The doors and windows are made of wood, and the flooring is created by compacting the soil (Figure 8).

These buildings we examined are considered ecological structures. This is due to the fact that earthen, the main building material, is produced from the clay soil of Sultan Marshes without the need for artificial energy. Additionally, local reeds, rushes, and trees from the nearest marshland are used in their construction. These buildings are constructed with minimal energy and do not require specialized skills.

3. PROTECTION AND SURVIVAL PROBLEMS

In the mezras (hamlets) of Sindelhöyük, it can be observed that the number of earthen buildings has decreased in modern times, and in newly constructed buildings, different materials are used instead of earthen and traditional building materials (Figure 9). The main reasons for this can be listed as follows:

1. Migration from the settlement areas resulted in a decrease in the local population.
2. Reduced need for new construction.
3. Lack of skilled craftsmen knowledgeable about traditional material production and construction techniques.
4. Destruction of the marshland due to global warming, unsustainable farming practices, uncontrolled grazing, and fires.
5. Degradation of the natural environment of the settlements led to a decrease in the availability of clay, trees, and reeds, which are the raw materials for earthen.
6. Inadequate durability of the structures in terrestrial climate conditions.
7. Inability to construct new buildings to replace the collapsed ones.
8. Lack of maintenance and repair, resulting in the inability to carry out necessary repairs and maintenance of the buildings.
9. Inability to meet the comfort conditions of modern times.
10. Lack of conservation awareness among the local population.
11. Insufficient support from authorities and governments regarding earthen structures.
12. Insufficient coverage of these buildings in architectural and engineering education leads to a failure to transfer this knowledge to future generations.

Figure 9. A traditional earthen building about to be demolished in Sindelhöyük, 2023.

4. SUGGESTION

Earthen, with its traditional cultural value, ecological nature, affordability, ease of production, and ability to provide a balanced indoor humidity and temperature, offers many advantages. However, the earthen structures we have examined in the current settlement area are rapidly disappearing. The main reason for this is the adverse effects of climatic conditions on the earth. However, social and economic factors also play a role in this. The prevention of these structures from disappearing can be achieved through maintenance and repairs, raising conservation awareness, preventing the abandonment of buildings due to migration and comfort-seeking, and taking protective measures.

The structures we have examined are also part of rural cultural heritage. However, due to the relatively new concept of rural cultural heritage, there are legal and social deficiencies in this regard. Our responsibility here is to be aware of and responsible for preserving our traditional cultural heritage and passing it on to future generations. With this sense of responsibility, planning for the entire area should be carried out as rural cultural heritage in collaboration with all stakeholders. Then, the structures should be documented for inventory purposes, and these documents should be archived in a way that is accessible to the local community. Training programs should be provided on earthen construction techniques, materials, and conservation measures to educate new craftsmen and increase the knowledge of building owners.

Additionally, due to the fact that the production method of earthen used in the hamlets affiliated with Sindelhöyük Mahallesi, Develi District, Kayseri Province, does not resemble the known method of earthen production, it should be included in the intangible cultural heritage recognized by UNESCO. This will ensure its recognition and importance worldwide.

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Paper Number: 19

Evaluation of Period of Vibration and Vulnerability Assessment of a Historical Masonry, Sama Center: A Case Study

Pooja Amatya[1,2] Rohit Ranjitkar[2,3]

Lochan Rijal[2], Prachand Man Pradhan[1,4]

[1]Kathmandu University Department of Civil Engineering, Dhulikhel, Nepal

[2]Kathmandu University Department of Music, Tripureshwor, Nepal

[3]Kathmandu Valley Preservation Trust, Patan, Nepal

[4]Manmohan Technical University, Morang, Nepal

pooja.amatya@ku.edu.np, rohit.ranjitkar@kvptnepal.org, lochan.rijal@ku.edu.np, prachand@ku.edu.np

ABSTRACT

The restoration of 'Kathmandu University Bal Krishna Sama *Saichik Guthi*[1] (Sama Center)'; the birthplace of the foremost Nepali playwright and artist Bal Krishna Sama; is being carried out by Kathmandu University with the vision of the amalgamation of tangible and intangible heritage in Nepal. This historically important Rana-period[2] architectural heritage will be ultimately transformed into an academic discourse center and a hub for music, theatre and literature. This paper analyzes the old structure of the Sama Center through contemporary approaches in order to create a practical database for future conservation of archaic, diverse and valuable Nepalese heritage sites. Despite the Finite element analysis of masonry buildings being very difficult to be considered feasible for analysis of the traditional unreinforced masonry structures due to the deficiencies faced during the modeling of the building in the computer program, it is widely used for the analysis of masonry due to the ease in studying the global seismic response of the structure. The primary objective is to study the structural performance of the building using a preliminary method of linear static analysis during the earthquake. The seismic coefficient and response spectrum method are adopted to analyze the dynamic nature of the building. The assumptions of materials have been considered with a similar review of the structures in Kathmandu valley whereas the connections and behaviour of elements are assumed and need to be refined in further analysis since the seismic inputs need proper care with the professional experience in how the building reacted to the earthquake. The time period of the existing building was measured using the ambient vibration method which was checked with the model in the computer program and further proposed building was studied in axial and shear stresses. Finite Element Modeling of the building is performed in CSI ETABS.

[1] Educational Trust
[2] Neoclassical buildings were built when Rana rulers were leading Nepal in the mid-19th – mid-20th century

Keywords: Linear Analysis, Ambient Vibration Test, Finite Element Method, Historical Masonry Building, Tangible and Intangible Heritage

1. INTRODUCTION

Masonry is one of the oldest construction methods known to human beings (NBS building science series 106. 1976). It is an art of creating a structure with bricks or stones laid one above the other with a binding component, mortar. The masonry can be used as both structural and non-structural units. The architectures during the Rana period in Nepal were Unreinforced Masonry (URM) structures, load-bearing structural units with walls made up of bricks in mud mortar and plastered in lime surkhi and timber in lateral load-resisting elements at the floor level.

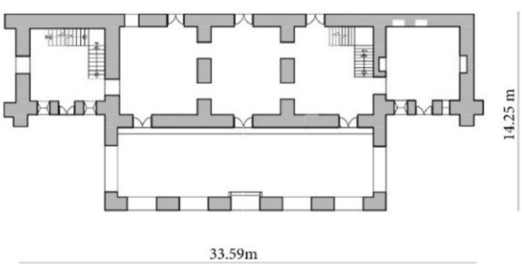
Sama Center, the birthplace of the then-playwright of Nepal, Bal Krishna Sama, is one of the magnificent architecture of that time. It is located at Latitude 27°42'36.5"N and Longitude 85°19'45.4"E. The building was built around 120 years ago. It has thick walls, and columns made up of masonry and arches to bear the load of the structure. The lateral support to the structure is given by the pinewood and Mild steel I section beams. The floors are made up of wooden joists planked with pinewood for flooring. It consists of a huge balcony in the main façade which is a point of attraction. These balcony columns extend vertically from the first floor up to the second floor. There is an open terrace above this balcony which is accessible from the third floor. The roof sections are covered with Galvanized Iron sheets.

1.1 Foundation

The foundation of the main building seemed stable since the walls of the ground floor and above were in a plumb line and no such settlement was seen in the walls above. From the conversation with the owner, the foundation of the building is around 10 feet deep. We could dig 7 feet deep to check the foundation until which the foundation bricks were seen, but due to the water level rise during the rainy season, further excavation was not possible.

1.2 Wall structures

The external dimension of the building is as shown in 'Figs 1 and 2'. The ground floor structural walls are 1 meter in width. There are huge arch openings on the ground floor whose crown sections have suffered damage to an extent, due to the installation of mild steel I sections right above the crown area without any wall plates during the initial repair of the building. Some arch sections are partially and some are filled with walls for partition. The insertion of I-sections and concrete to rest it in the wall has damaged the portions of the walls. The non-load-bearing partition walls were built in cement mortar and were about 23 cm in thickness. The northern wall seemed to be out of plumb by a few cm. Some wooden shores have been provided to the north façade walls of the building after the 2015 earthquake to support the building from further damage.



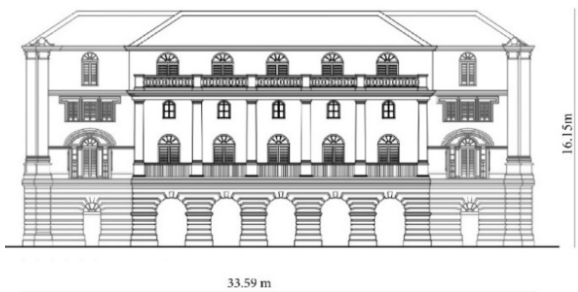


Figure 1. Typical Floor Plan of the Building
Figure 2. South elevation of the building

2. AMBIENT VIBRATION TEST

'A microtremor is a sophisticated instrument with a tri-axial velocity sensor, used to analyze the natural frequency and damping ratio of a building. The main advantages of microtremor analyses are simple, efficient, and quick, yielding reliable, accurate, and temporarily stable estimates of frequency and damping of the building's vibration modes from small amplitude excitation. '[1] It is also called the ambient vibration method to measure the motions generated due to wind, traffic, human activities, industrial machinery, etc. using highly sensitive instruments. This is a non-destructive vibration measurement technique for obtaining modal parameters of large structures. The identification of modal parameters through in situ analysis has been used to study buildings' seismic response and detect damages. The ambient time histories are recorded from the building, which further helps obtain the Fourier spectrum of each signal, resulting in the structure's natural frequency.

The fundamental properties need to be known for a proper design or analysis of any structure. For a seismic analysis, the fundamental time period of the structure is important. Micro tremor measurement gives the dynamic characteristics of buildings that play an important role in predicting their seismic behavior and in selecting the appropriate retrofitting approach in case of damage.

The fundamental vibration period of a building can be found in various codes.

Data Collection

For the measurement of the 3D geophone, a laptop with data acquisition software and a camera was used. For the building, one vertical and two horizontal measurements (east and north) were recorded, with a sampling rate of 100 Hz and a duration of 5 minutes for each location. The instrument was placed on each story wall. The topmost level of the existing building was reached as shown in 'Fig 3'.

The measurements' collected data were transferred to the Geopsy software for further processing. The software processed the time domain data into the frequency domain by a fast fourier transform algorithm as in 'Figs 4 and 5'. The frequency spectrum of the result was observed. Since clear peaks were obtained with less noise, usage of filter was not required.

From the frequency spectrum, frequency for peak amplitude in both east-west and north-south directions were found for each sample. Vertical vibration was not considered. The time period were calculated for the frequencies obtained in both directions. The experimental time period was compared with the existing building in the modelling software.

Figure 3. Data Collection at site. The highest point accessible in the mid longitudinal wall

[1] Gullapalli V.L., R RaghuNandanKumar , Reddy G.R., Assessment of Antenna Mounting Building Structural Strength using Micro tremor Analysis

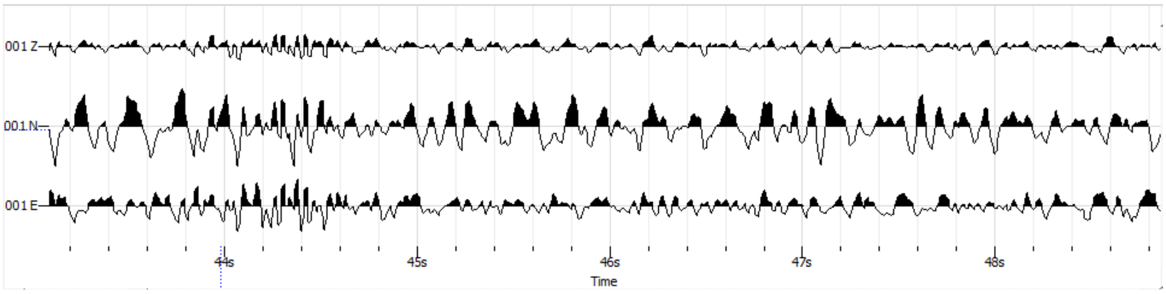
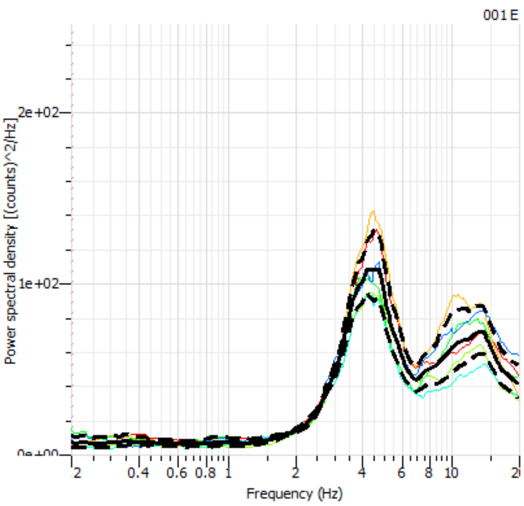
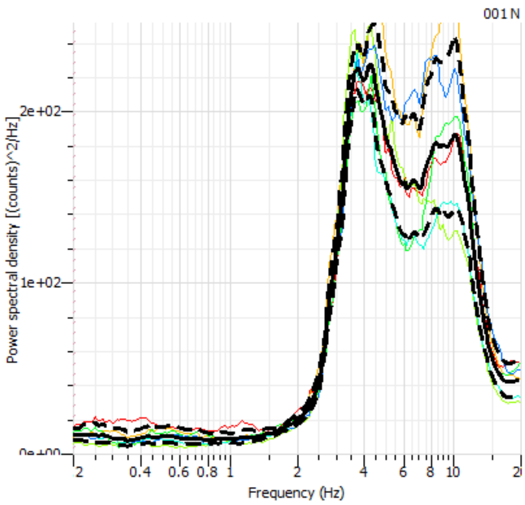


Figure 4. Sample of time domain data measured by micro tremor





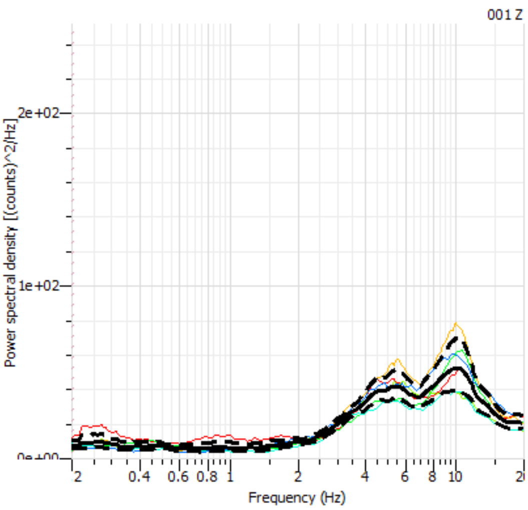


Figure 5. Frequency Spectrum of the building

The north-south direction of the building plays a fundamental role in the determination of the time period of the building. From the above graph in north direction, the frequency of the building can be taken as 4 Hz.

$$\text{Time period} = \frac{1}{\text{Frequency}} = \frac{1}{4} = 0.25 \text{ sec}$$

Comparison with that obtained from the results of highest Mass participating ratio from ETABS, gives the time period of 0.237 sec in a north-south direction. Since, the time period calculated by the building's model in ETABS matches 94% to the real structure, the model in the software is reliable

Table 1. Time period comparison

From Micro tremor	From ETABS model
North - South 0.25 sec	Y - Direction 0.237 sec
East – West 0.22 sec	X - Direction 0.196 sec

The ambient vibration test has been performed on the existing three-story building to check one of the parameters i.e. time period of the building and compared to the one generated by the software for analysis.

3. GENERAL DESIGN CRITERIA

3.1 Unit Weight and Material Properties

Unit weight of Brick Masonry in mud mortar: 19.61 kN/m^3 (Wood et al. 2017)
Compressive Strength of Brick Masonry in mud: 1.82 N/mm^2 (Shakya et al.)
Poisson's Ratio Brick Masonry in mud: 0.12 (Shakya et al)
Modulus of Elasticity Brick Masonry in mud, E=550 f_m : 800 MPa (FEMA 273)
Shear Modulus Brick Masonry in mud, G=0.4 E: 322.58 MPa
The mechanical properties from (Phajiu, S., and Pradhan, P.M., 2018.) have not been taken for masonry since the masonry used new bricks and cement mortar whereas we required values for existing bricks in mud mortar for analysis.

(IS 883: 1994)
Unit weight of Pinewood: 5.05 kN/m^3
Compressive Strength of Pinewood: 1.30 N/mm^2
Modulus of Elasticity Pinewood: 6800 MPa
Shear Modulus Pinewood: 2833.33 MPa
Poisson's Ratio Pinewood: 0.20

3.2 Earthquake Design Load as per NBC 105:2020

Soil Type : Type D-Very Soft Soil Sites
Seismic Zoning Factor, Z: 0.35 for Kathmandu
Importance Factor, I : 1.25
Ductility factor, Rµ : 1
Over strength factor, Ωs : 1.1
Fundamental time period, T, Sec : 0.237
Spectral Shape factor, Ch (T) : 1.625 for soil type D
Elastic site spectra C (T) = Ch (T) Z I : 0.71
Design Horizontal Base Shear coefficient : 0.646
Wall thickness (mm) : 1000, 860 and 300
Beam size (mm) : 200 X 150, 250X 150
Live Load : 3 kN/m^2, in general

4. ANALYSIS OF STRUCTURE

4.1 Assumptions

A Three-dimensional finite element analysis is prepared on the ETABS software, produced by CSI, California Berkeley, as per actual dimensions shown in 'Figs 1 and 2'.

The sizes of structural components are kept as per the real dimension on site of the existing structure and the new ones are as per the drawing.

Seismic loads will be considered acting along the two principal horizontal directions and not along the vertical direction.

The design seismic force has been applied automatically in different floor levels by the software.

Beams are modeled as rectangular frame elements whereas the masonry wall is modeled as a thick shell element.

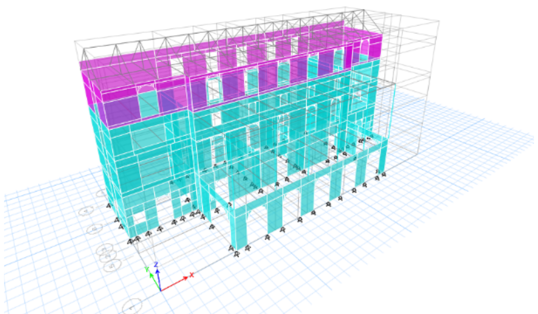
The diaphragm has not been assumed at floor level to be flexible in the horizontal direction.

The principal lateral load-resisting system in both longitudinal and transverse directions is a shear-resisting frame. The detailing shall be done as per the requirement of the shear-resisting frame.

4.2 Finite Element Modeling

The finite element model has been prepared in ETABS Ultimate 19.1.0. Beams were modeled as frame elements while walls were modeled as shell elements. The mechanical properties and loads were assigned as mentioned above. '**Figure** 6.' shows the finite element model of the building. Analysis of the building was prepared based on NBC 105:2020 code.

Whenever was necessary to check ETABS results, manual calculations were also performed. The walls have been taken as shell elements and the timber beams as frame elements. The connection of the building with the foundation has been taken as a pinned joint. The linear static analysis was first done followed by a linear dynamic analysis.



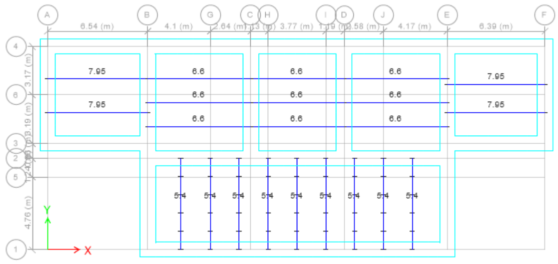


Figure 6. Finite element model of the building in ETABS
Figure 7. Floor Dead Load (kN/m^2) in plan

4.3 Analysis Results

4.3.1 Axial Stress

The axial stress patterns in the two elevations are as shown in 'Figs 8 and 9'. The average compressive stress is 0.5N/mm^2 which is within the limit whereas the tensile stress is exceeded in some openings as recorded after the earthquake in the building as shown in 'Fig 14'. The foundation of the building was checked for its bearing capacity for four story which resulted safe.

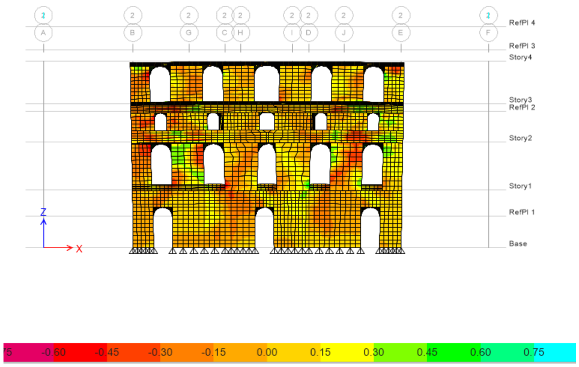


Figure 8. Axial Stress Diagram for Grid 2

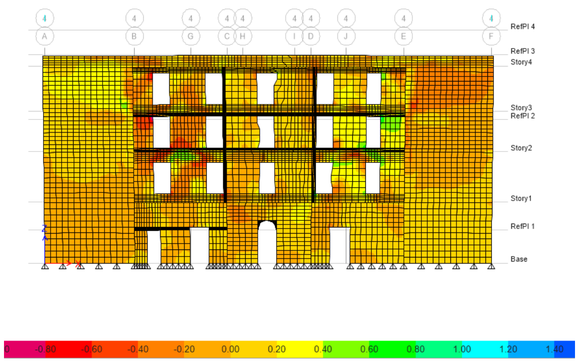


Figure 9. Axial Stress Diagram for Grid 4

Table 2. Axial Stress in Compression and Tension

(N/mm^2)	Calculated from ETABS	Permissible	Remarks
Compressive	0.5	0.67	Safe
Tensile	0.6	0.1	Exceeded near the openings

4.3.2 Shear Stress (Walls parallel to Y axis)

The shear stress from the model is recorded as 0.04 N/mm^2 which is within the permissible limit as shown in 'Figs 10 and 11'.

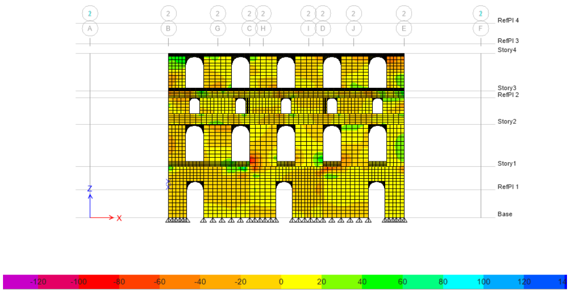


Figure 10. Shear Stress Diagram for Grid 2

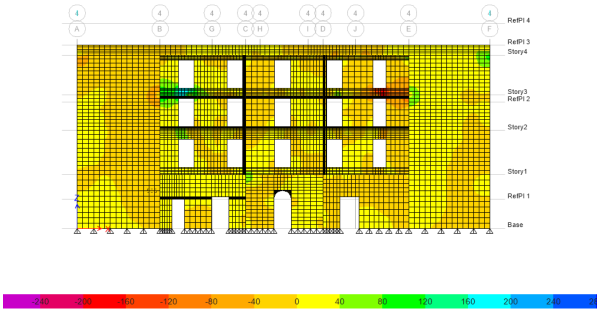


Figure 11. Shear Stress Diagram for Grid 4

Table 3. Shear Stress from ETABS in comparison to permissible stress

	Calculated shear from ETABS	Permissible shear stress	Remarks
(N/mm^2)	0.04	0.10	Safe

4.3.3 Out-of-plane Horizontal Bending

The out-of-plane bending seems to be between 0 to 40 kN-m/m avoiding the local stresses near the openings as shown in 'Figs 12 and 13'. The second-floor central portion seems to have maximum horizontal bending stress. This might have occurred since the floor is of the smallest height which makes its stiffness higher compared to other floors and a huge balcony in the third floor that rests on the columns in the first floor which makes the section flexible resulting the maximum displacement compared to other floors.

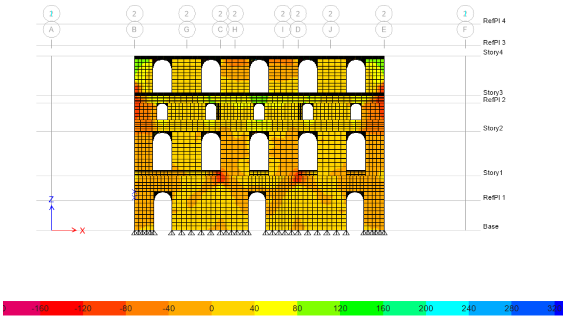


Figure 12. Out-of-Plane Horizontal Bending for Grid 2

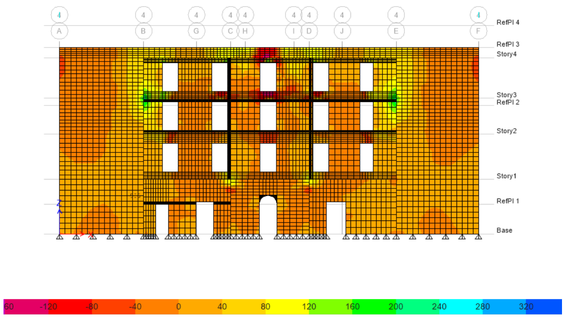


Figure 13. Out-of-Plane Horizontal Bending for Grid 4

Figure 14. Photographs of the cracks in the openings and the arches after the 2015 earthquake

5. CONCLUSION AND RECOMMENDATION

This paper discussed the vulnerability of a load-bearing Rana period architecture which in its current state is a 3 story building but needs to be built to its original state ie four stories as per the monument act since it has been listed as a heritage building according to Department of Archaeology. The time period of the existing state of the building (3 stories) was measured at the site and compared with that in the ETABS model. The time period was 94% close to the real-time period of the structure. Hence, ETABS was further used for the analysis of the proposed building with four stories. The walls have been taken as shell elements whereas the timber beams have been taken as frame elements. The joists and planking in the flooring have not been considered except few cases. The connection of the building with the foundation has been taken as a pinned joint. And the properties for the masonry were adopted from papers that analyzed existing buildings.

The stresses of the building have been observed through the finite element method. The building acts well in compression and shear since the walls are thick. Certain local stresses have been seen in the horizontal bending when analyzed using the Dynamic Analysis Method on the third floor which is due to the presence of a balcony that rests on tall columns and fewer cross walls. A diaphragm should be created to increase the stiffness of the balcony and the third floor whereas the local stresses in the corners of the openings can be strengthened using some wire mesh inside the plastered surface.

6. ACKNOWLEDGEMENTS

We are grateful to the Kathmandu University Department of Music for funding the research through Rebuilding Bal Krishna Sama Educational Guthi. Similarly, the researcher would like to thank Er. Sudip Karanjit, Khwopa College of Engineering for their support in microtremor analysis and Er. Ravi Sharma Bhandari for software analysis.

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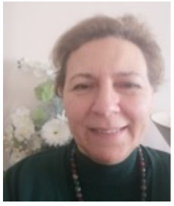
Paper Number: 20

Architectural and Social Adaptation of Traditional Housing from Past to Present; The Sample of Karahüyük in Konya




A.Deniz Oktaç Beycan, Sinem Tuğçe Şahin

Konya Technical University

adobeycan@ktun.edu.tr
sinemt.duraksahin@hotmail.com

ABSTRACT

The rapid urbanization caused by Industrial Revolution has become a problem for all cities around the world. The transformation began with reinforced concrete structures and continued with the use of iron and steel has led to a new era in buildings. With the recent social and cultural changes, traditional materials and sustainable housing are no longer preferred. Therefore, people are abandoning their traditional homes and neighborhoods. The recent increase in apartment construction has narrowed the distance between people, but has also led to a lack of social interaction. In contrast, when distances are greater in traditional housing neighborhoods, human relationships become stronger, and traditional living spaces close to nature also create a comfortable social space. Therefore, restoration and reinforcement work, including addressing spatial and structural deficiencies, is necessary for traditional living areas to continue to be used. Konya is one of the cities where villages on the outskirts of the city are undergoing transformation and becoming central neighborhoods. One of these transformations is taking place in the Karahüyük neighborhood of Meram district in Konya. While the neighborhood continues to stand with original and traditional materials and techniques, it is caught in an intermediate section between rapid urbanization. In this study it is shown that a traditional residential structure can meet the needs of modern life and the requirements of a modern family while providing comfort. The condition of a building made with traditional materials and structure, such as adobe, in a traditional region is discussed, and the spatial happiness of a modern family living with a traditional perspective in the region is conveyed. In conclusion it is reached that social, ecological, and economic sustainability can be achieved without disrupting traditional pattern and construction.

Keywords: Adaptation, Adobe Houses, Konya-Karahüyük, Historical Housing Style

1. INTRODUCTION

In recent years, the increasing urbanization and population growth on a global scale have led to architectural and structural transformations in urban areas. These transformations cause a threat to traditional structures and habitats, and complicate the protection of the cultural and historical heritage. In this context, the preservation and sustainability of traditional buildings are of great importance.

Rural areas around the cities are also affected by rapid urbanization, causing them to lose their rural characteristics. It is observed that these areas come under the pressure of urbanization without adequate protection for their cultural, socioeconomic, and architectural aspects. As a result of this transformation, rural settlements in the vicinity of cities lose their traditional, rural, and historical features and transform into multi-story urban zones.

Konya is a city located in the central Anatolia region of Turkey. In recent years, its rapid growth has led to the transformation of villages in the outskirts of the city into central neighborhoods. One of these transformations is taking place in Karahüyük Neighborhood, which is part of the Meram district of Konya. While striving to preserve its original rural structure and traditional architectural style, Karahüyük Neighborhood has started to undergo changes through urban planning efforts influenced by rapid urbanization.

The aim of this study is to demonstrate to be able to maintain the urban life for people in the areas which don't lose their historical, rural, and natural significant properties. A house built with traditional adobe material in a rural area integrated into the city has been examined. In this study it is shown how the family living in this house can meet their modern comfort needs while still preserving the traditional style, thus demonstrating their integration into urban life.

Photography, observation, interviews, and survey techniques have been employed as methods. These methods have allowed for a detailed examination of the garden and surroundings of one of the traditional residential structures in the region. Additionally, interviews with residents in the area have provided insights into their living conditions and expectations.

In this study it is concluded that in order to continue the use of traditional, historical, and rural living spaces, urban planning in the region should adopt an approach that preserves the regional characteristics. By maintaining the traditional pattern and urbanization while ensuring compatibility with the city and modern life, social, ecological, and economic sustainability can be achieved.

2. CHARACTERISTICS OF TRADITIONAL SETTLEMENTS AND CONTEMPORARY CHANGES

Anatolia has been home to many civilizations [1]. The structures in the cities of Turkish period were shaped in accordance with their context and traditional culture [2,3]. The pattern and structural characteristics of settlements are derived from various aspects such as lifestyle, traditions, livelihoods, products obtained, product evaluations, and the reflection of small crafts in space [4].

The rapid urbanization occurred as a result of the Industrial Revolution and the rapid industrialization of our country after the 1950s have affected traditional residential areas [5]. Nowadays, traditional residential areas rapidly undergo transformation. In this process of transformation, traditional residential areas in rural areas within and around the city have been seen as structural areas of new neighborhoods consisting of high-rise buildings and have not been adequately preserved.

Especially many of the urbanized rural areas have turned into new neighborhoods consisting of apartment blocks built on residential, commercial, and agricultural lands. Very few traces of the old settlements remain, and they have been virtually engulfed by the city. Although many rural areas have lost their traditional characteristics, a small number of rural settlements have been fortunate enough to urbanize while preserving their settlement fabric, traditional courtyard houses with gardens, local structures such as mosques and municipal buildings, and their spaces.

2.1 A View to the Structures showing Rural-Traditional Dwellings from the framework of Living Conditions and Sustainability changed in our presentday.

With modernization, the societal mindset has also been influenced, and people's preferences, desires, and expectations have changed [6]. After a while, these changes began to have negative effects on cities, societies, and individuals [7]. One way to eliminate these negative effects is to ensure the sustainable lifestyle of the past in line with present-day conditions [8]. Nowadays, there is a growing importance placed on the concept of sustainability and buildings that are designed accordingly. Traditional textures and spaces are highly valuable examples where sustainability can be achieved in terms of economy, social development, and environmental conservation [9]. These low-rise, nature-oriented, and traditional areas are ecologically and sustainably significant [10]. Therefore, evaluating traditional residential fabrics, integrating them into contemporary life, and preserving them will yield valuable gains in terms of cultural identity, urban memory, and the understanding of sustainability, which are highly valued today [11].

In the presentday, with the limitations imposed by the pandemic [12] and the destruction caused by earthquakes in multi-story reinforced concrete buildings [13] the value of low-rise, garden-based housing has increased for humanity. Traditional houses that possess these characteristics have been recognized as important not only for providing a healthy environment but also for preserving social distancing. Revitalizing and making traditional residential areas to a sustainable form is crucial for the health and quality of life of the community.

3. KONYA CITY AND ITS TRADITIONAL ARCHITECTURE

Konya is the largest province in Turkey in terms of area (Fig. 1, Fig. 2). Surrounded by the Taurus Mountains, the Konya Plain has a partially closed basin-like appearance. Konya, one of the oldest settlements in the Central Anatolia Region, was established on the alluvial cone of the Meram River. Throughout history, Konya has been one of the world's most significant ancient cities. It has been a site of important civilizations from the Neolithic period to the present, including the renowned Çatalhöyük settlement located near the city center [14].

	
Figure 1. Turkey in the world map[15].	**Figure 2.** Konya in the map of Turkey. [16].

After being conquered by the Anatolian Seljuk State and established as its capital, the physical structure of Konya had changed [17]. Today, there are many historical structures survived from this period. Until the 1950s, Konya largely preserved its historical and traditional architecture [18]. The houses on both sides of the city's streets were built with adobe materials, featuring large courtyards and one or two stories [19, 20, 21].

In recent years, there has been significant migration from rural areas to urban centers, from east to west, from earthquake-prone zones to safer areas, and due to the settlement of refugees throughout the country. Konya, being in the midst of this rapid urbanization process, has also experienced the effects of these migrations and has had to urbanize quickly. In this rapid urbanization process, the city of Konya has expanded beyond its center, undergone renewal with high-rise buildings, and has been unable to preserve traditional housing structures, particularly [22]. In recent times, the city has transformed into a structure that engulfs the historical, traditional, and naturally significant rural neighborhoods on its periphery [23]. The surrounding rural neighborhoods have completely transformed into a high-rise urban appearance (Figure 3). Only a few settlements, such as Karahüyük, which is the subject of this study, have been able to preserve their own structure to a lesser extent, withstanding urbanization pressures.

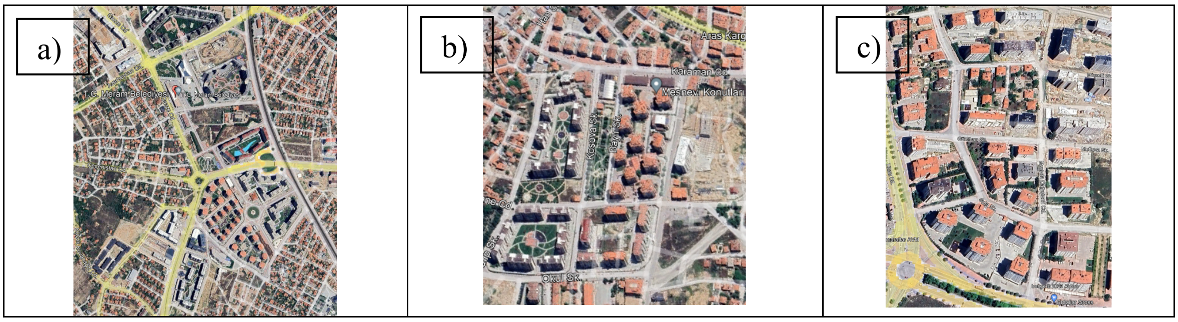


Figure 3. Examples of 10-12 story apartment buildings observed in the outskirts of Konya in rural and vineyard areas are as follows: **3-a)** Kovanağzı vineyard area [24], **3-b)** Kumköprü vineyard area [24], **3-c)** Hocacihan village [24].

3.1. Field Study: Evaluation through Karahüyük Neighborhood and Ahmet Şahin House

Karahüyük Neighborhood:
Karahüyük is a historical, traditional, and naturally significant rural settlement located in the south Konya. Like all rural areas around Konya, it has been affected by the rapid growth of the city. However, it stands out as a settlement that tries to resist change. Despite the urbanization pressures, the region has managed to continue its development without significant disruption, thanks to its planned growth and the local community's resistance to high-rise construction. As a result, there are still Konya families living in old adobe houses with courtyards, nestled within the natural environment and traditional architecture.

Karahüyük is a neighborhood belonging to the central district of Meram, located 15 km southeast of Konya. Excavations initiated in the region in 1953 under the leadership of Archaeologist Sedat Alp are still ongoing, and research has shed light on the settlement layers of Karahüyük dating back to around 3000 and 2000 BC (Fig. 4-a) [25].

Karahüyük is a rural area consisting of traditional courtyard houses. Its residents rely on agriculture, with wheat and grape production being particularly common [26]. Unfortunately, none of the four village chambers, one inn, or six water wells in the neighborhood have survived to the present day. The sources of livelihood have also shifted away from agriculture.

Karahüyük Neighborhood is undergoing architectural changes through various urban planning modifications in recent times. As a result of these modifications, new roads are being opened, the garden and plot areas of houses are being waned, and new buildings are being added to the pattern. Despite the decrease in garden and cultivation areas, the neighborhood still retains traces of being a rural settlement. Karahüyük Neighborhood strives to preserve its traditional architectural elements as much as possible in the present day (Fig. 4). Within the scope of this study, the changes experienced in a courtyard-style traditional house of a family transitioning from rural to urban life in Karahüyük Neighborhood will be examined to provide insights into the transformation of the region.

Figure 4. The location of Karahöyük: **4-a)** Its position on the map [27], **4-b)** Aerial photograph of Karahüyük Neighborhood in 2023 [28], **4-c)** Aerial photograph of Karahöyük Mound in 2023 [28].

Ahmet Şahin House

Karahüyük Neighborhood, Pirhasan Street, parcel number 12 of plot number 37403, located in the Meram district of Konya province, is where the structure was built between 1980 and 1985 (Fig. 8). The late Ahmet Şahin, who passed away recently, was the current owner of the building. The structure is currently occupied by his spouse, Nadire Şahin, and their children [29]. In the initial intervention to the building, an external reinforced concrete staircase was added, dividing the structure into a ground floor and an upper floor. As a result, the building is used by two separate families. In 2019, there were further changes made to the courtyard as a result of urban planning regulations.

Figure 5. The 2023 satellite image of the project area [30].

During its initial construction, the entrance to the house was through the courtyard gate opening onto Pirhasan Street in the northeast direction. The house was built adjacent to the northeast wall of the courtyard. The courtyard included elements such as an outdoor kitchen, a tandoor-oven area, a woodshed, and a toilet (Fig. 6-a, 6-b). However, due to the 2019 urban planning parcel regulations, the courtyard was reduced in size (Fig. 6-c, 6-d). The outbuildings that were originally present in the garden were demolished under municipal control. A road was constructed in the demolished area, resulting in a smaller garden. Currently, the house remains on a corner plot at the intersection of three streets (Fig. 6-c, 6-d). Today, the courtyard is accessed through Pirhasan Street in the northeast direction, just as it was in the past. The entrance to the building is from the northeast, opening into the courtyard. In the remaining part of the courtyard, new kitchen, storage, and toilet facilities have been built to meet the needs of the present day (Fig. 6-c).

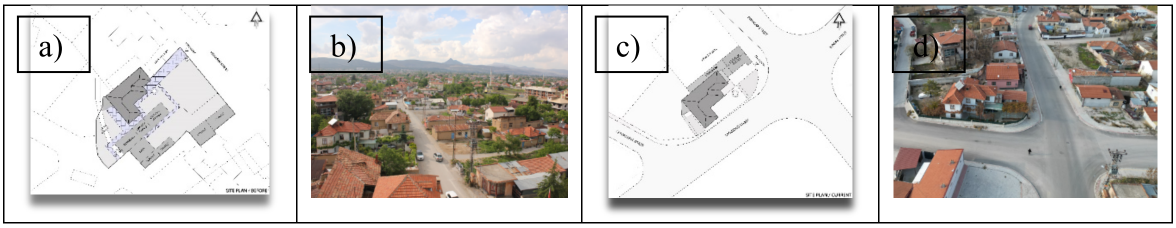


Figure 6.a) Site Plan in 2017 [31], **6.b)** Street Texture of the Year 2017 [28], **6.c)** Current Site Plan [31], **6.d)** Street Texture of the Year 2022 [28].

Şahin House was built using the traditional construction material of adobe and the technique of rammed earth. The building has two floors, with a central hall (sofa) and three rooms opening onto the hall on each floor. The lower floor walls were constructed with two layers of main adobe and one layer of small adobe, with a thickness of 60 cm. The upper floor walls were built with one layer of main adobe and one layer of small adobe, with a thickness of 30 cm.

The building has a sawtooth-shaped floor plan. The entrance to the rooms is through the central hall (sofa). The central hall serves as a space that connects the rooms and the staircase, and it is accessed from the courtyard on the ground floor (Fig. 7-a). Both floors consist of three rooms and one central hall (Fig. 7-a, 7-b). Due to the sawtooth-shaped floor plan, the external facade of the building has a dynamic appearance. The ground floor windows open to the northeast, southeast, and southwest directions (Fig. 7-c, 7-d).

Figure 7.a) Ground Floor Plan [31], **7.b)** First Floor Plan [31], **7.c)** Rear (Southeast) Elevation and Garden of the House [28], **7.d)** The House's Courtyard After Renovation and Its New Kitchen [28]

Alterations:

After the initial renovation, the lower and upper floors are used by two separate families. Access to the upper floor is provided through an external staircase. Today, this staircase has been removed, and both floors are used by the owner as originally intended (Fig. 7). The current user of the building has renovated the storage areas and the windows of the lower floor when they purchased the house (Fig. 8). Due to the maintenance difficulties of the grid wooden system, the ceilings have been covered with wooden paneling. Additionally, a wooden staircase has been added later on. In the central hall (sofa), there is a wooden staircase that connects to the upper floor (Fig. 8-b). The heating system of the building was provided by a stove until 2016. With the introduction of a natural gas pipeline to the neighborhood, heating is now done using a natural gas central heating system (Fig. 8-a).

On the ground floor of the building, there are two rooms, and the same rooms on the upper floor have niches and storage areas. The storage areas include wet areas to meet the bathroom needs (Fig. 8-d). The kitchen requirement of the building is designed in one of the rooms on the ground floor, specifically for kitchen use (Fig. 8-c).

Figure 8.a) Ground Floor Reception Room and House Entrance [28], 8.b) Ground Floor Reception Room [28], 8.c) Kitchen [28], 8.d) Niche and Cupboard in the Living Room [28], 8.e) First Floor Reception Room [28], 8.f) Niche and Cupboard in the Living Room on the Upper Floor [28].

The exterior facade of the building was initially finished with a layer of clay over the adobe plaster, followed by a lime wash (Fig. 9-a). In the exterior facade renovation carried out in 2018, a cement-based plaster was applied to the entire facade. The roof covering was repaired, and the eaves were covered with wooden material (Fig. 9-b).

Figure 9.a) Building Photo Before Facade Renovation in 2011 [28], 9.b) Building Photo After Facade Renovation in 2022 [28]

The owner of the house, who is a professional architect and engineer, currently lives in this building with their grandchildren. The building is located in a neighborhood that is close to the city yet still preserves its traditional rural characteristics. In terms of the number of floors and size, along with its garden and courtyard, the building meets the needs of the residents. The construction system of the building provides easy heating during the winters and creates a cool space during the hot summers of Konya's climate. The spacious garden brings joy and provides a relaxing environment for the family, especially during the pandemic period when the garden has become an even more valuable space for soothing the family [29].

4. RESULTS

Traditional buildings are important elements that reflect the culture and history of a region. However, in today's urbanization process, many traditional textures and structures have been destroyed or deteriorated. Konya is an important center in Turkey in terms of history, culture, and art, and it is home to many traditional buildings. However, in recent years, urbanization has also spread to the surrounding rural areas. This situation has been changing the socio-cultural, economic, and architectural structure of these rural areas. The study was conducted on Karahüyük Neighborhood as an example of a rural area that has undergone the least architectural changes among urbanizing rural areas.

Karahüyük Neighborhood is a historical and rural area located in the center of Konya. The traditional buildings in this area are still actively used by the local community. However, planned urban development projects in Karahüyük Neighborhood have led to the destruction and deterioration of these traditional structures. Preserving the architectural characteristics of the traditional buildings in the neighborhood and adapting them to meet modern needs is crucial for sustainability. The building has been designed as a traditional Konya house. Despite undergoing changes and transformations in 2019, it continues to maintain its original structure. During the renovation process of the building, which was constructed using adobe materials, emphasis was placed on preserving its original form and utilizing local materials for restoration. In line with this approach, the building has been reorganized to accommodate the requirements of modern living while ensuring its sustainability. This study demonstrates that social, ecological, and economic sustainability can be achieved without compromising the integrity of traditional architecture and urban fabric.

In conclusion, the utilization of this building in Karahüyük is important for preserving traditional architectural elements and ensuring the sustainability of the natural environment. Karahüyük Neighborhood (Village) serves as an example of a rural area that has undergone urbanization while preserving its architectural character and avoiding high-rise construction, which reflects the desires of the local community. The traditional residential structures in the area are being reorganized to meet the requirements of modern living, transforming them into healthy, comfortable, and sustainable living spaces. As a result, the residents of the neighborhood are able to enjoy a convenient and happy life, being close to the city while surrounded by a natural environment.

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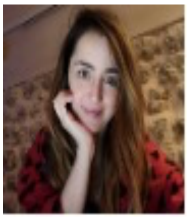
Paper Number: 22

Adobe Materials Decay Patterns of Historical Buildings in The Southeastern Anatolia Climate




[1] **Lale Karataş**, [2]**Murat Dal**
[1]Artuklu University, Mardin
[2]Munzur University, Tunceli
lalekaratas@artuklu.edu.tr
muratdal@munzur.edu.tr

ABSTRACT

Adobe, made from mud bricks, is an expression of diverse cultural values tied to architectural heritage by different societies. In this context, adobe can vary in physical, chemical, and mechanical properties in different geographical contexts. For an effective preservation program for adobe structures, diagnostic and conservation interventions need to take place within a socio-cultural context. When examining studies on adobe structures in various geographical and socio-cultural contexts, it's evident that degradation types in adobe materials exhibit different patterns in different regions. Specifically in structures located in the Southeastern Anatolia region, it is known that they are generally subject to degradation due to environmental factors. This study identifies degradation patterns resulting from environmental factors in adobe structures within the Southeastern Anatolia Region. These problems are classified based on structural elements and the factors causing the issues are explained within the geographical context. The results highlight that the storage and transfer properties of adobe material have a significant impact on degradation patterns due to the climatic conditions in the Southeastern Anatolia region. These conditions rapidly alter the material properties of adobe structures, leading to various types of degradation. Issues such as cracks and deformations, warping and bending, and changes in color were observed in structures due to temperature variations. These problems were most notably observed in the load-bearing exterior walls. Additionally, it was observed that physicochemical events significantly affecting the mechanical properties of the adobe and extreme temperatures causing drying and cracking issues in wooden floors in the region.

Keywords: Building; Adobe material, Decay, Southeastern Anatolia climate, Temperature differences

1. INTRODUCTION

Historical structures, constituting our cultural heritage, are in complex interaction with the natural environment. Climate change, erosion, geological factors, and other environmental impacts can significantly affect the resilience and longevity of these structures [1-3]. Therefore, conducting environmental research before embarking on the restoration process of historical structures is a critical step to develop accurate and sustainable restoration strategies [4-7]. Environmental research on historical structures involves studying the geographical and geological environment where the historical structures are located and assessing the impact of these environmental factors on the resilience and longevity of the structure [8]. Such research encompasses various elements, ranging from the characteristics of the ground where the structure is located to climate conditions, potential natural disasters, and local materials and techniques [9]. Studying climate changes in the region where the structure is situated and determining the effects of climate variables on the structure's resilience and materials is essential in formulating long-term restoration strategies. Climate changes affect the climate conditions to which historical structures are exposed [10-14]. Effects such as rising temperatures, increased humidity, and water inundations can reduce the load-bearing capacity of structures and harm building materials. Research conducted considering these environmental impacts allows for implementing appropriate measures during the restoration process to adapt to these changes effectively [15].

Adobe, a building material made from a mixture of soil, water, plant fibers, and organic matter, is a natural material. Due to its natural composition, it is susceptible to changes and deteriorations from various environmental influences. Adobe structures can be subjected to various deteriorations under environmental influences. Adobe can interact with water, leading to issues such as swelling, dissolution, and erosion [16]. Precipitation and high humidity levels can increase the water absorption capacity of adobe structures, weakening the building. Wind can cause erosion and abrasion on the external surface of adobe structures, with wind speed and duration eroding soil particles on the adobe walls and weakening the structure. Sudden temperature changes, another environmental factor, can cause expansion or contraction of adobe structures [17]. All these processes can result in cracks and deformations in adobe structures. Cold weather and freeze-thaw cycles can weaken adobe structures by freezing and thawing the water within the structure, leading to cracks and deteriorations. Salts and minerals present in the soil can react with the materials within adobe structures, causing deterioration through chemical reactions [18]. In this context, to enhance the durability of adobe structures and withstand environmental influences, appropriate protective measures need to be taken. To implement these protective measures, it's essential to first accurately identify the environmental factors and issues affecting the adobe structure [19].

In the scope of the relevant literature, no study proposing a restoration recommendation based on environmental issues for adobe structures in the Southeastern Anatolia Region was found. Therefore, this study is important as it identifies material issues in adobe structures located in the Southeastern Anatolia Region and provides a sustainable restoration recommendation. The aim of the study is to classify the deterioration types caused by environmental factors in adobe structures in the Southeastern Anatolia Region and to provide a detailed damage classification of the structure. The study is crucial in terms of categorizing observed primary deterioration patterns and processes affecting the material by classifying material deteriorations of adobe structure samples in the Southeastern Anatolia Region based on structural elements and explaining them in a geographical context. The results of the study indicate a close connection between the storage and transfer properties of adobe material and the relatively rapid occurrence of deterioration patterns due to the climate conditions in the Southeastern Anatolia region. It was determined that the most significant damage occurred in the load-bearing exterior walls, with temperature variations being the major contributing factor. The study highlights that the mechanical properties of adobe structures in the region are significantly affected by physicochemical events that cause a decrease in mechanical strength. The results of the study emphasize that for future preservation interventions to remain effective in the long term, measures should be taken not only to repair the deterioration caused by temperature differences but also to minimize the material's susceptibility to temperature variations. These measures will be vital for preserving adobe structures in the region effectively.

1.1 The Climatic Conditions of Southeastern Anatolia Region

The Southeastern Anatolia Region is one of Turkey's seven geographical regions. The provinces constituting the Southeastern Anatolia Region include Adıyaman, Batman, Diyarbakır, Gaziantep, Mardin, Şanlıurfa, Siirt, Şırnak, Kilis, and Adana. These provinces are located in the southeastern part of Turkey, bordering the Mediterranean Sea, Syria, Iraq, and Iran. The climate in the Southeastern Anatolia Region is generally under the influence of the typical Mediterranean climate, characterized by hot and dry summers and mild winters. However, the eastern parts of this region experience more of a continental climate, with cold and rainy winters. During the summer months, temperatures typically range between 30-40°C, while in winter, they can vary between 5-15°C. Some parts of the region, especially under the influence of a desert climate, can experience temperatures exceeding 40°C in the summer. Rainfall is generally more abundant in the winter months and decreases during the summer. The annual precipitation decreases from north to south. While the annual average rainfall is around 1200-1300 mm in the foothills of the Taurus Mountains and high-altitude areas, it can drop to 300 mm in low-lying areas. The average evaporation in the region ranges from 1500 to 2500 mm, and the annual average temperature fluctuates between 12º-18º. The humidity level shows a significant difference between summer and winter months, with the annual average humidity ranging from 42% (Şırnak) to 65% (Savur). There is a long and dry period that is not limited to the summer months and, rarely, can extend up to 10 months. These meteorological conditions play a crucial role in the material deterioration of adobe structures in the region. This study examines the impact of these factors on the degradation patterns of adobe structures in the region, and the findings are presented in the results section [20].

2. METHOD

In the study, to elucidate the degradation patterns of adobe structures in the Southeastern Anatolia Region caused by environmental factors, an initial literature review was conducted regarding the climatic conditions of the region. In the second stage, adobe structure samples from the Southeastern Anatolia Region were inspected on-site and documented through photography. A detailed examination was conducted in the field, taking into account the deteriorating effect of climatic influences on adobe materials. In the third stage, the documentation phase, the adobe material issues in the region were thoroughly explained based on the findings and photographs identified in the field.

3. RESULTS

In the observations conducted on adobe structure samples in the Southeastern Anatolia region, it was determined that the material deteriorations in the structures are predominantly due to temperature variations. This section provides a detailed explanation of the degradation types caused by environmental influences in adobe structures.

3.1 Damage Occurring on the Walls

The most notable damage identified in the adobe structure samples examined in the region occurred predominantly in the load-bearing exterior walls. Exterior walls are in direct contact with the external environment, making them more exposed to outside temperature fluctuations. Adobe material expands in high temperatures and contracts in low temperatures. Over time, these processes have caused damage such as cracks, deformations, and loosening within the structure. High temperatures and low humidity levels have led to the drying of adobe material in the walls, resulting in crack formation during the drying process. These cracks have enlarged over time, weakening the structure. Temperature variations throughout the day have also caused expansion and contraction of the adobe material, leading to stress and cracks on the structure. As a result of these effects, the material weakened, reducing its durability and causing damage to the structure. Apart from temperature differences, the moisture level is another significant factor in adobe structures. High humidity has caused the adobe material to absorb more water, and this water has had harmful effects during freeze-thaw cycles. Additionally, direct exposure to sunlight intensifies temperature variations, exacerbating the damage to the material (Figure 1).

Figure 1. The adobe structure examples located in the Alakuş neighborhood of Kızıltepe, Mardin, exhibit issues such as 'cracks and deformations, warping and bending, and color changes' attributed to temperature differences.

3.2 Damage Occurring in Wall Cavities

The elements located in the wall cavities of adobe structures in the region, such as windows, doors, and arches, experience damage attributed to temperature differences. The hot weather causes the adobe structure elements to expand, leading to stress and cracks in these elements. These cracks on windows, doors, and arches have reduced the stability of the structure elements and marred their aesthetic appearance. It is evident that these issues will harm the structural integrity in the long run. High temperatures can cause the moisture in the adobe elements to evaporate and the material to dry out. This drying process has led to warping and bending in thin and long structure elements like windows, doors, and arches in the region. Such deformations have adversely affected the functionality and durability of the structure elements, particularly hindering the smooth operation of doors and windows. Furthermore, material differences between the adobe structure elements and windows, doors, and arches (e.g., wooden or metal frames) react differently to temperature changes. These differing responses have caused discrepancies and stresses between the elements. These discrepancies have led to dislocation, cracks, and breakage of elements, particularly causing aesthetic and structural issues in arches. Extended exposure to sunlight has caused fading or changes in the color of the adobe elements. Visually unpleasant color variations can affect the appearance of the structure elements, resulting in an inconsistent look when viewing the structure (Figure 2).

Figure 2. In the adobe structure example located in Diyarbakır, issues such as 'cracks and deformations, warping and bending, and color changes' have been identified due to temperature differences.

3.3 Damage Occurring in Floors and Roofs

It has been observed that many of the floors in adobe structures in the region are covered with soil on top of wood. This situation has led to material issues and structural damages due to various temperature differences. Wood and soil react differently to temperature changes. Wood expands in hot weather and contracts in cold weather. These different rates of expansion and contraction have caused cracks and deformations in floor materials. Wood is sensitive to temperature changes, and these changes have led to cracks and deformations in the wood. Prolonged temperature changes, in particular, have resulted in permanent cracks in the wood flooring beneath the soil cover. Temperature variations can affect moisture and water levels in the wood beneath the soil cover. Especially during heavy rainfall periods, water penetrating the wood can lead to decay and structural weakening. In hot and arid regions, extreme temperatures have caused the wood flooring to dry and crack (Figure 3).

Figure 3. Issues like 'cracks and deformations, fungal and pest damage, warping and bending, and color changes' observed in the flooring of an adobe house in Şırnak are due to temperature variations.

4. CONCLUSION

The study identified degradation patterns arising from environmental factors based on examples of adobe structures in the Southeastern Anatolia Region. Specifically, it was determined that the storage and transfer properties of adobe material significantly affect degradation patterns due to the climatic conditions in the Southeastern Anatolia region. These conditions rapidly alter the material properties of adobe structures, leading to various types of degradation. According to the findings of the study, problems such as 'cracks and deformations, warping and bending, and color changes' occurred in the structure due to temperature differences. These issues were most prominently observed in the load-bearing facade walls, with temperature variations identified as the major contributing factor. Additionally, it was emphasized that physicochemical events significantly affecting the mechanical properties of adobe structures in the region and extreme temperatures leading to drying and cracking in wooden flooring had a considerable impact. These results indicate that for conservation programs to remain effective for an extended period, appropriate measures should not only address the degradation caused by temperature differences but also minimize the material's susceptibility to temperature variations. These measures will contribute to the preservation of adobe structures by enhancing their durability and longevity.

Damage resulting from temperature differences in adobe buildings is a significant factor affecting their durability and longevity. To minimize these damages, building owners and restoration experts should aim to reduce temperature fluctuations by employing appropriate insulation methods. Additionally, regular maintenance and monitoring, enabling early detection of potential damages and timely interventions, will play a critical role in preserving adobe structures. Considering temperature differences during the construction and maintenance of adobe buildings is important, and measures such as proper insulation and moisture control should be taken. For instance, the lifespan of adobe structures can be extended, and they can withstand environmental effects by implementing measures like waterproofing, regular maintenance, temperature control, and controlling plant roots. Moreover, when using earthen floor coverings on wooden subfloors in adobe structures, attention should be paid to temperature variations and moisture balance. Regular maintenance, waterproofing, and appropriate precautions can enhance the durability of flooring materials and prevent structural damages. To mitigate damages caused by temperature differences in elements like windows, doors, and arches in the wall cavities of adobe structures, proper insulation, regular maintenance, and restoration using suitable materials are essential.

Summary; the measures that can be taken to reduce the problems arising from temperature differences in adobe structures and minimize the material's impact are listed below:

- Temperature and Humidity Monitoring: Using sensors to monitor temperature and humidity levels inside and outside the building can be a suitable method for data collection. These data can form the basis for understanding temperature changes in the structure and taking appropriate measures.
- Insulation and Thermal Protection: Properly insulating the exterior surfaces of the building to minimize internal and external temperature differences is a consideration. Using insulation materials to reduce heat transfer can protect the structure against temperature fluctuations.
- Sun Protection: Using sunscreens such as pergolas, projections, or strategically positioned trees to control sunlight can be another method. This can reduce direct exposure to sunlight and hence minimize temperature differences.
- Proper Ventilation Systems: It is essential to regulate indoor temperature by using adequately and appropriately designed natural or mechanical ventilation systems. This can help prevent extreme temperature fluctuations.
- Protection of Wooden Flooring: Applying appropriate protective coatings to wooden floors to counter problems such as drying and cracking caused by extreme temperatures can be considered. These coatings can preserve the wood's moisture and prevent damage.

- Regular Maintenance: Regularly inspecting the structure and promptly intervening when any signs of damage or deterioration are observed can be a method. Early intervention can prevent the escalation and spread of damage.
- Water Management: Considering proper drainage systems to control rainwater and prevent it from causing damage to adobe material is important. Using drainage systems to minimize the long-term effects of excess moisture and water on adobe is essential.
- Education and Awareness: Conducting training for building owners, users, and maintenance personnel regarding the potential effects of temperature differences is crucial. This can be effective in implementing appropriate measures.

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Paper Number: 23

Examining Architectural Restoration Trainings in Terms of Professional Equipment and the Place of Adobe in Education

Emine Sibel Hattap

Mimar Sinan Fine Arts University

sibel.hattap@msgsu.edu.tr

ABSTRACT

Although Architectural Restoration education is given in two-year vocational school in Turkey, four-year education is also given in different programs that train conservators and restorers in different universities. Within the scope of the study, an evaluation will be made on the example of Mimar Sinan Fine Arts University Vocational School Architectural Restoration Program. This department trains restorers as technical intermediate staff. In this program, mostly architects and restorers, faculty members from various disciplines give lectures, and support is received part-time from experts in their fields in certain courses. In the two-year program, practical courses and internships are of great importance. This program, which cooperates with the sector and local municipalities from time to time in order to create conservation awareness and support it with restoration education, organizes workshops for its students to protect traditional cultural assets and provide practical training. Although there are lessons on Stone, Wood and Metal materials in the trainings, Adobe is briefly explained in only one lesson. In the study, the importance of adobe as a natural material and the necessity of its inclusion in education will be emphasized.

Keywords: Architectural Restoration, Professional Equipment, Adobe, Material

1. INTRODUCTION

Adobe occupies an important place among the natural materials that are being reused today. In particular, earthquakes have actually shown that the use of Adobe material not only for health but also by strengthening it with today's technology, is a very important material for earthquakes.

The parts that can also be called old-type bricks that arise as a result of mixing the soil with straw and water, pouring it into wooden molds, and leaving it to dry in the sun are called adobe. In addition, it has the property of being the first building material used by human beings on earth. It was used a lot in ancient times [URL 1]. Nowadays, its use is becoming widespread not only in rural areas but also in big cities.

2. ADOBE MATERIAL FROM THE PAST TO THE PRESENT

The use of Adobe materials dates back to ancient times. The use of adobe belonging to the first periods was encountered in Mesopotamia in the 10th century BC. Looking at Anatolia, it can be seen that the first use of adobe was in the Çayönü settlement in Diyarbakır around 8500 BC. The first use of adobe in the European continent was in VI. century in Germany.

While the adobe is preparing the material, the soil must be suitable, which is measured by having the appropriate clay content and granulometry. If the existing soil does not fit this description, it is useful to add some sand or clay to make it suitable. This process is called "preparation of adobe mud". For the adobe mud to be well-formed, its consistency must be well-adjusted with the water to be added to the soil. Adding too much water will cause the adobe to dry hard and reduce its strength. Reducing the water that will enter the mixture also makes it difficult to mold the sludge, thus requiring compaction and ramming to place the sludge in the mold well. The formation of voids in the structures of adobe blocks that are not well compacted will also directly affect the strength of these blocks negatively.

The larger adobe molds are called mother, the smaller ones are called lamb. Adobe is also the most economical building material, there are no transportation problems and there is no cost to obtain. By adding horsehair, straw, etc. to the existing soil, its binding is increased, mixed with water, poured into molds and dried in the sun, making it ready for use. The structure is built by using it as a brick. It is a sustainable material and does not harm the ecological balance either [1].

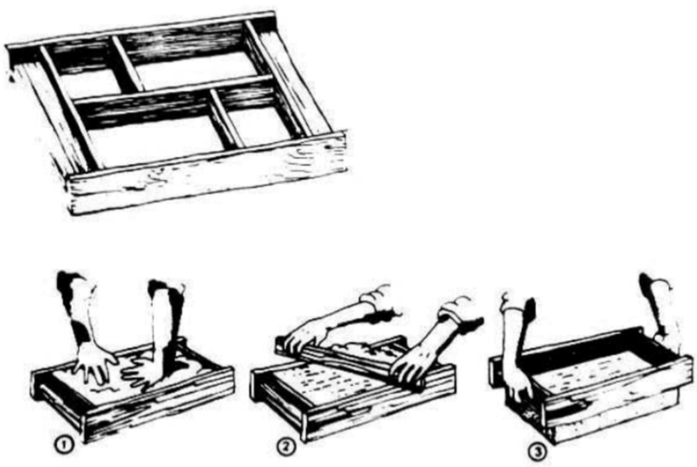

Figure 1. Production of adobe wall block with wooden mold [1].

In addition to its positive properties, the contact of adobe with water, which is a material that is easily affected by water and moisture, should be avoided to the maximum extent. Walls made of adobe material, which are also used in humid climatic regions, should be protected from moisture. Therefore, it is not recommended to use adobe materials in the foundation and sub-basement parts of the building that come into contact with water. In particular, buildings should be protected from areas at risk of flooding and from areas that may be exposed to groundwater, and materials such as stones that will be less affected by water up to the subbasement level should be preferred. "In regions with heavy snowfall, the snow above the sub-basement level should be cleared. When the plasters swell or spill, they should be cleaned and re-plastered immediately. When ceiling and floor beams of adobe structures begin to rot, they should be replaced rather than reinforced. In the repair of flowing earth roofs, additional soil or barren should not be laid on the roof, the existing soil or barren soil should be removed and the earthen roof should be rebuilt" (TS 2515) **[2].**

According to Prof. Dr. Bilge IŞIK, who has been working on adobe for many years, working to make adobe a material that is still used today by using new methods and technology, and making adobe spaces, Adobe structures have come up to the present day with the master-apprentice relationship, and this material has been developed every day. It is the best proof to see that especially well-built adobe spaces survived the earthquake. The 'improved adobe' made by strengthening with gypsum called 'alker' is more durable than traditional adobe.

The "BKM Plateau film building" in Köyceğiz/Muğla, built under the supervision of Prof. Dr. Bilge Işık, and the "Visitor Center" built in Göbeklitepe, Urfa, the "Women's Education and Production Center" designed by Architect Özgül Öztürk and implemented in Elazığ are some examples of modern adobe structures.

Figure 2. BKM Plateau Film Building, Köyceğiz/Muğla [Tarım, A., 2019]

Figure 3. Göbeklitepe Visitor Center [URL 2].

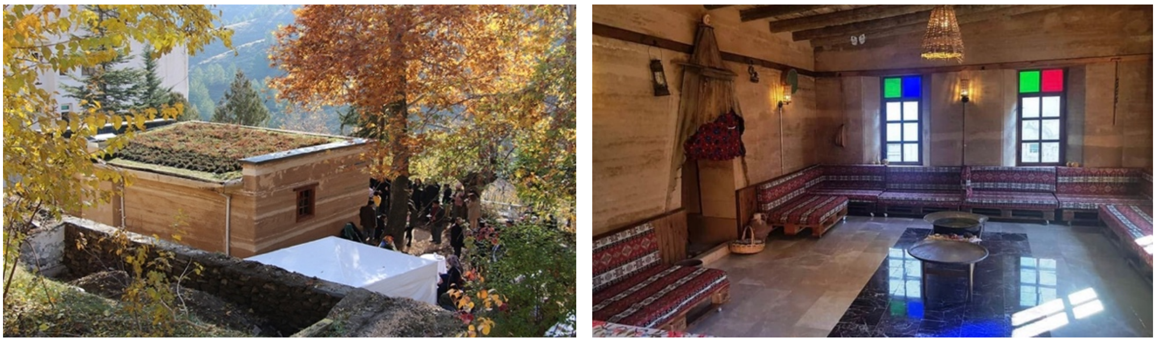

Figure 4. Elazığ Women's Education and Production Center [Öztürk, Ö].

Arg-ı Bem Castle, located in Bem, Iran, is considered the largest adobe-built building complex in the world. It is known that the history of this castle, which was built on an area of 6 km2, which became the important center of the region in a short time, dates back to the 12th century. It has been recognized as the cultural and historical heritage of Iran with a history of 2000 years. It is estimated that the castle, made of a mixture of adobe bricks, straw and palm tree branches, was first established during the Sasanian period (224-637) [URL 3].

Figure 5. Arg-ı Bem Castle [URL 4].

Another main feature of the Chan Chan campus, which is also one of the largest mudbrick structures in the world made of adobe, is that it is the largest adobe castle in America. This place covers more than 20 km2. Chan Chan consisted of a total of ten forts, among which were more than 100,000 workshops, pyramidal temples, streets and walls. It is estimated that between 60,000 and 100,000 people live in this labyrinthine frame. It was included in the UNESCO World Heritage List in 1986.

Figur 6. Chan Chan Citadel: America's largest adobe city [URL 5].

The historic adobe houses on the UNESCO Cultural Heritage List, located in the "old city" neighborhood of Sana'a, the capital of Yemen, are also the oldest apartment buildings in the world. Like the old city neighborhood of Sana'a, the town of Shibam, one of the most important historical regions of Yemen, is also known for its old houses made of adobe. About 500 of these houses consist of 5- to 10-storey apartment buildings. The tallest adobe buildings in the world are located in Shibam with heights exceeding 30 meters [URL 6].

Figure 7. Adobe structures found in Shibam [URL 7].

Figure 8. The adobe houses of Sana'a, the capital of Yemen [URL 8].

In our country, adobe has been used since ancient times. One of them was discovered in the Urartian settlement. According to the statements of Assoc. Dr. Erkan Konyar, the works carried out in the mound in the area north of the Van Castle shed light on the 7,000-year-old history, especially in the Urartian and Ottoman periods. Konyar stated that they uncovered an Urartian neighborhood with a adobe body in the mound, and that the architects and restorers in the team analyzed the Urartian adobe and completed the walls with new adobes they produced.

Figure 9. The use of adobe in the Urartu Quarter on the mound north of Van Castle [URL 9].

Figure 10. Adobe house in Merzifon [S. Hattap, 2023].

Figure 11. Adobe house in Tokat [S. Hattap, 2023].

New Mexico'da yer alan Taos Pueblo'daki Taos kerpiç evleri ile dikkat çekmektedir. Taos Pueblo De Taos, located in New Mexico, attracts attention with its adobe houses. Traditional pueblo construction used limestone blocks or large adobe bricks; the latter were made from clay and water and generally measured approximately 8 by 16 inches (20 by 40 cm), with a thickness of 4 to 6 inches (10 to 15 cm). In the early 21st century, modern construction materials were sometimes used in tandem with adobe, creating stronger and more durable structures [URL 10].

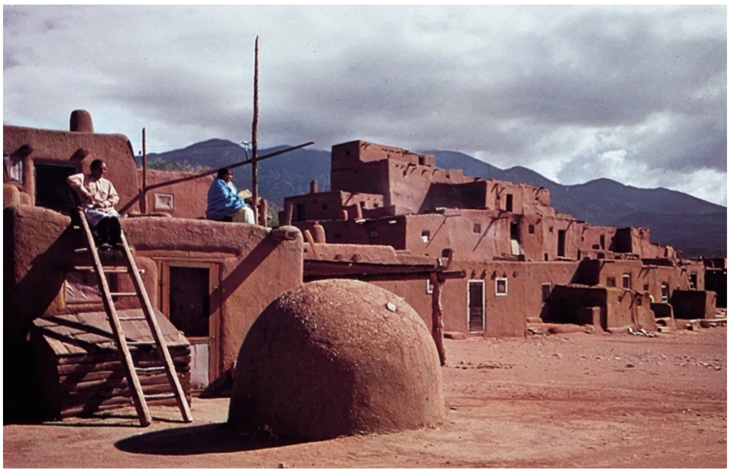

Figure 12. Taos Pueblo De Taos adobe houses in New Mexico [URL 11].

Taos Pueblo is a UNESCO world heritage site and a national historic landmark. Some call the adobe-style houses "Pueblo" houses. Since the Pueblo people could not find enough lumber to build houses, Adobe used the most durable and easy-to-find material. The first adobe-style houses here had a pit design. They were half underground, half above the surface of the earth. Around 800 AD, circular adobe-style houses began to have separate rooms. The builders divided these rooms into sections of the house according to different types of soil. Modern Pueblo-style houses resemble traditional architecture, which the indigenous people of Southwest America embraced. Today, most of these houses have a Spanish interior motivated by the indigenous building materials during the Spanish colonization era.

The early adobe-style homes had a distinctive circular design but later adopted a rectangular prism interior which is more in demand today. Modern adobe-style houses feature some interior updates, but the indigenous architectural elements remain intact [URL 12].

Figure 13. Modern Pueblo-style houses [URL 13].

3. THE PLACE OF ADOBE MATERIAL in EDUCATION

While Wood and Stone Materials are given as separate elective courses in the Architectural Restoration Program of Mimar Sinan Fine Arts University Vocational School, there is no separate course for adobe materials. Traditional Building Systems and Elements are explained in the course. Information is given about the construction techniques of adobe, material properties, places of use in traditional architecture, and sample structures from the world and our country are shown as above. Apart from this, there is also no separate adobe course in architectural education. In recent years, the fact that adobe is a natural material, it has a long service life if it is used by strengthening, it is beneficial for health, etc. for such reasons, master's degree and doctoral courses related to adobe materials have started to be held. Especially in these studies, experimental studies conducted with adobe attract attention.

As an example of these studies, in 2019, apart from the exhibitions and scientific studies aimed at better introducing the modern usage possibilities of adobe materials widely used in Anatolia, a special work was also hosted at the 7. Adobe International Conference, where Mimar Sinan Fine Arts University academics and graduate students had an intensive participation. The adobe Outdoor Sculpture with the theme "Permeability and Form", which was executed by MSGSU Faculty Member Assoc. Dr. Umit Arpacioglu, started with workshops and theoretical studies at Mimar Sinan Fine Arts University in the summer of 2019, and after this special study, which continued throughout the summer, a manifesto was prepared and the works were exhibited at the symposium [URL 14].

Figure 14. Outdoor sculpture made at the Adobe'19 International conference (9x3m.) [S. Hattap, 2019].

4. CONCLUSION

Compared to modern building materials, adobe produces minimal total waste and zero hazardous waste. Since the adobe is collected from the environment of the building, the transport energy is significantly reduced. Among other advantages of Adobe, it also has financial advantages due to low noise transmission and simplicity of construction method, expensive construction equipment is minimized. Also, an adobe house is very customizable in terms of design.

While adobe houses gain value again because they protect nature and health, adobe structures are a better option for those living in dry climates for their long-term durability. While adobe material has gained such importance, it should be taught as a lesson in architecture and restoration education, not only for its use in traditional buildings, but also as a contemporary material with new materials and technology in today's buildings.

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Paper Number: 25

Drafting an Approach for The Preservation and Rehabilitation of The Murcheh-Khortcastle-Village

Arezoo Khazanbeig

Rue de l`enseignement 41, Brussels 1000, Belgium

arezoo.khazan@gmail.com

ABSTRACT

Iran has several numbers of fortified complexes and settlements. These architectural constructions played an essential role in people's social, economic, and political lives throughout history. Fortified complexes of Iran, called Qaleh or Qal'eh in Persian, neglecting the value of their cultural heritage, are left abandoned for the sake of unbalanced development.

Lack of documentation and monitoring of these historical compounds threatens these properties and delays the development of an appropriate management mechanism to preserve them with rural and urban development. Residential fortifications, in which defensive structures serve to protect the settlement and residential units, are one type of fortified complex.

Murcheh-khort is one of the largest adobe residential fortifications (castle-village) of Iran and a great example of these architectural complexes which three main elements of water resources, roads, and proximity to the city of Isfahan generated its formation.

Murcheh-khort castle-village is located in the Murcheh-khort rural district, 40 km from Isfahan in Iran. This fortified settlement was located beside the main ancient road of Iran, the secondary road of the silk road, that crossed from north to south of the country and had a crucial role in the historical events and the development of Isfahan during different dynasties.

During the last century, with rural development, population growth, industrial development, and socio-political transitions in Iran, this complex lost its function and gradually became depopulated and abandoned. The authenticity and integrity of the Murcheh-khort fortification have been hampered by decay, and it is mainly abandoned currently.

Since significant numbers of fortifications of this type and scale are present in almost all the provinces of Iran from north to south, this research work will serve as an example of the sustenance of the heritage structures of this scale and values.

The research process revolves around information obtained through a number of sources and institutions, as well as a limited observation made on the site and its surrounding. This research-based study aims to demonstrate a clear image of Murcheh-khort castle-village, and the influential factors on its creation, continuity and destruction.

Based on the information retrieved from several analysis in different levels and aspects, it was learned that the cohesion and interwoven framework of the fortification prevented the destruction of the main structure of this historical monument. Besides the community's attachment to this cultural asset, this interwoven framework didn't let the owner destroy and reconstruct their property. Religious buildings as the core of the castle-village are the only functioning buildings in the area that have remained standing all these decades.

Highlighting the religious buildings as the core of the site and considering the socio-economic relation of the old and new inhabitants of the village and all the internal and external potentials and threats, policies and regulations for the site and the entire village, future possibilities for the historical site and its surrounding was predicted and the rehabilitation proposal was proposed to preserve this cultural heritage and generate the development of the village and prevent its decay.

Keywords: Residential fortification, rehabilitation, castle, village, destruction.

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10th International Conference
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Paper Number: 27

Timber Supported Mudbrick Masonry in Ancient Architecture in Anatolia: An Evaluation of R. Naumann's Work

Nilüfer Baturayoğlu Yöney
University of Central Florida, Department of Anthropology,
Orlando, Florida, USA
nilüfer.yoney@gmail.com, nilufer.yoney@ucf.edu

ABSTRACT

Although the characteristics of vernacular architecture and their importance for sustainable new designs and technologies has become a focus of architecture, this data generally excludes and disregards archaeological research. Among the reasons for this are the facts that excavation and survey data is difficult to reach because reports and publications rarely include such details, and that archaeologists rarely look at continuing tangible and intangible building traditions in their vicinity. Although archaeological research in the last 50 years in Anatolia has created a great amount of additional data, Rudolf Naumann's book *Ancient Architecture in Anatolia* (1955, 1971), still remains to be the seminal work on this subject, bringing together the information from many sites in Turkey and explaining the basic principles and connections. Both an architect and archaeologist, Naumann was able to see the connections others overlooked.

This paper focuses on a presentation and evaluation of Naumann's work on historic mudbrick architecture in Anatolia, and especially on the use of timber elements as beams (*hatıl*s) in masonry. Naumann looked at examples from different sites and building types, beginning from the Neolithic period to the end of the Hittite Period, and compared his findings with contemporary rural or vernacular examples. Evidence for timber beams were present in archaeological finds. These were used between stone wall footings or foundations and mudbrick walls; horizontally, parallel and sometimes vertical to wall faces to strengthen the masonry; and/or vertically to support walls, sides of openings, and timber superstructures.

Keywords: Ancient Mudbrick Technology, Mudbrick Architecture in Anatolia, Timber Beams (*Hatıl*s), Rudolf Naumann

1. INTRODUCTION

Although the characteristics of vernacular architecture and the importance of such building traditions, technologies and materials for the development of sustainable new designs and systems has become a focus of architecture in the recent decades, such data derived from historic sites and buildings, generally excludes and disregards archaeological research. One reason is that excavation and survey data is usually more difficult to reach because annual reports and publications rarely include such details. It is hard for architectural researchers to understand the technological and material design from the remains in a single visit. Such research requires the accumulation of data over many seasons, or in other words, being part of the archaeological project. Having access to and collecting such data from more than one or two excavations is nearly impossible for architectural researchers. Archaeologists, on the other hand, do not always concern themselves with more recent and/or continuing tangible and intangible building traditions in their vicinity, and instead focus on what they uncover in excavations. Their knowledge on the technological and material aspects as well as construction systems in architecture is also limited and cannot be compared to that of an architect, specializing in such research. This situation is often reflected in their publications concerning the reconstruction of period buildings and their technologies.

However, Rudolf Naumann's work is different in terms of know-how and scope. He was an architect and archaeologist, and thus, he was able to see the connections most archaeologists overlooked. He was also one of the first scholars to relate Anatolian architecture of different periods to their contemporaries in the Near East and Greece. His book *Ancient Architecture in Anatolia from its Beginnings until the end of the Hittite Period* (*Architektur Kleinasiens von ihren Anfängen bis zum Ende der hethitischen Zeit,* Wasmuth), originally published in 1955, revised and republished in 1971, and published in Turkish in 1975 (*Eski Anadolu Mimarlığı,* Türk Tarih Kurumu, 1975, 1985, 1991, 1998), still is the seminal book on this subject, bringing together the information from many sites in Turkey and beyond its borders. Although archaeological research in the last 50 years in Anatolia has created a great amount of additional data, Naumann's research remains to be the only study, explaining the basic principles and connections. No other researcher since created a similar inventory for Anatolia and the Near East.

This paper focuses on a presentation and evaluation of Naumann's work on historic mudbrick architecture in Anatolia, and especially, on the use of timber elements as beams (*hatıl*s) in masonry. Naumann looked at examples from the Neolithic period to the end of the Hittite and Neo-Hittite Period, roughly from the 4th millennium to the 9th century BCE, and compared his findings with contemporary local rural or vernacular examples. Evidence for timber beams was present in archaeological finds. However, the beams themselves did not survive; they were completely deteriorated or burnt, leaving voids and sometimes imprints on the mudbrick masonry surfaces (Fig. 1). Timber beams were used between stone wall footings or foundations and mudbrick walls; horizontally, parallel and sometimes vertical to wall faces to strengthen the masonry, also creating timber support grids; and/or vertically to support walls, sides of openings, and timber superstructures. There were also examples where the timber system was defined as a "half-timbered" structure and evidence for horizontal and vertical ribbing for roofs and claddings. Naumann's research identified examples from different building types and different sites in Anatolia and the Near East, including city walls, palaces or megarons, storerooms etc., mostly from the Bronze and Iron ages in Troia, Hattusha, Kültepe, Zincirli, Tell Tayinat, Tell Atchana and Tell Halaf and supported with earlier examples from the Chalcolithic and Neolithic periods from Can Hasan, Beycesultan, Çatalhöyük, Hacılar etc.

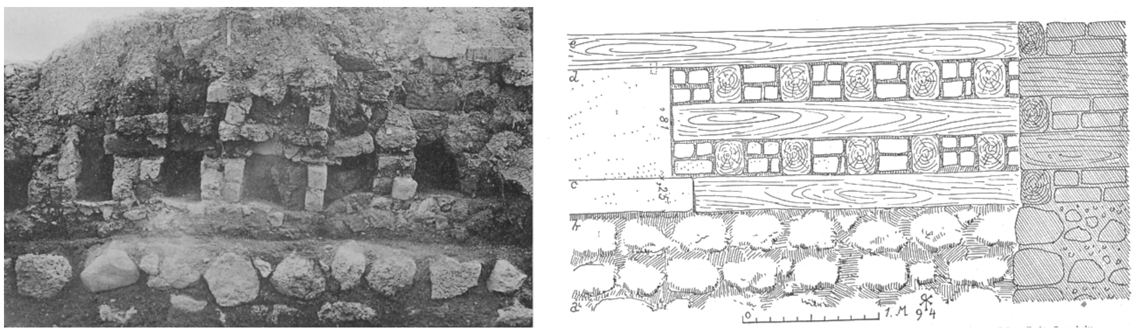

Figure 1. Zincirli, detail photograph from the Lower Palace, Hilani III, Tower B, showing a deteriorated and deformed timber beam, *c*. 25cm high, placed horizontally along the wall face and the voids left from the other beams placed vertical to the wall face in masonry which were probably rounded (a; left) [1]; and reconstruction drawing for the same wall elevation and section, also showing the beams between the stone footing and the mudbrick wall (b; right) [2].

2. TIMBER SUPPORTS IN MUDBRICK MASONRY

2.1 Timber Beams in Stone Masonry and Between Stone Footings and Mudbrick Structures

Stone walls, especially constructed with smaller and/or unshaped units, often had timber beams as well. Such beams were also instrumental in achieving leveling of the wall and the stone courses. Because mudbrick walls usually had timber support systems in order to minimize the wall thickness and stabilize the walls against lateral loads such as wind and earthquakes, timber bases were necessary underneath these more or less skeletal or box-like structures. These beams separated the mudbrick wall systems from the stone footings and levelled the upper structure (Figs 1b and 2a). There were also cases where the mudbrick masonry was located directly on the stone footing without any timber beams or structural elements (Fig. 2b). Remains of earlier buildings were also used as stone footings in some cases (Fig. 2c). In larger and more substantial buildings, there may be larger beams and complex systems (Fig. 3).

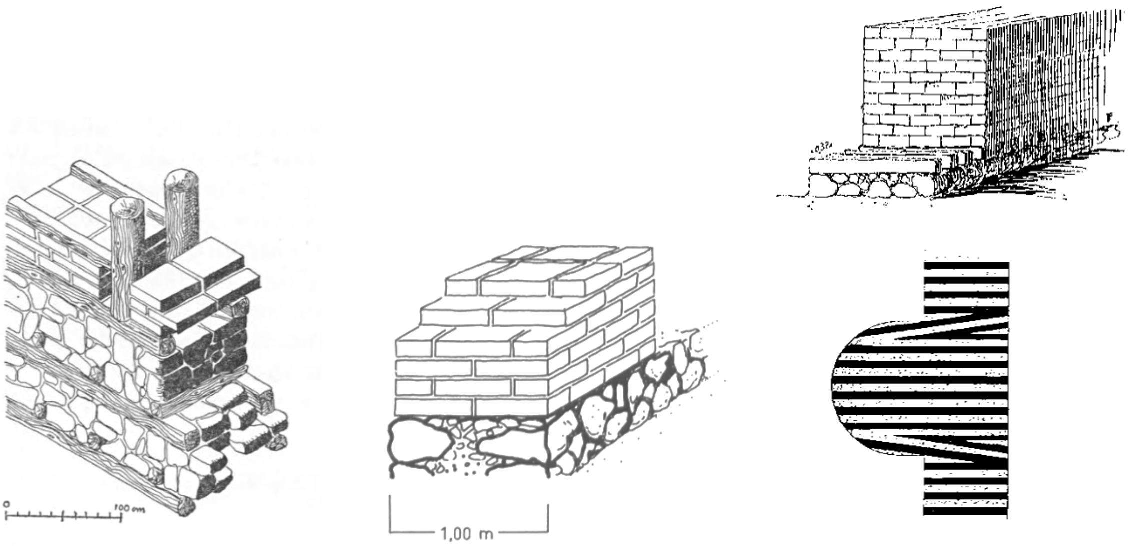

Figure 2. Beycesultan, Palace in Level V, courtyard I, detail from the courtyard wall [3] (a; left); Boğazköy/Hattusha, building in Level II with mudbrick masonry directly placed on the stone footing [4] (b; center); and Zincirli, mudbrick citadel wall on the stone wall of an earlier building separated with timber ribbing [5] (c; right).

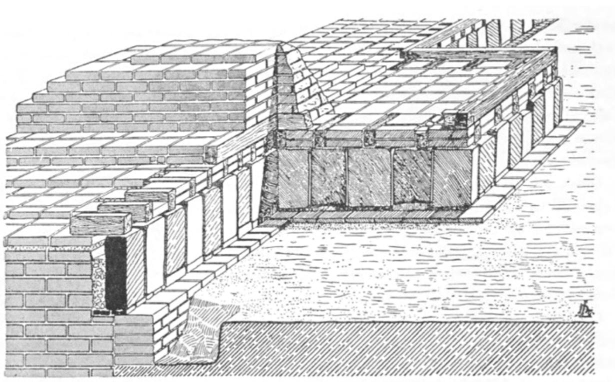

Figure 3. Tell Halaf / Guzana, Palace and Temple Complex in Level II, timber beams over orthostats on the south façade [6]. This timber supporting grill, 50cm in depth, could serve to support the mudbrick walls over them even if the orthostats were pulled out while making efficient use of available wood.

In Beycesultan, there were horizontal timber beams in the stone masonry of the foundations, and also a series of thick timber beams underneath the stone footings (Fig. 6b). these probably served the purpose of leveling the ground as well as creating a more stable base for the building on problematic soil. Because these underground beams continued underneath the spaces as well, Lloyd also argues that these were bases for "heating passages", forming channels with joist placed above or, alternatively, these chambers were later filled with mud [7].

2.2. Horizontal and Vertical Timber Beams in Mudbrick Masonry

Timber beams in different directions were often used in mudbrick masonry. They may be placed horizontally, along the wall faces (Figs 2a and 4); again, horizontally but perpendicular to wall faces, joining the beams parallel to the wall faces, forming grid systems (Figs 1b, 5 and 6); vertically to support wall corners, joining walls and the sides, of openings in the walls such as doors and windows (Figs 4a, 7 and 8). Horizontally placed timber grids, examples of which were seen in Troia (Megaron IIA in Level II) and Zincirli (Hilani III, Tower B and Lower Palace) [8], levelled and tied the walls whereas horizontally and vertically combined three-dimensional systems in masonry must have strengthened the walls against lateral loads and buckling.

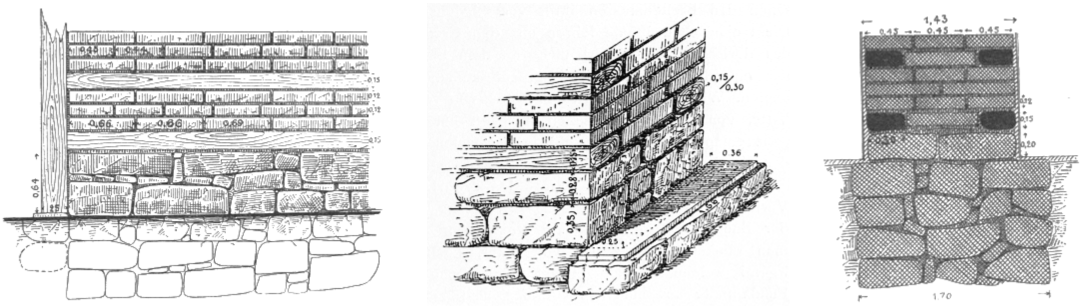

Figure 4. Troia, Megaron IIA in Level II, front room (*Vorhalle*) mudbrick masonry wall with horizontal timber beams, placed parallel to the wall faces [9]. The mudbrick walls were 1.43m thick with a stone socle of the same width and 1.70m wide stone foundation wall underneath. The timber beams were 30cm wide and 15cm high, placed at intervals of *c*. 41cm or three courses of brick. The timber *anta* or *parastas* in front is visible on the left.

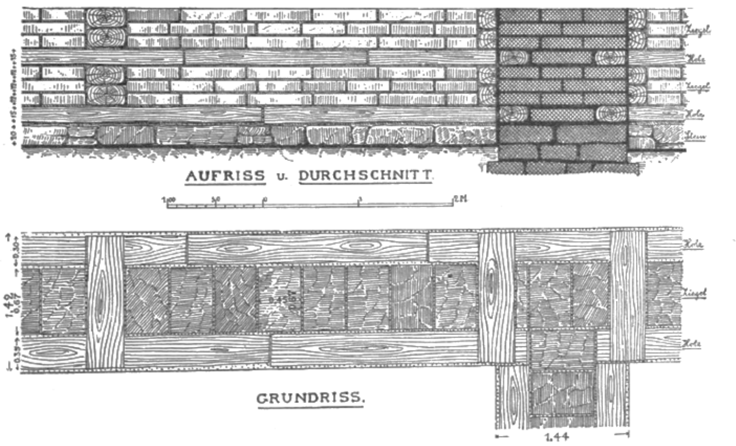

Figure 5. Troia, Megaron IIA in Level II, inner room, mudbrick masonry wall with horizontal timber beams, placed parallel and vertical to the wall faces, forming a two-dimensional levelling and structural strengthening grid [10]. The mudbrick walls were 1.49m thick. The timber beams were *c*. 30-35cm wide and *c*. 15cm high, located at an interval of three courses of bricks with two beams placed vertical to the wall face in each interval. The transverse beams perpendicular to the wall faces were located at *c*. 4m intervals. The beams were connected at the wall corners.

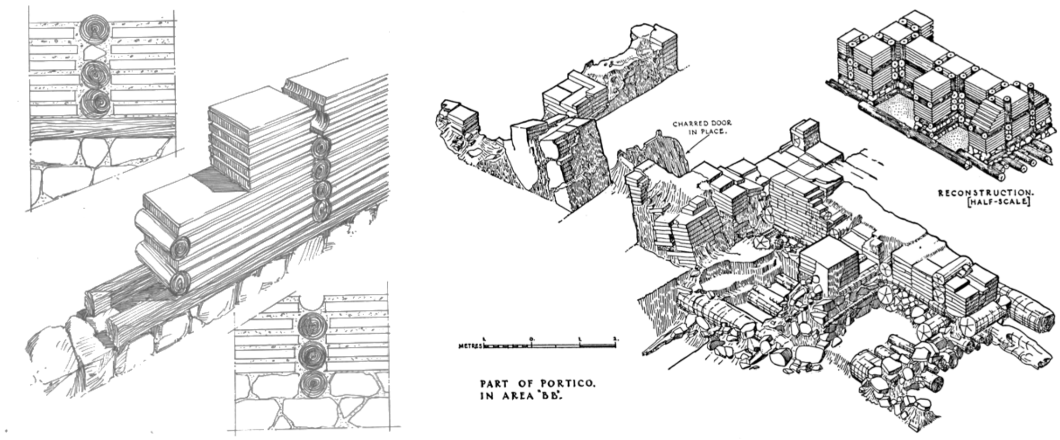

Figure 6. Kültepe/Kanesh, horizontal beams located perpendicular to the wall surface in mudbrick masonry with parallel beams between the stone footing and the mudbrick wall [11] (a; left) and Beycesultan, horizontal beams in mudbrick masonry in Level II [12] (b; right). The timber beams are circular in section with little shaping, if any.

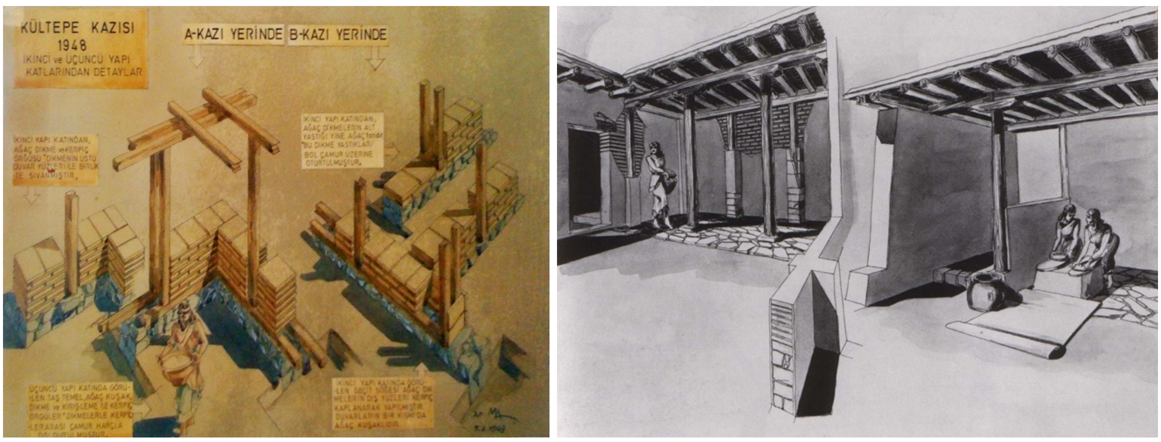

Figure 7. Kültepe/Kanesh, mudbrick masonry walls with vertical timber supports, also on the sides of the door and window openings from the Assyrian colony (Karum) period [left: 13; right: 14].

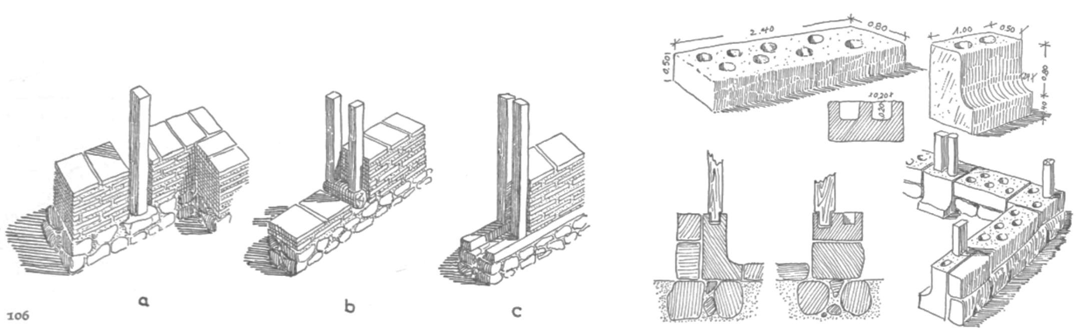

Figure 8. Kültepe/Kanesh, mudbrick masonry walls with vertical timber supports, also on the sides of the door and window openings from the Assyrian colony (Karum) period (a; left) [15]; and Alacahöyük, stone sockets for vertical timber supports in mudbrick masonry (b; right) [16].

Stone walls were also used to strengthen mudbrick walls and support the sides of opening in some cases (Fig. 9). Mudbrick was used as a filling material in large cassette walling, perhaps as a cheaper and more efficient solution. There are examples from Boğazköy/Hattusha in Naumann's work. Another well-known later example is from the Medieval citadel of Konya, where the mudbrick infill is exposed inside the tower underneath the Kılıçarslan II Kiosk.

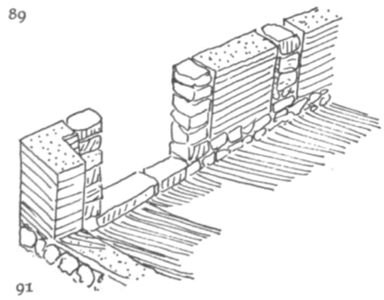

Figure 9. Kültepe/Kanesha, mudbrick wall supported with stone walling [17].

The more developed technology was the so-called half-timbered systems with three-dimensional skeletal structures (Fig. 10a); using this technology it became possible to build much thinner walls. These systems may still be seen in most vernacular and traditional architecture in Anatolia, in those areas where timber was available in abundance. The timber beams sometimes were shaped into square sections, and other times used in circular sections with minimal shaping (Figs 6 and 8). There was evidence for horizontal and vertical ribbing for wall claddings. Horizontal beams vertical to the wall surfaces but placed at the edge of the walls must have supported the exterior claddings, such as the *anta*s on the front side of the megarons (Figs 4a and 10b).

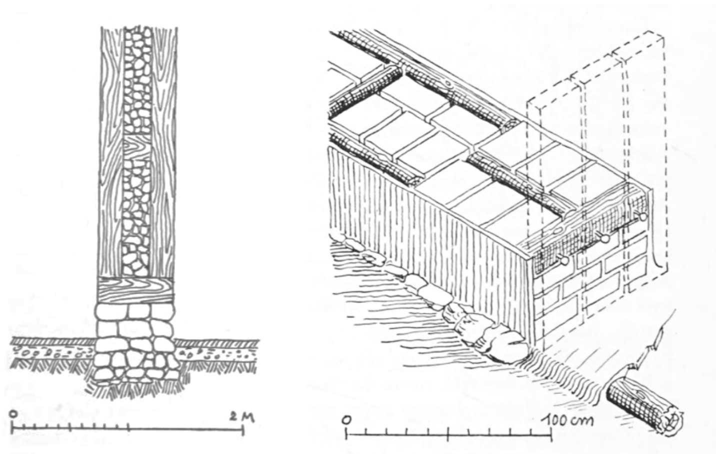

Figure 10. Tylissos on Crete, half-timbered mudbrick masonry wall (a; left) [18] and Beycesultan, the timber *anta* or *parastas* of Megaron A in Level IX (b; right) [19].

2.3. Timber Supported Superstructures on Mudbrick Masonry Buildings

Vertical timber supports within the masonry or freestanding on its side were also required to support the superstructure (Fig. 11). Depending on the roof span, additional timber columns were required inside the spaces in order to support the roof beams (Fig. 8). The roof beams were supported with corbelled partial horizontal or diagonal beams (Fig. 12). The shape of the superstructure was another concern. In the earlier periods, especially the Bronze Age, flat roofs covered with earth/mud were probably more common. Evidence for such roofing could be gathered from burnt pieces of the roof covering recovered; these sometimes have burnt imprints of woven matts, used underneath the mud. The tradition of flat earth roofs continues in many places in Anatolia with mudbrick architecture. There was evidence for horizontal and vertical ribbing for ceiling claddings in different examples as well (Fig. 12).

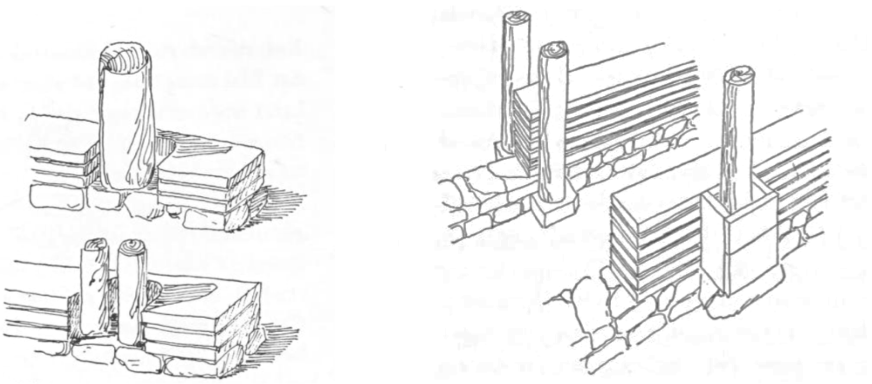

Figure 11. Kültepe/Kanesh, vertical timber supports or columns inside the mudbrick masonry (a; left) [20]; and freestanding on the sides of the wall (b; right) [21]. These elements' primary purpose must have been supporting the spanning roof beams.

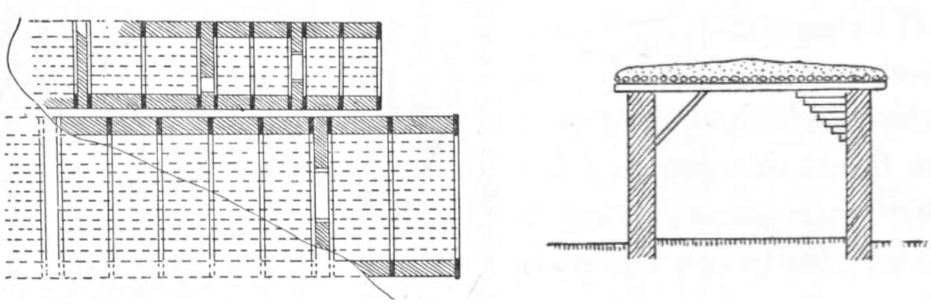

Figure 12. Troia, Megarons IIA and IIB in Level II, evidence and reconstruction for the corbelled horizontal or diagonal beams supporting the spanning roof beams and timber ribbing for ceiling cladding; plans of Megarons IIA and IIB (a; left) and reconstructed section for IIA (b; right) [22].

3. CONCLUSION

Rudolf Naumann worked in Anatolia for a long time. He was the director of the German Archaeological Institute (DAI) in Istanbul between 1961 and 1975, during which period he also taught at Istanbul University. He directed the excavations at Myrelaion in Istanbul, Didyma and Aizanoi. Earlier, as a research associate of DAI, he worked at various sites, including Boğazköy/Hattusha with Kurt Bittel, Kommagene and Nemrut Mountain with Friedrich Karl Dörner, Agora in İzmir/Smyrna with Selahattin Kantar, and Euphemia Church in Istanbul Hippodrome with Alfons Maria Schneider and Hans Belting. Outside Turkey, he worked at Takht-i Suleiman with Hans Henning von der Osten. [23]

For the first German version of the book published in 1955, Rudolf Naumann stated that he collected data over a decade. For the second German version published in 1971, he added data from more recent publications. He used published material beginning from the end of the 19th century for the drawings in his book. Concerning the subject discussed here, these are partial reconstruction drawings showing technological details in plan, elevation and axonometric forms. Some of these drawings are reproduced in this paper from the original sources, as indicated in the references. Due to the reproductive nature of the book, the styles differ in details of architectural expression.

In the past 50 years since early 1970s, the corpus of archaeological research in Anatolia has grown considerably. Many new sites are being excavated, where data is being collected and published. Archaeological research does not focus solely on monumental buildings anymore, but also covers ordinary residential areas and houses. However, the problem about the data and research concerning architectural materials and technologies persists. No other work, similar to Naumann's in terms of context and content, has been published. A comprehensive study with a similar scope, perhaps focusing on subsidiary geographical areas and their materials and technologies would be a valuable addition to literature. Such research would also make it possible to draw connections between the older examples and the more recent rural and vernacular ones, also showing the way forward for contemporary sustainable architecture.

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[12] Naumann, *ibid*., p. 104, Res. 97

[13] M. Akok, partial architectural reconstruction drawing, colored, signed and dated 1948, from the Kayseri Archeological Museum; also published in T. Özgüç, *Ausgrabungen in Kültepe 1948*, vol. V, no 10, TTK, Ankara, 1950.

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[16] Naumann, *ibid*., p. 110, Res. 108.

[17] C. Goff, perspective drawing, published in Lloyd, *ed.cit.*, p. 36, fig.3; reproduced in Naumann, *ed.cit*., p. 100, Res. 91.

[18] Naumann, *ibid*., p. 110, Res. 107.

[19] Naumann, *ibid*., p. 109, Res. 103.

[20] Naumann, *ibid*., p. 109, Res. 105.

[21] Naumann, *ibid*., p. 109, Res. 104.

[22] Naumann, *ibid*., p. 103, Res. 95.

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Paper Number: 28

An Investigation on Translucent Adobe as an Exterior Wall Material


Elif Yapıcı, Çetin Süalp
Mersin University, Mersin
Gebze Technical University, Kocaeli
elifyapici@mersin.edu.tr - elifyapici96@gmail.com

ABSTRACT

Exterior walls have many functions and a great influence on spaces since they are the borders between interiors and exteriors also, represent the culture or some messages as an "interface" for the observers. All these functional requirements and meanings have shaped the exterior wall throughout the history by means of both the construction techniques as well as the materials. The need of getting light into spaces was achieved through windows in the early eras of the history of architecture but the desire of letting more sunlight in or having an uninterrupted relationship with surroundings made many kinds of translucent and transparent materials being used for exterior walls. For adobe as an exterior wall material, there are many studies to enhance its insulation or mechanic performance using different kinds of reinforcements but the possibility of it becoming a translucent material still remains undiscovered. There are some studies on translucent concrete, which includes recycled glass aggregates, plastic optic fibers or glass fibers also on providing translucent wood by adding some polymers while excluding lignin. It is thought that it can also be possible to produce translucent adobe too by using some reinforcements or additives. This study aims to investigate whether is it possible to make adobe as a translucent material and what would be the advantages or disadvantages of using this material in building exterior walls in means of performance requirements and ecological sustainability.

Keywords: exterior wall; material technology; translucent adobe; reinforcements for adobe.

1. INTRODUCTION

Earth is such a kind of construction material that is used by a third and a half of the world's population (app. three billion people from six continents) to create liveable spaces [1]. With the emerging technologies, novel approaches are demonstrated to enhance the quality of built environment. As it is known that walls that are produced from earth material does not allow large openings for light and ventilation due to its structural features. Therefore, it is needed to create more livable spaces for people with the help of new technologies. The use of translucent materials still shapes the architecture by means of both experiencing spaces throughout the cyclical change from morning to evening, which are varied still further with the weather and the seasons of a year also getting the performance requirements at the same time aiming to sustain these performances. In this paper, it is investigated that how earth walls can be translucent to enhance the indoor visual quality. The ways to create translucent earthen walls are explored. At first, the techniques that make earthen walls translucent are classified according to the defined techniques. Then the suitable technique is examined from several ways and sustainability of the technique is also discussed.

2. TRANSLUCENT WALLS

Ever since humankind started to constitute habitats to achieve their needs in the form of comfortable space, the need for letting light, air, heat or cold in were distinct requirements expected from the shell of that shelters. The desire and need of getting light into spaces has been achieved through windows using thin slabs of marble, sheets of mica or oiled paper until the development of glass. Glass has been also used as infill material of curtain walls since when the modern movement started to manifest itself with new construction techniques that started to become available [2]. These techniques and new facade systems have been followed by the developments in material technology. Today it is possible to construct facades that are visually open, which directly transmit the light (transparent) or visually open in different ratios, which capture, manipulate, and disperse the light (Figure 1). They have integrated steel load bearing systems or frames to transfer the loads to structure systems of buildings within [3].

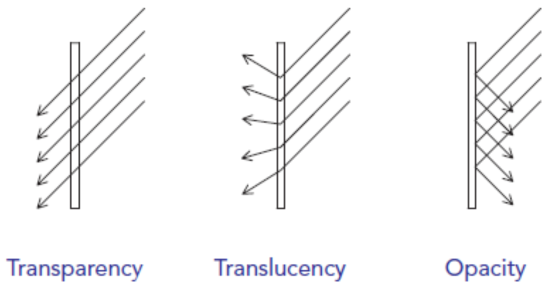

Figure 1. A demonstration of the terms; transparency, translucency and opacity in means of light transmittance [3].

It can be stated that there are two essential methods to create a translucent wall. One of them is to make the building material translucent and the study is within this scope. The other method is creating links to transmit the light between two sides of a wall. There are fewer examples for this method. There is a technique called "bottle wall", which is creating a wall using adobe or another opaque material and including plastic or glass bottles inside while constructing the wall. The bottle wall technique was used in a daycare center, which was built in Chimundo, Mozambique in 2009 (Figure 2, left) [4,5]. Translucent building materials are being obtained by either applying different kinds of surface treatments and coatings to glass (etched glass, sandblasted glass, dichroic glass) or creating polymer-based materials (PMMA, PC, ETFE) or combining these materials by creating laminated panels [6]. It is also possible to make an opaque material behaves like a translucent material in terms of light transmittance and it can be achieved either by cutting the material as thin layers (for example marble or wood), by adding different kinds of reinforcements (like glass fiber into concrete) or by changing the chemical structure of the material (excluding lignin from wood) (Figure 2, middle & right) [7,8]. Adding reinforcements that transmit the light, works in a similar way to the second method mentioned above since both bottles and glass fibers create links between interior and exterior to transmit the light but the bottle wall technique can't be counted as making a translucent material since bottles are joining to the wall in later steps of construction process than the fibers. Also there is a difference in means of scale of these addings, makes fibers can be counted as reinforcement and bottles can not.

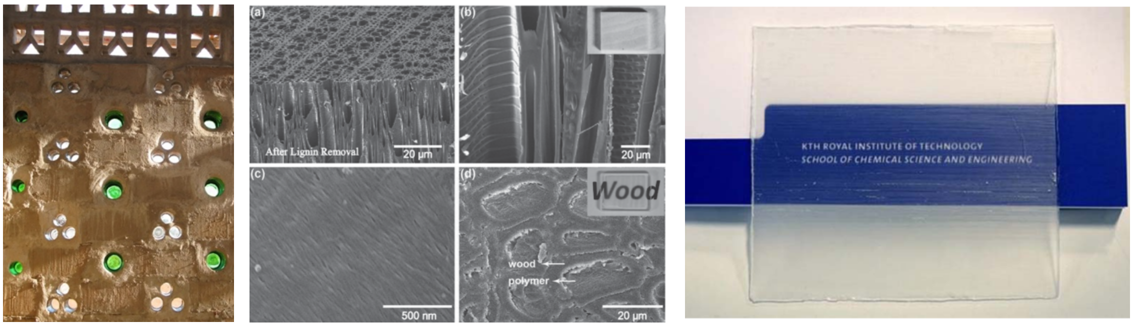

Figure 2. Bottle wall of Daycare center in Chimundo, Mosambique (left) [4], the process of lignin removal from the wood (middle) [7], the translucent wood sample created at KTH (right) [8].

Creating translucent facades by obtaining translucent materials is a commonly used technique and construction technology has already been improved by applying the materials like PMMA, PC, ETFE or treated/coated glass. On the other hand, making an opaque material behaves like a translucent material has still much more to explore. One of the earlier and well known examples of this approach can be The Pius Church, which was built between 1961-66 in Meggen, Switzerland by Franz Fueg (Figure 3). The translucent Greek marble slabs that have 28 mm thickness are used to cover the facades of the Church [9]. The Beinecke Rare Book & Manuscript Library designed by Skidmore, Owings and Merrill has constructed in the same era in 1960s and is a modern building still stands like a monument in Yale Campus, USA. The dead load of grey veined white marbles with a 30 mm thickness is transferred to a system of prefabricated steel trusses that transfer the weight to the four enormous concrete piers that stand at each of its four corners. This facade system provides controlled ambient lighting without the direct exposure of sunlight and thanks to nature of the material, marble gives an amber glow to the interior of the building when sunlight hits the faces of the building (Figure 4) [10].

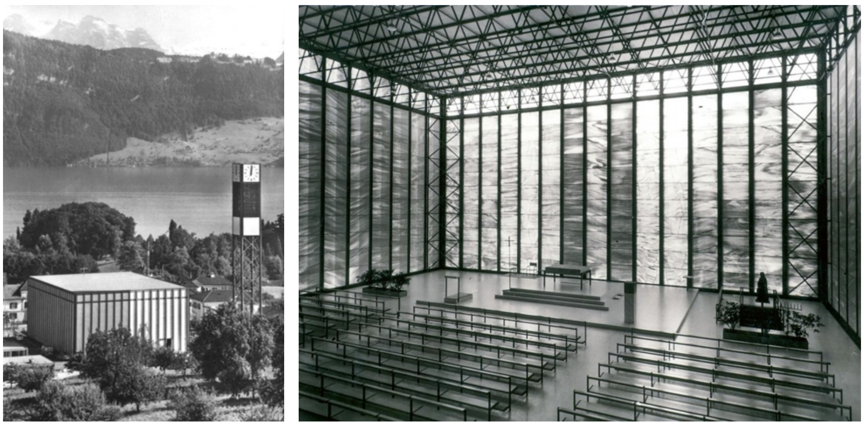

Figure 3. The exterior [11] and interior photographs of Pius Church built in 1960s in Meggen, Switzerland designed by Franz Fueg [9].

Figure 4. The exterior and interior photographs of Beinecke Rare Book & Manuscript Library built in 1960s in Yale, USA designed by SOM [10].

There are also few built examples that using optical glass fibers and polymer-based optical fibers can transmit light as a reinforcement to concrete. The main entrance door of Museum Cella Septichora can be given as an example, which consists of Litracon Classic blocks that have 10 cm thickness. To construct the panels, 4% glass optical fiber and 96% concrete was used (Figure 5, left) [12]. Another example that have been built in Jordan using glass fiber reinforced concrete panels is 14 meters high stairwell of Amman Capital Bank; made of 30 mm thick light concrete panels which mounted on a steel structure above undercut anchors (Figure 5, middle & right) [13]. Even though there are built examples, it still seems like glass or plastic reinforced concrete is not available to apply in large scales or without a supporting load-bearing system. To widen the usage of this material it is necessary to study and improve the structural performance of this material. Therefore, a study found on the literature exhibits that translucent concrete containing 2%, 4%, and 6% volume ratios of plastic optical fibers has a lower compressive strength, significantly decreased flexural strength, ending moment, shear stress, normal stress, and bending stress carrying capacity but on the other hand better ductility and energy absorption and higher flexural toughness comparing the opaque concrete [14].

Figure 5. The main entrance door of Museum Cella Septichora (left) [15], the translucent concrete facade of Amman Capital Bank (middle & right) [13].

3. INVESTIGATION OF THE PRODUCTION WAYS OF TRANSLUCENT ADOBE

Due to mainly their load-bearing function, the walls constructed using adobe as the wall material have a thickness (approximately 50 cm) that does not provide translucency via the thickness of the wall. On the other hand, the method of creating connections to transmit the light between two sides of the wall appears to be the best method for adobe walls. As mentioned in the previous chapter, it has been applied in larger scales of connections such as bottle walls but if we consider the fiber optics at the same principle in a different scale there is no example or a study found in the literature that investigates this method.

Before the investigation of how to apply and why should this method be improved, it is crucial to consider the traditional techniques that have been used to build adobe walls and their potential for the subject of this study. Mainly two conventional methods are used in architecure: pouring earthen material into a formwork (rammed earth) and laying adobe bricks to create a wall [1,16]. Rammed earth is a method in which the entire wall is casted in several steps and the result depends mostly on the success of workmanships unlike the adobe brick technique. Also, it seems hard to hold the fiber optics in tension in the formwork of the entire wall. However, since hundreds of bricks are casted for a building in adobe technique, it can be predicted that the production will be much faster and more practical in the context of making a single formwork that the stretched fiber optic cables are placed in each formwork and using them repeatedly.

Considering the literature review it is thought that including optic fibers into adobe will decrease its structural strength, just like it does for concrete, in means of compressive and flexural strength also bending moment and stress carrying capacity. It may still enhance the ductility and energy absorption while providing higher flexural toughness at the sime time. However, it is not possible to predict the affect of adding optic fibers into adobe in means of thermal performance since there is no study that investigates thermal properties of these kind of reinforcements. Still all these changes in behaviour of the material can be optimized and combined with other reinforcements already being used to improve adobe's structural and thermal performances.

4. CONCLUSION

In the paper it is investigated that to enhance the indoor environmental quality in earthen architecture via the improvement of lightning. With the emerging technologies of materials especially for concrete, the ways to create translucent walls are demonstrated. Therefore, the answer of the possibility to produce translucent walls are discussed. Investigation of optical fibers usage within the scope of earthen material becomes an interesting approach in that it brings together hi-tech fiber optics and lo-tech earth construction techniques (Traditional materials and current research).

In this way, it seems possible that the usage of earth material in architecture, which has thick walls due to the structural reasons and only allows a small number of openings, can be transformed into contemporary spaces. At the end of the life of a building, since it is thought that there will be no adherence problems between the materials (plastic and soil), fiber optic cables can be easily stripped from the soil and gathered, thus preventing any possible the environmental pollution.

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Paper Number: 30

The use of hemp as a sustainable building material and its potentials in Turkey



Hasan Taştan, Nazlı Arslan, Esin Yılmaz
Yıldız Technical University

hasantastan88hotmail.com
nazliarslan89@gmail.com
esinylmaz3@gmail.com

ABSTRACT

One of the most destructive and extensive interventions of mankind in the environment is the construction activities. Concrete is used in most of these construction activities today. Looking at the manufacturing process of concrete and its components, it is a building material that is far from sustainable, as it requires a lot of energy and has a strong impact on the environment. The increasing environmental problems make it necessary to reconsider natural, sustainable, harmless to human health and traditional building materials with modern techniques. In this context, practices that focus on energy savings and human health in the production and use of buildings are gaining importance. The hemp plant, a fiber crop that has been cultivated by humans for about 10,000 years, is used in many fields such as textiles, cosmetics and food. Hemp is a fast-growing renewable resource that can be cultivated in most regions of the world. Hemp, which has been rediscovered as a building material in Europe in recent years, can be used to make insulation and filling materials, as well as building materials similar to concrete and brick. Legal regulations and incentives for the use of hemp are being created worldwide, and research is being conducted into the efficient use of the material. This study first gave examples from the literature on the use of hemp plants such as hempcrete (hemp concrete), hemp wool, fiberboard, insulation material and evaluated the use of hemp as a building material in the context of sustainability. Hempcrete, first used in France in the 1990s, is a carbon-negative, lightweight and environmentally friendly building material obtained by mixing hemp stalks with lime. The material can be used in the form of blocks or as a filler material, as well as in plaster or spray molds. Hemp wool is used for the production of thermal and sound insulation panels, which can be used on ceilings, walls and floors. The study also discussed the production and use of hemp in Turkey, evaluated the relevant regulations, and made suggestions for its widespread use. It is recommended that regulations and incentives be established for the use of hemp as a building material, which is produced in 19 cities in Turkey. As a result, the use of hemp in construction enables the realization of energy-efficient, economical, thermally and acoustically efficient and healthy constructions and contains potentials in the context of meeting sustainable development goals. Hemp can be an alternative to concrete as an economical, safe and healthy local building material in Turkey.

Keywords: Sustainability, Hempcrete, Building materials

1. INTRODUCTION

The construction sector, whose energy consumption is increasing with increasing population and urbanization, is responsible for 11% of the greenhouse gas emissions that cause global warming [1]. Following the climate agreements, many countries have developed guidelines aiming to reduce energy use in buildings, and thus, research on new construction methods to minimize energy consumption has become a priority [2]. In the construction industry, reducing energy requirements, damage to nature and carbon footprint is desirable. Since most of the building materials used in construction, such as concrete and cement, are materials that emit substances that may pose a danger to the environment and human health, there is a need for alternative sustainable materials [3]. In this context, hempcrete, a biobased material with low carbon emissions, can contribute to making construction processes more sustainable. While the hemp plant cleans the soil from pollutants, it also cleans the air owing to its high carbon absorption [4]. Buildings constructed with hempcrete create a healthy environment while continuing to clean the air, and at the end of the life of the structure, it disappears in nature on its own. Hemp became popular again and its use in the construction sector became widespread thanks to the innovations realized in the early 1990s when hempcrete (hemp-lime) was discovered in France and started to be used in buildings [5]. However, hempcrete has been used professionally in the last 20 years [6]. Hempcrete and similar hemp-based building materials are used as infill walls, hempcrete blocks, insulation materials, sprayed hempcrete and prefabricated panels. In addition to building carbon-negative structures with hempcrete, inefficient former structures can be renovated to become more sustainable structures [7]. New product development studies for the use of hempcrete in modern buildings are ongoing. The widespread use of the hemp plant, which has a deep-rooted history in the memory of Anatolia and is used in many fields, in the construction sector will bring socio-cultural and economic development in different fields. In this context, it is important to investigate the ways of using hemp in construction and the advantages it provides, to investigate the use of hemp as a building material in Turkey, and to determine the necessary legal regulations.

2. PROPERTIES OF HEMP AND HEMP PRODUCTION

Hemp is a plant that can be evaluated separately with its fibre and seeds. Seeds, stems and leaves of hemp plants are used in different fields and provide economic benefits [8]. Hemp, native to Asia, is an annual and summer plant of the Cannabaceae family. Cannabis (Cannabis) has subspecies Cannabis sativa and Cannabis indica. Especially Cannabis sativa is a species with high economic value and can be used in different manufacturing fields. It is known that hemp cultivation and production on a national scale dates back to Ottoman times. Hemp, one of the most important crops, is widely cultivated in Samsun, Sinop, Kastamonu, Amasya, Çorum, Tokat, Yozgat, Ordu, Burdur, Urfa and Malatya. Hemp, which is frequently used in the production of fabric, rope and sacks as well as navy, was also used in local paper factories producing fiber and cigarette paper until the recent past [9]. Hemp is used in different manufacturing and industrial fields today. There are different usage fields including clothing, paper, construction materials, automotive, fuel and food products. As it is an environmental, renewable and recyclable resource, it contributes to both economic and environmental sustainability [10]. The fibres obtained from hemp stalks can be used in rope, twine and fishing nets. In addition, fibres are used as construction and insulation materials and seeds are preferred in cleaning and cosmetic products. Extracts obtained from seeds are used as an important raw material in the pharmaceutical industry. It is also used in biofuel production due to its high productivity and high cellulose content [11]. In addition to providing economic benefits, hemp also points to a sustainable cycle in terms of its requirements in the production chain. The advantages of hemp fibre production are that it does not require high water consumption, can be grown without the need for fertilisers and pesticides, and is a plant suitable for crop rotation. Especially the strength, durability, insulation, acoustics and resistance to ultraviolet rays of industrial hemp fibres highlight their use as building materials [11]. In fact, the strength of hemp fibres enabled Henry Ford to develop a car prototype from biological alloy materials in the 1930s [12].

The history of hemp production dates back to 8000 BC. Hemp is the raw material of 80% of textile products in the world until the end of the 19th century. As of the beginning of the 20th century, the effectiveness of hemp production decreased with the introduction of cotton fibre. In the 1930s, anti-marijuana policies and the use of synthetic fibre narrowed the production areas [13]. Being a plant that can be used in different fields from the pharmaceutical industry to the construction industry has made hemp and its related products one of the most traded products worldwide. According to global knowledge, the trade of hemp and hemp-based products was over 8.1 billion dollars in 2020 and this figure is estimated to be more than 65 billion dollars by 2026 [9]. According to the hemp cultivation regulation in Turkey, the provinces where hemp cultivation is permitted here are Amasya, Antalya, Bartın, Burdur, Çorum, İzmir, Karabük, Kastamonu, Kayseri, Kütahya, Malatya, Ordu, Rize, Samsun, Sinop, Tokat, Uşak, Yozgat and Zonguldak. Although production outside these provinces is prohibited, the ministry may grant permission for production for scientific research purposes, provided that the provisions specified in the regulation are complied with [14]. Although hemp has been produced in our country for many years, it is understood that there has been a decrease in production over the years.

3. USE OF HEMP IN BUILDING CONSTRUCTION PROCESSES

Although the use of the hemp plant as a building material is quite old, the plant has been rediscovered and revalued in the last 20 years. Together with binders such as lime, clay and earth, hemp is used as an insulating material for ceilings, walls and floors. This study focuses on the construction techniques and building materials developed with a lime-hemp mixture. Today, hemp is used as a building material in the form of in-situ concrete, hemp concrete block, prefabricated walls and panels, hemp wool and spraying hempcrete.

Hempcrete (Hemp-Lime): When the stem of the cannabis plant (Cannabis Sativa), a binder such as lime and water are combined, hempcrete is obtained. Hempcrete, a biobased material, is a natural, carbon-negative building material whose use has increased in recent years [15]. Hempcrete is a unique building material that is a combination of a bio-fiber (hemp hurd or shiv) and a mineral binder (lime). These ingredients are mixed with water and the moistened binder covers all the particles of the hemp blade. A chemical reaction occurs between the lime binder and water, causing the binder to harden and the scrap particles to stick together [16] (Figure 1).

Monolithic Cast Walls (Cast in Place): Cast in place is an installation technique that involves using form boards and packing the hempcrete in between form boards to create walls. In-situ pouring method is applied by preparing the hemp, water and lime mixture in the construction site by hand or with the help of a mixer machine and pouring it into molds. Wooden or metal molds are placed where the wall will be formed and the mixture prepared gradually is poured. Molds can be removed after 24 hours. This is the most artisanal approach to hempcrete, however it can be labor intensive [17]. This process is economical as it is carried out on the construction site. After the molds are removed, they are left for several weeks, then a finishing lime / clay plaster is applied. In addition, wooden or stone facade cladding can be used [18].

Hempcrete Block: Producing Hempcrete outside the construction site and bringing it to the construction site ready for use provides various advantages, especially speed and ease in production. The fact that the supply and assembly of ready-made blocks can be done quickly enables this method to compete with other precast construction methods [16]. Hempcrete blocks are connected to each other with lime mortar and lime plaster is applied (figüre 2). The blocks are often used as insulation for exterior and interior walls, as well as floors and roofs. While saving labor and time compared to Cast in Place hempcrete, hemp block has a smoother surface as it is prepared in the factory environment. Binder/hemp ratio and hemp shiv sizes in hemp block vary.


Figure 1. Hemp, lime and hempcrete [19]. **Figure 2.** Hempcret Block [20].

Precast walls and panels: Similar to the hempcrete block, walls and panels can also be produced. These insulating walls and panels, produced in the factory environment, provide rapid construction of both sustainable and aesthetic-looking projects with their rustic appearance. The precast wall system is created by spraying hempcrete onto the metal or wooden frame created in the factory environment. Precast walls transported to the construction site provide easy and fast building construction (figüre 3).

Figure 3. Prefabricated Panel usage [21].

Hemp Wool: Hemp fibers can be used as a much more efficient insulation material than conventional insulation products without using any binder or with the help of very low binder. Natural Fiber insulation used primarily for exterior walls, including floors, ceilings, and partition walls. Pre-formed and flexible plant based insulation designed to be inserted by friction fit between wooden or steel frames [22].

Spraying Hempcrete: Spraying Hempcrete is a form of production in which hempcrete is pumped from a cement mixer through a hose and a spray nozzle. Hempcrete requires the use of industrial spray equipment to build the wall, saving time compared to using cast-in-place hempcrete. With this method, which is used in England and France, the application and drying times of the material are shortened, while the material used is of lower density, thus less material is used [16]. This method can be used on flooring and walls. The spraying method is mostly used in large-scale projects and renovation projects as it can be applied on existing materials such as stone and brick [23].

3.1 Hempcrete Propertıes

There are not many new building materials in the construction industry [16]. Because it takes time for a material to become standardized and accessible everywhere. However, environmental and economic concerns require the exploration of new material types. The features of Hempcrete that make it preferred by designers and users have been the subject of various researches. The widespread use of Hempcrete is possible by defining its properties and developing new hemp-based materials through innovation studies.

Density: Hempcrete has a porous structure thanks to the lime that surrounds the hemp shivs/hurds. And it weighs only one-eighth of the weight of normal concrete. Its low density makes it resistant to cracking, thus making it preferred in earthquake zones. Hempcrete reduces the emissions associated with the transport of heavy materials, reducing the energy required for construction [5]. It reduces the overall weight of the structure.

Locality: Industrial hemp can be grown in a wide variety of climates and soils, making it an excellent alternative as a local building material [5]. Locality means less transport costs and lower carbon emissions. In addition, the widespread use of hempcrete provides an increase in employment and welfare in the region due to the economic value of hemp.

Compressive Strength: The compressive strength of Hempcrete is approximately 1/20 of the concrete. It cannot be used in structural systems such as columns, beams [5].

Construction Cost: Since Hempcrete is a new and uncommon material, the construction cost is higher than reinforced concrete. However, it is also advantageous in the long term due to its insulation feature [24]. The fact that the cannabis plant, which can adapt to different climatic conditions, can grow almost everywhere, has the potential to reduce the transportation costs of the building material [4].

Sustainability: Hemp has a negative carbon footprint because it absorbs more carbon dioxide when it is grown than is later used to make building materials. Hemp concrete has high thermal insulation and heat retention. This reduces the need for energy [18]. The scrap used to make hempcrete is a by-product of industrial hemp production for hemp fiber and seed used in other areas. Hempcrete therefore makes hemp farming an attractive option and is a sustainable material [16]. It is completely biodegradable after the end of its building life [18]. It has a lower carbon footprint compared to traditional building materials; it is resistant to biodegradation [25]. Its resistance to fire, mold, fungus and moisture and its carbon-negative properties and ability to absorb carbon dioxide make hempcrete an ideal eco-material to reduce the negative environmental impact of the construction industry. It has a long service life and low maintenance cost [26].

Thermal and Acoustic Performance: Hemp concrete is a good thermal insulator, its heat storage capacity is certainly greater than mineral materials such as mineral wool. It provides thermal stability and saves energy costs [18]. Thanks to its porous structure, it provides heat balance by giving the heat it stores during the day to the environment when the air temperature drops at night. It has low sound and heat conductivity. It provides custic comfort in the space where it is used [25].

Moisture Handling and Resistance: Hemp concrete allows you to build healthy buildings thanks to its ability to absorb moisture from the air (hygroscopic). This helps passively regulate humidity and prevents condensation that can lead to toxin accumulation and mold growth [18].

3.2 Potentials and Threats

Used in a variety of industries, work is ongoing worldwide to adapt Hempcrete to many other potential uses [16]. Research on hemp and the production of innovative products is expected to increase in the coming years [2]. However, the acceptance and diffusion of a new material in the construction industry is a long process. Although hemp has regained popularity in recent years, it has a bad image due to its illegal use, which makes its development difficult and slow [23]. In Turkey, controlled production is allowed in 19 provinces. In addition, studies are being carried out to create an industrial hemp species with a low content of narcotic substances.

Table 1. Properties of hemp-based materials and advantages

Propertises	**Advantages**
Compressive Strength	Compressive strength is low. It has no carrier feature. It can be used in the construction of non-bearing walls in buildings and as an insulation material [5].
Eco-Material	It cleans the soil from pollutants and has a high carbon absorbing feature. It has a negative carbon footprint [4], [16], [25]. The cannabis plant grows fast and is an efficient building material [23]. It can be grown almost anywhere because it can adapt to different climatic conditions [5]. The plant needs little care and needs neither chemical fertilizers nor pesticides [27]. It is healthy, no chemicals are used in the production process. It does not contain toxic materials [16]. Lime in Hempcrete

	continues to absorb carbon dioxide for a long time [27]. The life cycle of hempcrete is about a hundred years and the destroyed structure is mixed with nature.
Moisture handling and resistance	It has high moisture retention thanks to its porous structure. Thus, it can remove indoor humidity from the building. It is a suitable building material for hot, cold and humid climatic regions [16]. It is a healthy building material that can breathe and pass steam [28], [23]. Since it contains lime, it prevents the formation of mold [2].
Fire Resistance	Since hemp fibers are covered with lime, the fire resistance is high [16], [25], [2].
Thermal Performance	Its thermal conductivity is low. It is a unique insulation material [16], [25], [2].
Acoustic performance	It has low acoustic conductivity. It provides sound insulation [16], [25], [2].
Structural life	Hempcrete is resistant to biodegradation [25]. The lifetime of the Hempcrete structure is estimated at 100 years. The lime it contains turns into limestone over time and becomes stronger.

4. CONCLUSION

This study demonstrates the usability of hempcrete as a building material. Hempcrete, an environmentally, socially and economically sustainable material, can be sprayed into an existing structure, compressed in moulds, used as blocks, as insulation material or as precast wall and panel systems. Hempcrete whose thermal and acoustic performance is much higher than conventional materials, is an alternative material that increases the energy efficiency of buildings while reducing environmental damage in building production processes. Its ability to quickly remove moisture from the structure thanks to its breathability, its resistance to rot, mould and fire makes it an excellent material for human health. On the other hand, the lack of carrier properties of hempcrete and the length of the application period are the main disadvantages. Although industrial hemp production is regal in some regions in Turkey and its use in different industries is increasing, it is not used as a building material due to the deficiencies in regulations and legal arrangements. Increasing the use of hempcrete in the construction sector can revitalise rural economies in parallel with the increase in hemp production. As a substitute for conventional building materials, hempcrete can reduce the burden on forests by reducing carbon emissions and energy consumption. The widespread use of hempcrete in countries such as France and the USA has been made possible by the involvement of managers, builders, hempcrete producers and insurance companies in setting professional production, design and application principles. In order for hempcrete to be widely used in Turkey, in addition to legal regulations, innovative studies and the production of products such as hempcrete block, hemp wool, wall panel and more interdisciplinary and transdisciplinary academic studies are needed. As a result, guidelines should be developed to facilitate the use of hempcrete in buildings and designers and contractors should be encouraged to prefer hempcrete.

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Paper Number: 31

Use of Adobe in the Kurul Fortress (Ordu, Türkiye)

Ahmet Emirhan Bulut
Dicle University, Faculty of Letters, Diyarbakır, Turkey
ahmetemirhan.bulut@dicle.edu.tr

ABSTRACT

Mudbrick is a basic architectural material that has been used for thousands of years to satisfy the human need for shelter. Mudbrick is still in common use, especially in rural areas, and can be considered a carrier of thousands of years of knowledge, tradition and culture – a phenomenon that can clearly be seen at Kurul Fortress – a Late Hellenistic period settlement (120–63 BC) that contributes significantly to the archeological knowledge of the Black Sea region. Aside from the large number of mudbrick fragments dislodged from the walls that have been found inside the rooms, thousands of mudbrick blocks that formed the walls have been unearthed in-situ. An analysis of mudbrick samples reveals them to be created from local soils, aggregates, and, in some samples, dried grass or straw. Considering the use of mudbrick for the construction of the walls of almost all of the structures of the Kurul Fortress, it can be understood that tens of thousands of mudbricks were produced, and when the time, climate, labor force and cost associated with mudbrick production is considered, it can be understood that a highly elaborate production process would have been required to support the construction of the Fortress.

This paper provides qualitative and quantitative information about the mudbrick blocks used in the construction of Kurul Fortress, which can be considered an important source of data due to the existence of in-situ mud-brick walls, of which there are few examples from the Hellenistic period. The acquired data can contribute further to literature through comparisons with other archaeological settlements in terms of the constructed architectural features.

Keywords: Kurul Fortress, Black Sea Region, Architecture, Hellenistic Period, Mudbrick

1. INTRODUCTION

The Kurul Fortress is located on the western bank of the Melet River, which separates Central from Eastern Black Sea, within the boundaries of the Altınordu district of the province of Ordu (Fig. 1). Situated about 9 km south of the Black Sea shore, the highest point of the castle has an altitude of 571 meters [1]. Perched atop a rock mass of andesite-limestone, the fortress has a length of 250 meters along the northeast-southwest axis, and a width of 20 to 45 meters along the northwest-southeast axis, with a long and narrow topography of settlement (Fig. 2). Towering above the large piece of land from the fortress to the sea, and with a view of the Black Sea and the Melet River, as well as the higher points of the Canik Mountains (Paryadres Mountains) thanks to its strategic location, the Kurul Fortress is an example of intentional settlement.

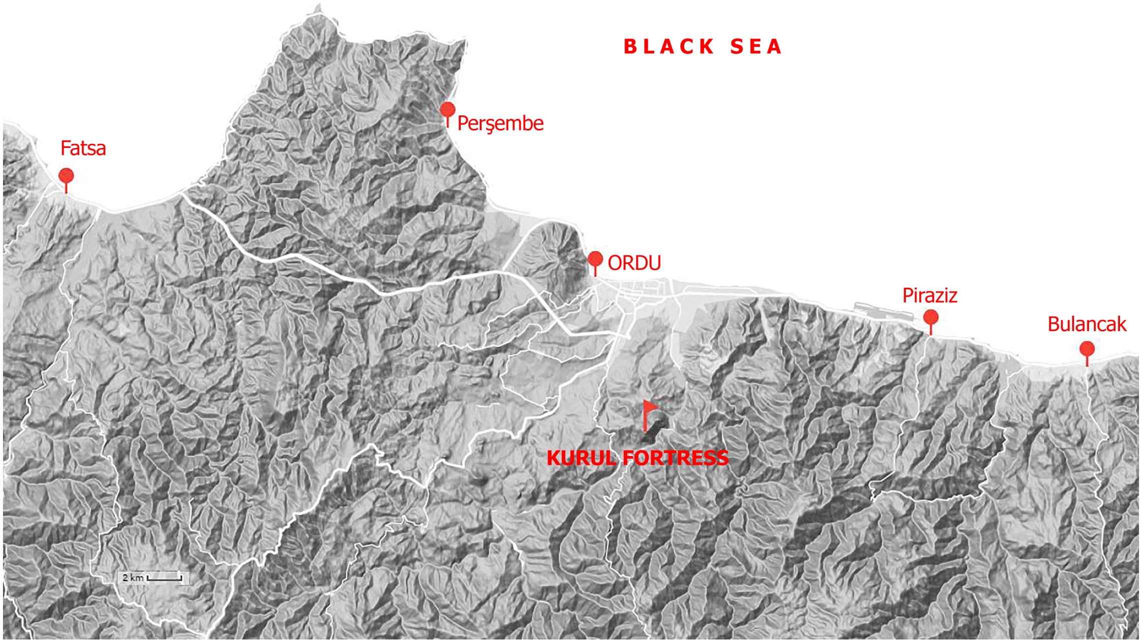


Figure 1. A Map of the Kurul Fortress and Its Vicinity.

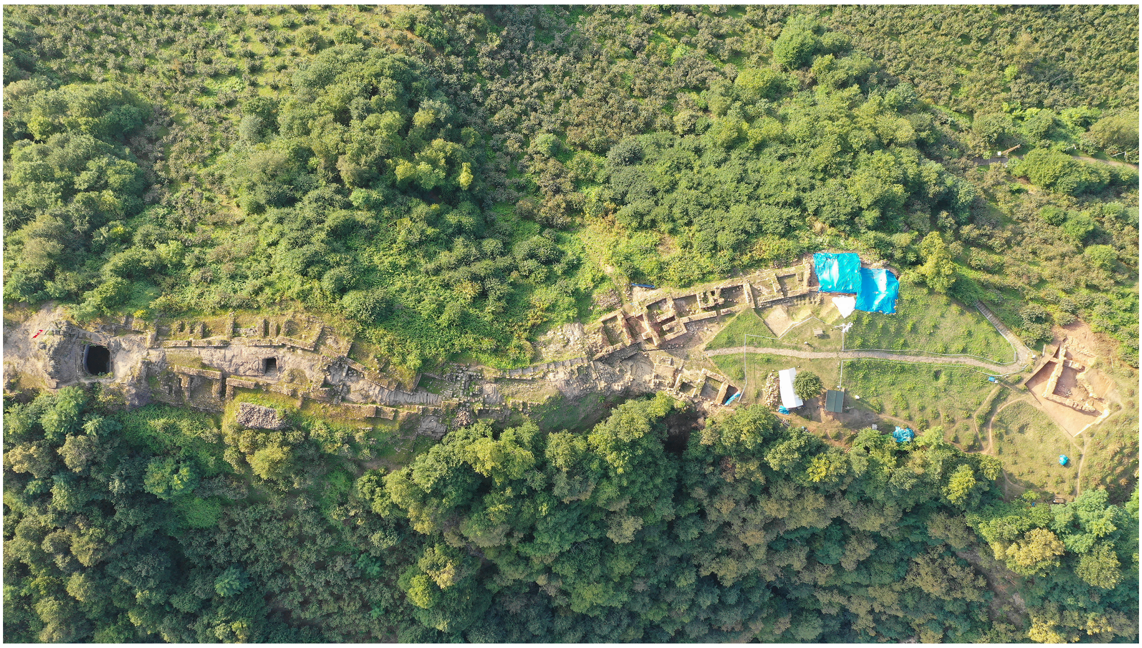


Figure 2. An Aerial Photograph of the Kurul Fortress.

Scientific excavations in the Kurul Fortress began in 2010 and have since been regularly undertaken every year. Thousands of artifacts from these excavations, including coins, terracotta ceramic containers, figurines and protomes, metal weapons and tools of daily life offered valuable information about the life styles of the locals, and shed a strong light on the darkness covering the Kingdom of Pontus, of which we have only limited archaeological knowledge. Considered to be one of the more important fortresses of the Kingdom of Pontus (BC 301-63), which was one of the Hellenistic kingdoms founded after Alexander the Great, the Kurul Fortress mostly exhibits characteristics of the reign of Mithridates VI. As the final king of the Kingdom of Pontus, Mithridates VI ruled over a large territory extending from the north of the Black Sea to a significant portion of Greece, and fought fiercely against Rome, the imperial power of the day [2]. After the Kingdom of Pontus met its demise at the hands of the Roman Empire, Kurul Fortress was vacated and has remained unsettled ever since. The lack of settlement over the layer of the reign of Mithridates VI made it possible to have a clear context for the architectural remains and archaeological artifacts unearthed [1].

Kurul Fortress excavations were undertaken in three main sectors. The first was the "Inner Fortress," the highest point of the fortress and the one with the earliest marks of settlement; the second was the "Northern Terrace," which offered a wider area for settlement and provided access to the fortress; and the last was the "Site of Administrative Buildings," which had buildings of a higher architectural quality compared to the other two sectors.

2. ARCHITECTURAL FEATURES IN KURUL FORTRESS

The most important factor shaping the settlement plan of the Kurul Fortress is its topography. A rocky hill overlooking its vicinity was selected for settlement. This rocky site dictated the overall structure of the settlement, and architects and builders of the Kurul Fortress created a settlement plan to make maximum use of the area available atop the hill. Accordingly, they have built adjoining rooms along the eastern and western sides of the hill, usually in a single line. The small size of the area prevented the creation of building complexes along the north-south or east-west axes. As a result and consistent with the topography, buildings were single file [3].

The construction technique observed in the Kurul Fortress can be briefly described as follows: First, the soil covering the site where a building is to be put up is removed and the bedrock is exposed. Then, beds are created on the rock for walls to sit on, and the bedrock is carved to enlarge the square footage. Wall foundations consisting local andesite stones are laid on two-layer beds. Abode blocks, the main wall elements, are laid on top of the wall foundations made of stone, 1 to 1.50 meters tall. Remains of roof coverings to protect the places from the elements, from sun, rain, cold air, etc. were found in almost all buildings [4].

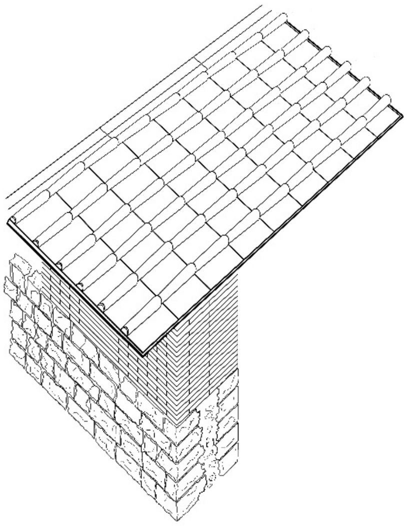
Most of the stones used in the architecture of the Kurul Fortress are andesite, the same rock making up the hill on which the Kurul Fortress is located. Andesite was used in all the four-walled structures. Wall foundations made of stone are of the plain masonry type with mortar [5]. Exterior wall elements are straightened without much elaboration. Andesite wall elements have square or rectangular shapes, and are attached using soil mortar with some lime added. The cavity between the interior and exterior faces of the walls are filled with amorphous rocks and soil. Sandstone, another type of rock found in the buildings, was mostly used in the gates between sectors. Sandstone has a creamy, light yellow color, and its use in the gates indicates intentional choice. Sandstone blocks mostly have rectangular shapes, and are attached to one another with clamps and dowels. Of these sandstone gates, the most significant is the Kybele Gate, which also connects the fortress to the outside world [3] [4].

Structures in the Kurul Fortress are covered with roof systems. Wooden frames were constructed on the walls, spanning the entire space, and covered with tiles. Two types of roof tiles were used in the Kurul Fortress: *stroter* (*Corinthian*) and *calypter* (*Laconian*). Stoters, the main covering elements, were laid on the wooden frame without any gaps. Calypters were then placed in between stroters to prevent leakage (Fig. 3) [3] [4].

3. ADOBE IN THE ARCHITECTURE OF KURUL FORTRESS

Adobe plays a very important role in the architecture of the Kurul Fortress. Walls are erected thanks to the adobe bricks laid on stone foundations. Adobe remains are found during the excavations inside and in the vicinity of the structures, some shattered and some crumbled to thousands of pieces. On the other hand, a large number of in-situ, well-protected adobe blocks were also found on the walls of the structures in the Site of Administrative Buildings and the Northern Terrace. In particular, 25 rows of adobe bricks were found on the eastern wall of the structure İYA-5 in the Site of Administrative Buildings (Fig. 4), which indicates heavy use of adobe in the architecture of the Kurul Fortress.

Adobe bricks used in the Kurul Fortress have pinkish red or brown colors, consistent with the local soils and rocks. Adobe bricks found in the fortress come in two different types or sizes. The first is the full brick, which was produced in much larger quantities compared to the other type, and is the dominant brick type in the site. Full bricks are square prisms with dimensions of 40 x 40 x 10 centimeters. Three full bricks placed next to one another are 1.20 to 1.30 meters long, which is also the thickness of many of the walls in the Kurul Fortress. The other type is the half brick. Half bricks are rectangular prisms and have dimensions of 40 x 20 x 10 centimeters.



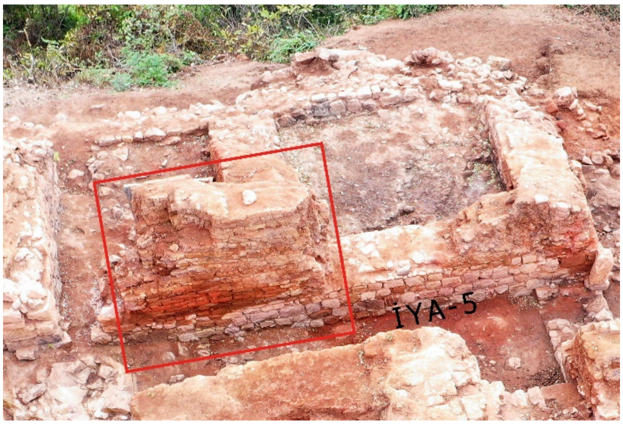


Figure 3. A Schematic Drawing of a Wall and Roof **Figure 4.** The Eastern Wall of İYA-5 (25 rows of adobe bricks were unearthed).

The short sides of two adobe bricks adjacent to one another touch the middle of the upper and lower bricks they are in contact with, and aligned with the next rows up and down. This pattern ensures that the adobe bricks attach to one another more strongly, and helps build long-lasting walls. This pattern means there are bound to be gaps at the end points of the walls, which are then filled with half bricks (Fig. 3).

Adobe is commonly used as a construction material in places with dry and hot climates, such as the Central, Eastern, and Southeastern Anatolian regions of Türkiye. However, the province of Ordu, where the Kurul Fortress is located, has a rainy and humid climate, characteristic of the Black Sea coast. This naturally gives rise to the question why adobe was used in a settlement with lots of rain and heavy humidity in summer. The most logical explanation seems to be that adobe brick production is cheaper and requires less labor than stonemasonry. Mortarless walls consisting of rectangular blocks, with bossages, common to contemporary cities, were only used in the construction of the three gates in the Kurul Fortress, and the towers and fortress walls had the same structure (plain masonry with mortar) with the rest of the buildings reserved for daily use. This underlines the local nature of the architecture of the Kurul Fortress, and indicates that craftsmanship and visual aspects were not primary concerns. Moreover, adobe walls have the advantage that they are easier to repair compared to stone walls. As a fortress controlled by Mithridates VI (BC 120-63), a ruler whose reign was mostly consumed by fierce fighting against the Rome [6] [1], the Kurul Fortress was probably under constant threat of war. This indicates that the use of adobe may be an intentional choice as it offered a practical solution.

In-situ adobe walls were found only in the sectors of Northern Terrace and Site of Administrative Buildings, but we have strong grounds to believe that adobe use characterized the entire architecture of the Kurul Fortress. Excavations carried out from 2010 to 2022 have unearthed 46 structures. Given that all these walls were adobe walls built on top of stone foundations, tens of thousands of adobe bricks must have been produced. For a structure that is 4 x 4 meters long and 2.5 meters high, with wall thicknesses of 1.20 meters (these figures represent the estimated average size of a structure in the Kurul Fortress), a minimum of 3,000 adobe bricks would be needed. To build 46 of these structures, one would need a minimum of 138,000 adobe bricks. Given that the outer walls of the Kurul Fortress have thicknesses of about 1.60 to 1.70 meters, the total number must be upwards of 150.000 bricks. These data show that the construction of the Kurul Fortress has involved the production of adobe bricks on a large scale.

The manner in which the adobe bricks used in the Kurul Fortress were produced is another important issue. According to a laboratory analysis of construction materials carried out in 2018, some of the adobe samples were produced by baking at 600-700° [7]. However, it should be kept in mind that a massive fire has taken place in the Kurul Fortress, which probably resulted in the desertion of the fortress and the traces of which are visible in all the remaining structures. The adobe samples collected were from the interior walls of the buildings and directly exposed to the fire. Therefore, it is not clear whether the samples were subjected to the temperatures cited above during the production process or during the fire. Answering this question would require further laboratory analysis. On the other hand, more than half of the settlements atop the hill were unearthed in excavations carried out since 2010, but no archaeological observations were made that would indicate adobe or ceramics production. This is an indication that the adobe bricks were sun-dried.

Because of the rainy and humid climate, an effort was made to protect the adobe bricks in the Kurul Fortress by coating the walls with an earthen plaster. This is evidenced by wall plaster found in-situ and well-protected at a number of places in the Kurul Fortress (Fig. 5).

Figure 5. The Plaster on the Face of the Western Wall of the İYA-3 Structure.

4. A RECONSTRUCTION EXAMPLE FROM HATTUSA (BOĞAZKÖY)

A reconstruction project was carried out on adobe production in Hattusa, the capital of the Hittites, that provided important clues as to production capacity, labor force, the setting/climate of production, and the production process, among others. The project aimed to re-erect parts of the city walls of Hattusa and two towers in 2003-2005. The city walls and towers were, similar to the Kurul Fortress, in the form of adobe walls built on top of stone foundations. The total length of the reconstructed portion was 65 meters. City walls were 7.1 to 8.3 meters high, and the towers were about 12.5 meters high [8]. The adobe bricks produced for the reconstruction work in Hattusa had the dimensions of 45 x 45 x 10 centimeters. The bricks weighed 44 kilograms upon removal from their molds, and 34 kilograms when completely dried [8]. The reconstruction process was recorded in detail, which led to the conclusion that it would take 2154 workers 4 months to build 1 kilometer of city walls [8]. The work lasted 7.5 months in total, and resulted in the production of more than 64.000 bricks (2,176 tonnes) [9]. The total cost for the reconstruction of the designated parts was reported to be €234,000 [8].

Ayanis, an important Urartian fortress in modern day Van, also made heavy use of adobe bricks. A. Çilingiroğlu notes that the entire fortress may have required the production of some 8,000,000 adobe bricks with dimensions of 51 x 35 x 14 centimeters [10].

This successful reconstruction work undertaken in Hattusa provides unique insights into the costs and labor force involved and the time required for the production of bricks in settlements that make heavy use of adobe. In light of the figures reported, it is clear that a large-scale brick production operation must have been undertaken in the Kurul Fortress. More than 150,000 adobe bricks must have been used in the construction of the excavated sites alone, indicating that the Kingdom of Pontus was quite advanced in terms of criteria such as construction costs and speed, and process management.

5. CONCLUSION

Kurul Fortress excavations, one of the more important excavations to be carried out in the Black Sea region—which attracts less attention from researchers compared to the frequency of archaeological work undertaken in the Aegean and Mediterranean regions—provide important clues as to the past beliefs, settlements and life styles prevalent in the region. Thanks to these excavations, currently the longest into a settlement from the reign of Mithridates VI, we now possess important information about the settlement plan of the Kurul Fortress, as well as about the functions of buildings and construction materials [3] [4]. Without a doubt, adobe is the most important of these materials. Heavy use of adobe in the Kurul Fortress is somewhat surprising given the rainy and humid climate of the region, but was probably necessary because of the advantages it offered. Thousands of bricks found in or around the walled structures, or in some cases in-situ, on the walls themselves, show that adobe was the primary construction material in the architecture of the Kurul Fortress. Special care and specialized work are required to protect these adobe bricks, produced about 2150 years ago using local materials. Efforts are made to this end by covering the adobe walls with tarpaulin and other strong materials. There are plans to replace these palliative solutions with permanent protective measures and ensure longer-term preservation of the adobe walls against the elements.

Future plans include the reproduction of the adobe bricks of the Kurul Fortress using proper materials, and re-erect, at the very least, the walls of one or more of the structures with intact stone foundations.

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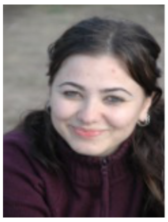
Paper Number: 32

Specialized Architects in Earthen Architecture




Evrim Solhan, Ümit Arpacıoğlu
Mimar Sinan Fine Arts University
solhan1evrim@gmail.com
umit.arpacioglu@msgsu.edu.tr

ABSTRACT

Earthen building material has been used in building production since history and still continues to be used. In this study, the process of using earthen building material in the world from history to the present day was described, the situation after changing environmental policies was evaluated and the current use process was discussed. Afterwards, the earthen construction application examples of the architects who left their mark on the earthen architecture were examined and an evaluation was made on the usage patterns of the earthen building material. Thus, an evaluation was made on the current transformation of earthen architecture, and it was examined at what points the material was developed and at which points it was integrated into today's production. The fact that the earthen building material, which has been used throughout history and continues to be used in different forms, still continues and is preferred despite many weak features, shows its importance in spatial memory as well as other positive features and reveals that it is a timeless material. In this context, the production processes of the structures of Hasan Fathy, Nader Khalili, Gernot Minke, Martin Rauch and Anna Heringer were examined and the techniques they used to develop the material were discussed. The main purpose of this study is to make an evaluation on the architectural design processes of the selected applications of architects specialized in the field of earthen application and the way they use the material. In this way, an assessment was made of the current transformation of earthen architecture, and the material was examined at which points it was developed and at which points it was integrated into today's production.

Keywords: Earhen architecture, architectural design processes, usage of earthen building material.

1. INTRODUCTION

Planned and built shelters began at the same time around the world. In shelters created by indigenous people on every continent, local resources; a regional adaptation has been achieved by blending culture, climate, sun, geological conditions of the region, and local factors. Thus, mixed, practical knowledge has been obtained throughout the history of humanity and building styles and construction methods have been created with traditional methods and techniques with advanced knowledge [1].

Construction in the past; It has created a diversity with different beliefs and daily habits, the climatic characteristics of the regions they belong to and the way traditional building materials are used. Structures, people who live in the habits of daily life, the culture, the aesthetics of manufacturers and users of the structure, beliefs, and priorities that have put their lives in integrity with the community environment and have created its original identity. This building culture, which continues in the footsteps of the past by connecting with the past, has formed the basic element of the settlement fabric of the region [2].

It can be said that earthen building material has been the most used material for indigenous cultures that have obtained their construction materials from nature throughout history and has been used as a building material since the beginning of human history [3].

Earthen building material becomes an important element in architecture when it is evaluated in terms of its spiritual feature in its structure and its effect on collective memory and allows many perceptual experiences. In this context, traditional architectural textures have an important place in terms of architectural identity, but they can also be considered as privileged areas in urban memory [4].

In this study, earthen structure application methods of architects who left traces in earthen structure architecture were examined and an assessment was made on the use of earthen building material. The architectural approaches of architects who have practiced in different cultures and regions have brought new perspectives to earthen architecture, have solved the requirements created with time and experience in terms of environmental problems, and have integrated the traditional architectural understanding with modern structures explained.

2. THE HISTORICAL PROCESS OF USING EARTHEN MATERIAL

Since the regions of Southeastern Anatolia and Mesopotamia were the first places that people preferred to live before Christ, examples of civil architecture in which earthen building materials were first used are found in these regions. In Anatolia, Mesopotamia, Iran, and the Mediterranean basin, where the oldest earthen structure remains are found in integrity, uncooked earthen blocks have been used to build the walls and roofs of buildings since Neolithic times [5].

Evidence of adobe buildings built ten thousand years ago has been found in the Middle East and North Africa, where impressive buildings up to ten stories high have been recorded, according to an unbroken architectural tradition that continues today [6].

When earthen-based structures that have been applied throughout history are examined, it is seen that they are used in low-rise simple applications as well as in applications such as large and ostentatious castles, palaces, tombs, and temples, which have visual appeal and historical importance. In addition, adobe, used as a building material in almost all ancient cultures, was used in residences and public buildings [7].

a. Reuse of Earthen Material with the Change of Environmental Policies

Although the earthen material, which was used in many geographies of the world at various times, lost its importance with the increase of interest in new materials that emerged with the development of the industry, two important developments that took place in the 20th century increased the interest in earthen building materials together with all traditional materials. The first of these developments is the use of earthen material in the 1st and 2nd World Wars, due to the inability to supply the technological.

The first of these developments is the use of earthen material in the 1st and 2nd World Wars, due to the inability to supply the technological materials that emerged with the Industrial Revolution the lack of access to the technological construction materials imported during the wars and economic reasons caused the production to gain importance again with the earthen material, which is economical and easily accessible, allowing fast production [8].

The second development is the energy crisis that emerged in 1970. Although the energy crisis has brought important developments in technology, it has emerged as a result of problems such as the consumption of natural resources with various effects, change in climate, and an increase in environmental pollution. Those reasons have led to the emergence of new concepts in architecture. These concepts, which are called names such as "Ecological Architecture" and "Energy

Architecture", it is aimed to produce with the least energy consumption and the importance of sustainable materials comes to the fore. Thus, it has been preferred to use building materials that provide the least consumption both economically and ecologically and can be produced under the desired comfort conditions. In this context, studies have been carried out on the possibilities of using earthen construction materials in many regions, and studies have begun to be carried out to improve the possibilities of using the material and to improve the weaknesses of the material by using today's technology [5,9].

b. The Current Use of Earthen Material

30% of the world's population still lives in buildings where earthen materials are applied. In rural settlements, most of the population, almost half of the developing regions, and 20% of the urban settlers use earthen structures [5].

Earthen material is an ecological building material that is low in cost, easy to manufacture, does not require a facility in its production, has high sound and heat insulation value, offers suitable living conditions for the user in all seasons, does not require heat and sound insulation layer in the building, and can easily return to nature. In addition, storing solar energy on winter days; in summer, it prevents solar energy from entering the building, reducing the energy requirement of the building and providing the user with an economy as well as healthy housing [10].

Since the impact of the energy crisis that emerged in 1970 continues to increase today, the importance of traditional building materials such as earthen building materials has increased with this process. Various studies and applications related to earthen building materials have been carried out in many countries and opportunities to benefit from the material continue to be developed.

3. THE PRACTICES OF ARCHITECTS USING EARTHEN MATERIAL

The production processes of Hasan Fathy, Nader Khalili, Gernot Minke, Martin Rauch, and Anna Herringer have been examined and how they use techniques to improve the earthen building material has been discussed.

a. Hassan Fathy

Hasan Fathy is one of the first names that comes to mind when it comes to earthen structure architecture. Egyptian architects have practiced in various countries, used earthen materials in most of their buildings, and, over time, created their unique architectural language throughout their life. His works are a criticism of modern architecture from a traditionalist point of view. Hassan Fathy frequently adapted the such as domes and vaults of traditional Egyptian architecture to modern structures in most of his buildings. His most famous known projects are the new Gurna village project and the Gragos ceramic factory produced in Egypt [Figure 1].

Figure 1. Ceramic Factory and New Gurna Village [11]

Fathy stands out with its humanistic, local, and participatory architectural approach and has given great importance to material, form, climatic sensitivity, production method, and cultural characteristics in building design. It has produced its structures from a point of view that does not break away from tradition and also takes into account the needs of the building owners. He also stated that the building owner and practitioners are at the forefront and affect continuity in the construction/use process. Fathy has argued that his designs' location and dimensions symbolize the structure's owner, so no structure built is the same, which increases the diversity [12].

Thinking that modern architecture ignores traditional values and human needs, Fathy has made various designs that attach great importance to climate data in his projects, are sensitive to the environment, dominate local forms and provide cultural diversity, and try to include users in the application. Fathy believes that modern architecture ignores traditional values and human requirements. He has made various designs that attach great importance to climate data in his projects, are sensitive to the environment, where local forms prevail and cultural diversity is ensured, and he has tried to involve users in the application [12; 13].

Fathy was influenced by Nubian and Coptic architecture in Egypt and worked with Nubian craftsmen and building users on his projects (Figure 4). He incorporated traditional Egyptian design elements such as courtyard, majaz, kaa, dorkaa, malkaf, selsebil, meşrabiye, and klasra as well as the dome and vault in most of his buildings [14].

b. Nader Khalili

Iranian-born American architect Nader Khalili studied the possibilities of making the most effective use of natural resources and conducted studies on building without the need for high-tech use. In this regard, he developed a system called Earthbag, which is also called "Superadobe".

This system, which allows fast and economical production, has a good seismic performance, as well as an environmentally friendly and energy-efficient feature, which has enabled it to be supported by many institutions and widespread production. This system, which has been studied as a model in many research institutions, has been used in the production of projects for NASA (National Aeronautics and Space Agency) on the moon and for the USA for the production of housing for the homeless, but in general, it has been developed as a solution to the problem of temporary housing [15; 16].

Khalili has developed the Superadobe system, which is formed by stacking bags on a circular plan and using belts in many parts of the world [Figure 2]. In addition, he established the organization called Cal-Earth, where the applications and training in which this system is used are carried out. With this system he created, the architect received the Aga Khan Architecture Award in 2004 [17; 18].

Figure 2. Eco Dome House and the Construction Phase of the Project [17; 18].

Nader Khalili is the creator of "Superadobe" which is fast, easy, and cheap production. The most important designs of Khalili are the Eco Dome Project and the housing project in which the vaulted technique is used. Projects produced as prototypes in California using earth construction materials have been produced and continue to be produced in many countries of the world in the same concept and different sizes.

c. Gernot Minke

Gernot Minke has produced structures that will set an example for ecological architecture by combining earthen construction materials with different materials and techniques by conducting experimental studies. Minke's most important buildings are residential buildings produced using earthen blocks, baked bricks, and wooden structural elements in Germany. The buildings are designed by ecological standards, simply arranged and in harmony with nature so as not to feel physical.

Since 1974, Gernot Minke has produced many structures in various regions of the world, especially in Germany, using various construction techniques with earthen building materials. Considered to be the father of ecological architecture, Minke produced with compressed earth, straw bale, bamboo, brick, and plastic bag filling methods, and frequently used green roofs in his buildings, arguing that buildings are a part of nature. Organic forms, illuminated domes, and arches are generally seen in their structures. Aiming to produce lowcost structures in his designs, Minke has conducted many research projects and workshops in addition to his experimental studies on the subject [19; 20].

In Minke's applications, he generally used earthen blocks with baked bricks, and wooden building elements [Figure 3] [21].

Figure 3. Kassel House [20]

d. Martin Rauch

Considering the weaknesses of the earthen building material, Rauch approached the material holistically. In this context, he produced by combining traditional construction techniques with modern techniques. The Rauch and M house projects implemented in Austria are his best-known buildings.

A ceramic artist and sculptor, Martin Rauch has come to the forefront with his works on construction technologies produced with natural materials. Researching new design possibilities with earthen material, Rauch created a conceptual framework for large-scale implementation, believing that some of the elements he applied on a small scale (Ceramic tiles, stove) would create a livable floor [22; 23]

Rauch projects include the light-shadow factor created on the facade surface by the linear surface movement created with earth blocks on the facade surface of the buildings and applied to slow down the water movement giving the building an identity and adding an aesthetic value to the space [Figure 4].

Figure 4. Rauch House [22]

Rauch has been interested in the rammed earth technique, which does not require coating and embellishment at the very beginning during the application process. According to him, the layering of the wall with this technique naturally gives it an ornate appearance and allows the material to express itself in other dimensions.

Rauch advocates the use of earthen construction material in a way that reduces energy consumption during the production phase, thus designing with an understanding that will allow the material to be enriched formally. Since Rauch is aware of the sensitivities of the earth-building material due to its connection with ceramics, he conducted technical experimental studies by examining the material mixtures holistically. In this context, in light of his experimental studies, he combined traditional construction techniques with new techniques and developed new tools for production. [24; 23].

e. Anna Heringer

Anna Heringer used earthen construction material, which is generally a local building material, in her buildings and argued that instead of being dependent on external systems, it is necessary to make the most of the existing resources. Heringer's best-known buildings are the METI handicraft school (Modern Education and Practice Institute) and Desi Education Center projects in Bangladesh.

Anna Heringer develops her designs within this framework, arguing that architecture improves human life and exploring architecture increases cultural and individual confidence, supports the local economy, and strengthens the ecological balance. Thinking that sustainability is directly related to beauty,

Herringer produces in her projects with a design approach that is compatible with location, environment, user, and socio-cultural context, as well as the use of design structure, technique, and materials. Arguing that instead of being dependent on external systems, the architect, who claimed that it is necessary to make the most of the existing resources, used the earth building material, which is generally the local building material, in her buildings [25; 26]

Herringer has carried out various projects for local labor and material used in Asia, Africa, Europe, and the USA, and has received many awards for these projects using earthen construction materials. In 2007, she was awarded the Aga Khan Architecture Award for her handicraft school (METI) project implemented in Bangladesh [Figure 5] [17].

Figure 5. METI School [25]

4. CONCLUSION AND SUGGESTIONS

Since the beginning of human history, earthen building material has been used both in civil architecture and in the production of structures of historical importance which are of great aesthetic value and ostentatious. Earth-based materials are still widely used in countries around the world. In addition to being an environmentally, economical, and healthy material, earthen building material comes to the fore due to the increasing energy need and the use of the importance of the material gains. In this study, the approaches of architects who have specialized in earthen architecture, Hasan Fathy, Nader Khalili, Gernot Minke, Martin Rauch, and Anna Herringer, who use earthen building materials in their buildings and develop the material and integrate it into today's production, are discussed.

Hasan Fathy has shown that the traditional has no boundaries in terms of time and history, and the earthen building material can be used with the appropriate technology in the production of modern buildings.

Nader Kahlili, in addition to meeting the need for housing with fast, easy, and cheap production, has developed a production technique called "Superadobe" with the 21st. the century has brought a new view to earthen architecture.

Gernot Minke, which produces structures that are part of the environment in their designs, has made production in a way that is completely compatible with the environment in these structures where earthen construction materials are used.

Martin Rauch buildings produced within the scope of contemporary forms are the first experimental study in modern earthen architecture. In addition, producing details that solve the weak points of the earthen structure gave identity and added aesthetic value to Rauch's buildings.

Anna Herringer has implemented her projects with a philosophy that gives importance to regional culture by using local resources to improve existing construction techniques and ensure sustainability, thus bringing a new form to local architecture.

As a result, factors such as architectural requirements developed application techniques, and user requirements have caused changes in earthen architecture as well as in all areas of architecture. These changes, the characteristics of the material, such as creating a healthy structure, being economical and energy efficient, which form the traditional earthen building culture and which are like the material, provide a link between the past and the future in architecture.

After the industrial revolution, with the development of construction and material technologies, the usage of earthen building materials, like other traditional building materials, has decreased. Despite the known environmental and economic advantages of the material, due to disadvantages such as low water resistance and seismic performance, the usage area is inevitably less nowadays.

Standardizing the production techniques of earthen building material, making studies within the scope of eliminating its weaknesses, and integrating it into modern construction techniques can increase its usage in modern architecture.

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Baghdadi Wall Techniques Used in Traditional Buildings: The Example of Diyarbakır Suriçi


Kader Baran, Associate Professor Nursen Işık
Dicle University, Diyarbakır
kaderbarnn@gmail.com
isikcn@gmail.com

ABSTRACT

Traditional and historical buildings are cultural and architectural heritages that have survived from the past to the present. These structures were built with different construction techniques and materials according to the requirements and technology of the era in which they were built. The most common materials in traditional buildings built with different construction techniques are stone, brick, adobe and wood.

Bagdadi construction technique on the walls of some traditional and historical buildings is one of the traditional construction techniques that has survived from the past to the present.

Baghdadi construction technique; Horizontal wooden laths are nailed on both sides with 1-2 cm intervals on the wooden frame structure and it is formed by plastering it. In the Baghdadi wall construction technique, there are examples where the interior of the walls is left empty, as well as filled with mud bricks and bricks. Wooden material is generally used in this construction technique. The lightness of the wooden material and the low load it brings to the building provide an advantage in the bagdadi construction technique. The wooden material provides the horizontal continuity of the wall in the bagdadi wall construction technique and creates a rough surface for better adhesion of the plaster. There are many academic studies investigating the bagdadi construction technique used in traditional wooden buildings. The aim of this study; wood, mudbrick, wood, etc. used in the bagdadi construction technique. The purpose of this study is to examine the construction style, usage areas, positive and negative features of materials with examples built in Diyarbakır Suriçi Region.

There are many examples of using the bagdadi construction technique in the Suriçi Region, where traditional and historical buildings are located. A field study was carried out to determine the current status of the traditional building examples made with this construction technique and these buildings were documented with photographs.

Keywords: Baghdadi Construction Technique, Diyarbakir, Traditional House, Deterioration

1. INTRODUCTION

Traditional and historical buildings are architectural heritages that contain traces of the past and form the main foundations of urban identity. These structures reflect the aesthetic understanding, lifestyle and technology level of the period in which they were built. In this context, the materials and construction techniques used in the building play an important role in conveying the character and durability of the building. Traditional buildings in Anatolia were built using natural materials such as stone, adobe and wood. The region where it was built determined the possibilities of using the material in traditional buildings. Wood is a natural material that preserves its frequently preferred feature in traditional buildings. The easy supply of wood, its ability to be processed and its ease of handling are among the important factors in its preference due to its easier behavior against loads. (Yüksek, 2008).

Anatolia is a place where earthquake risk is intense. The traditional wood frame construction system is therefore frequently used. The system created by filling the gaps between the pillars and beams in the wooden frame and covering it with plaster is classified as the hmış, bagdadi system. (Aksoy, 2010)

Buildings formed by filling the wooden skeleton with adobe and brick on a foundation made of stone material are called 'hamis' (Arseven, 1964), and structures formed by plastering 2-3 cm wide wooden laths on the wooden skeleton are called 'bagdadi' (Hasol, 1979) construction technique. . Structures with a wooden outer coating after the inner parts of the walls are built with the bagdadi construction technique and a certain amount of space is left between the inner and outer coatings are called "wooden covered structures". (Arseven, 1964).

Wood material is frequently used in building elements with its carrier feature and other areas of use. The bagdadi construction technique, in which it is used as a wooden frame and coating, is one of the traditional construction techniques applied especially on the walls. In this technique, wooden laths are placed horizontally on the wooden framed facade walls and the wall structure is formed by plastering.

In this study, five examples in which the bagdadi construction technique in Diyarbakir traditional houses were applied were selected. The current conditions of the houses built with the Baghdadi construction technique were documented with photographs, by conducting a field study in which observational determinations were made, and the current conditions of the traditional houses where the Baghdadi wall technique was used.

2. BAGDADI CONSTRUCTION TECHNIQUE

The Baghdadi construction technique is one of the oldest construction techniques. However, it is mostly found in buildings built in the 20th century. In the Baghdadi construction technique, wood and adobe were used as the main materials. The wooden laths that make up the wall structure provide integrity with the adobe material. Wood material has a fibrous and hollow structure. Due to these features, although it is light, its strength value is high. (Eriç, 1978).

Wood material is a natural material that provides flexibility, durability and lightness to the structure in which it is used. The wooden laths used in the Baghdadi construction technique ensure the horizontal continuity of the structure. The roughness in the natural texture of the wood causes the plaster to stick better. The materials used in the Baghdadi construction technique are generally natural and traditional materials and are obtained from local sources. The materials are selected in accordance with the geography and local characteristics where the wall will be built.

Different techniques can be applied on wooden carcass. One of them is the bagdadi technique and the other is the interskeletal filling. The space formed between the wall is filled with solid wood, brick, stone and adobe. This technique is called the hammock making technique. The adobe in the wood structure protects the wood and ensures its longevity. The wooden skeleton has high elasticity. Due to the hollowness of the wooden interior structure, it has the feature of absorbing sound. (Şimşek, 2003) On the other hand, adobe has a rigid structure. After the walls are completed, plaster is applied on them. This plaster is lime-binding and mostly a fiber called tow is used in it. 2 cm thick rough plaster is made with sand, hydrated-filtered lime and tow. When the rough plaster dries, it is completed with 0.5-1 cm thick plaster. (Perker,2012)

The wooden carcass system, in which the Baghdadi construction technique will be applied, is primarily the foundation floor of the future building. Wooden posts, row and connection beams, and horizontal and cross connectors are used in the carrier system of the carcass system structure. The Baghdadi wall is divided into two as the split bagdadi wall and the lathed bagdadi wall. In the split tie-dye wall, the laths are divided parallel to the annual rings of the wood with simple hand tools, and in the lath, smoother laths are obtained by using machines. Splitting tie-dye is an older technique and it is easier for the plaster to stick because its surface is rougher. In the split bagdadi technique, wooden boards with a thickness of 1-1.2 cm and a height of 15-30 cm are nailed to the wooden carcass. The boards are randomly separated according to their natural fiber properties by hand. Thus, thin laths of different sizes are obtained. (Kudde, 2009).

Horizontal laths are nailed to both sides of the wooden frame and the middle part is left empty. Keeping the middle part empty provides thermal insulation. At the same time, the space in between provides air circulation and causes the wood to stand for a longer time without deterioration. In this way, a dry wall system is formed and it does not stay humid thanks to the air circulation inside. After the laths are nailed, the wall is plastered. Plaster adheres better by entering the gaps between the laths, which increases the durability of the wall. There are also bagdadi walls plastered with plaster wire. In this system, nails are hammered into the wood at 15-20 cm intervals, and after the plaster wire is wrapped around these nails, it is plastered over the wire. (Perker, 2012). In addition, there are examples of this cavity filled with stone, brick and wood and called the shamrock construction technique (Kudde, 2009).

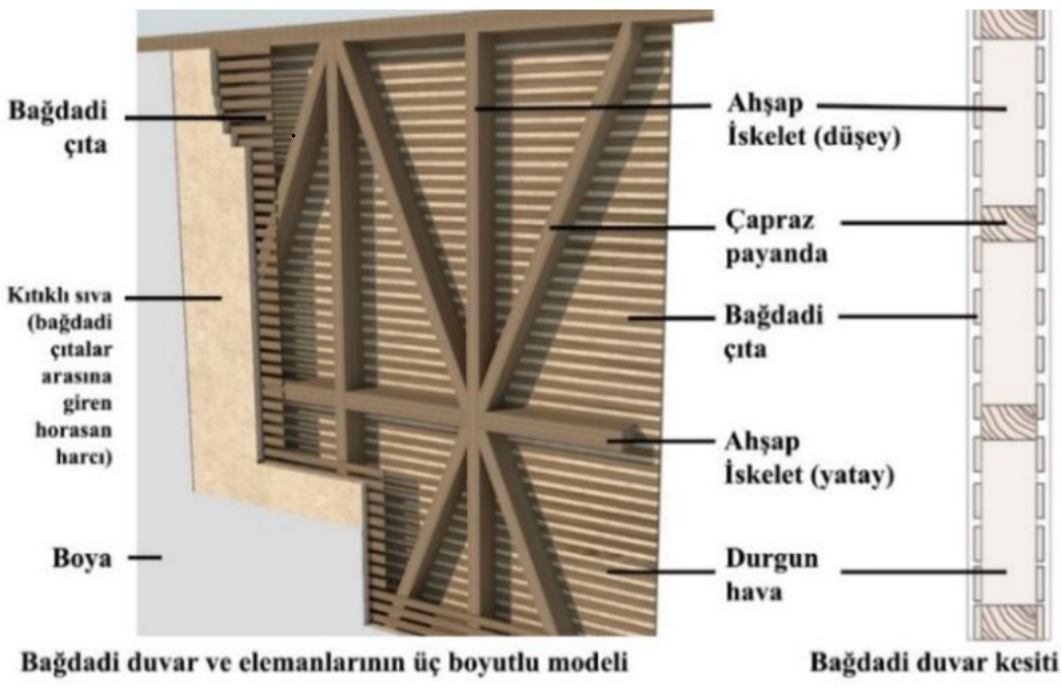

Figure 1. Baghdadi wall system and materials (Alemdağ, 2023)

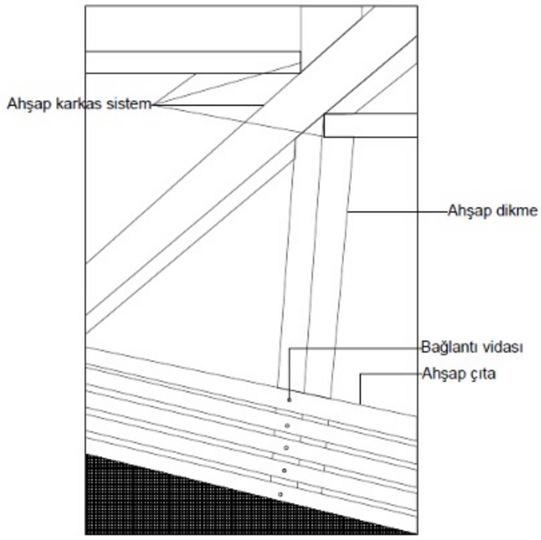

Figure 2. Baghdadi construction technique

2.1 Usage Areas

The Baghdadi construction technique is a very old technique and there are many examples in Anatolia. This technique, which has examples all over the world, has often been used in traditional houses and historical buildings. Today, there are examples where traditional buildings are applied with their original architecture in restoration or reconstruction.

2.2 Positive and negative characteristics

2.2.1 Positive features

- Natural and local materials are used in the Baghdadi construction technique. Therefore, it is environmentally friendly.
- Sustainable as local materials and techniques are used.
- It offers aesthetic value by reflecting the cultural and architectural heritage of the region.
- The wooden frame is flexible and this makes it earthquake resistant.
- The use of local materials brings climatic harmony and in this way, more comfortable spaces can be created.
- The construction technique is simple and fast. In this way, the construction time of the building is shortened.
- Since local materials are used in the building, energy loss is reduced. Apart from this, the sound insulation that occurs naturally in the bagdadi construction technique also saves energy. (Şimşek,2003)

2.2.2 Negative features

- Structures built with the Baghdadi construction technique can rot and deform over time. Rotting of wood material or damage to the plaster cause the durability of the structure to decrease.
- In this technique, the walls are damaged over time and the plaster is poured. Therefore, constant maintenance is required. If it is not done, it may lose its aesthetic appearance as well as its durability.
- It may be difficult to reach modern insulation standards in buildings using the Baghdadi wall technique.
- In the Baghdadi technique, the empty interior reduces the bearing power and rigidity (Tanaçan,

2002).

2.3 Location of Diyarbakır Suriçi Region and Examples of Baghdadi Walls Used in Traditional Houses

Diyarbakır Suriçi region is an important settlement center of the city where the historical building stockof the city is located. There are many different types of historical buildings in the region such as traditional houses, inns, baths, mosques and tombs. In traditional buildings, it is seen that local basalt stone materials and different materials such as wood, brick, limestone (limestone) are used together holistically. In addition, there are examples where different construction techniques are used in the buildings. The Baghdadi construction technique is one of the construction techniques used in traditional houses, especially on interior and exterior walls and bay windows (Figure).

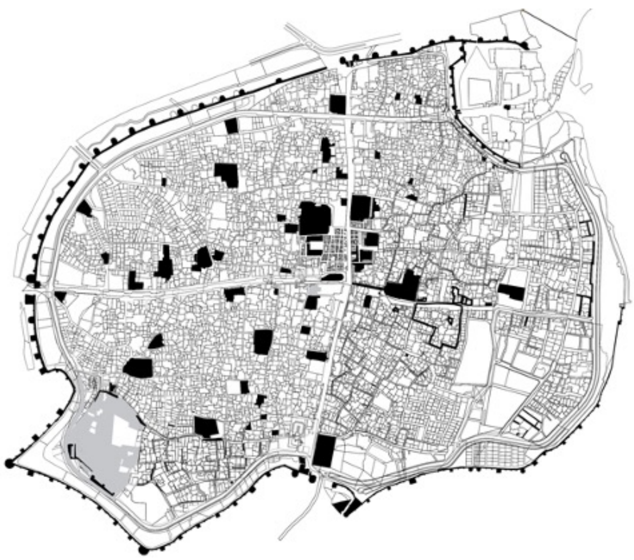

Figure 3. Location of the Suriçi Region (Ministry of Environment and Urbanization, 2023)

The plaster used in the Baghdadi construction technique is an important material that protects the wood material against external influences. However, lack of maintenance, abandonment, failure to make necessary repairs, external environmental conditions and the intervention of users with unqualified additions have caused an increase in the existing damages in the structure. The reasons such as the increase in the existing damages due to the effect of the outdoor conditions, the loss of the bonding properties of the plasters, the decay of the wood, the decrease in the combination of wood material and mudbrick material adversely affected the traditional structures made with the bagdadi construction technique. After the defenseless laths begin to rot and fall, the carcass structure is left alone and exposed to external factors. In the study, five houses selected from the traditional house examples built with the bagdadi construction technique, partially or heavily damaged, were examined. Existing problems were determined by examining the deterioration and damage on the bagdadi wall in the samples examined. It was observed that the plasters on the walls of the examined samples were generally deteriorated and partially or completely spilled. After the plastered sections were poured, the wooden laths rotted and deformed due to the effects of the external environment. Plaster and other material losses have affected the structure of the building, causing structural problems.

2.4. Examples of Baghdadi Walls Used in Traditional Diyarbakir Houses and Their Current Situation

In traditional houses in Diyarbakır Suriçi region, bagdadi wall techniques can be seen in wood-framed examples. These tie-dye walls, which can be seen on interior walls, exterior walls and bay windows, have changed over time due to user influence, outdoor conditions, etc. It has been damaged and building materials have been damaged due to reasons such as In the region, 5 traditional houses in which the bagdadi construction technique was used in the construction system were examined and their current conditions were observed.

The deteriorations in the traditional houses in the Suriçi Region, in which the Baghdadi wall technique was used, were determined by the observational determinations in the field study. These distortions;

- It is seen that the plasters on the Baghdadi walls have been poured, and the wooden laths in the areas where the plaster has been poured remain unprotected. As a result, unprotected wooden laths rotted and material loss occurred in places.

- It has been determined that in some of the regions where there are wooden laths with material losses, the wood carcass system remains open and the deterioration of this situation increases.

- There are color changes and spills in Baghdadi plasters.

- In general, rotting, color change and material loss have occurred in woods. These cause the wall to lose its function.

Example 1:

It is located in Ziya Gökalp Neighborhood in the Suriçi region. On the front of the bay window, which belongs to the building, it is seen that the plaster has been poured from place to place and there are deteriorations in the places that have not been poured. It is observed that the wooden laths are rotting and there are material losses in some exposed parts. On the side facade of the bay window, it is seen that almost all of the plaster has been poured and the wooden material has rotted and lost material here (Picture 1).

Picture1. A bay window made with the bagdadi construction technique in the Suriçi region of Diyarbakır

Example 2:

The traditional house example is located in the War District. In this house, in which the bagdadi construction technique is used in its bay window, the plaster has fallen from place to place, there have been losses of wooden laths, and wood decay has occurred. Wooden slats are deformed. Where material loss occurs in the wooden laths in the left corner, it is observed that there is also material loss in the carrier pillar (Picture 2).

Picture 2. A bay window made with the bagdadi construction technique in the Suriçi region of Diyarbakır

Example 3:

G An example of a traditional house is located in Iskender Pasa Neighborhood. There were losses due to plaster spills on the walls, especially on the windowsills, and rot in the wooden laths. It is observed that there is a color difference in the wooden laths used. Wooden laths have also undergone deformation due to rotting (Picture 3).

Picture 3. A bay window made with the bagdadi construction technique in the Suriçi region of Diyarbakır

Example 4.

The building, located in the Fatih Paşa district, is heavily damaged in terms of all building elements, except for the Bağdadi walls. It is seen that the bagdadi wall used on the outer wall is exposed and has lost its function. Most of the plaster has been poured, and there are deteriorations and losses in the wooden laths. Formal deformations have occurred in the wooden laths, the integrity of the wooden carcass has been disrupted and the static state of the wall has changed (Picture 4).

Picture 4. The exterior wall made with the Baghdadi construction technique in the Suriçi region of Diyarbakır

Example 5.

When the traditional house where the bagdadi wall was applied in the Mosque Kebir District in the Suriçi region was examined, it was determined that all the elements in the building were destroyed except the bagdadi wall. There were plaster losses on the wall, and it was observed that there were deteriorations in the wooden laths due to rot. Formal deformations in wooden laths are in a position to affect the structure of the building (Picture 5).

Picture 5. The exterior wall made with the Baghdadi construction technique in the Suriçi region of Diyarbakır

3. CONCLUSION AND RECOMMENDATIONS

The Baghdadi construction technique is one of the traditional construction techniques that has survived from the past. It has been used in many areas, generally traditional and monumental structures. This construction technique, created from natural materials, provides climatic comfort as well as adding aesthetic features to the spaces. The ease of construction and material supply made this technique a sustainable technique.

The bagdadi construction technique used in traditional houses has been used in many places in Anatolia. In addition to its aesthetic feature, the use of natural materials such as wood and adobe increases its effectiveness in natural disasters such as earthquakes with its carrier feature thanks to the flexibility of the materials used.

The bagdadi construction technique used in traditional buildings in Diyarbakır's Suriçi Region was used especially in the bay windows and walls that overflowed the street. The bagdadi construction technique, which is used in the bay windows and shahniş spaces on the upper floors of traditional houses surrounded by high courtyard walls, continues to be used in restoration works with original completions.

In the field study carried out in the Suriçi Region, it was observed that the existing problems due to neglect, abandonment and natural conditions increased in traditional houses using the bagdadi construction technique. Failure to make repairs in privately owned traditional houses has led to an increase in structural problems in houses over time. In addition, it has been observed that the completion of the walls and bay windows made with the bagdadi construction technique with unqualified additions by the users is one of the external factors that cause the deterioration of the original architecture with its carrier feature.

In this study, the current situations of traditional houses built with the bagdadi construction technique were examined, the existing problems were documented with photographs, and an archive was created for further research and studies.

As a result, the bagdadi construction technique is one of the traditional techniques that brings together the present and the past, and provides the formation of functional structures with its aesthetic and carrier feature. For this reason, in order to transfer the Baghdadi building technique to the future;

- The buildings in which the Baghdadi construction technique is used should be taken under protection and necessary repairs should be made.

- This technique used in traditional buildings should be re-adapted according to today's comfort conditions, and this technique should be kept alive and sustainable.

- The education and researches that enable the introduction of traditional construction techniques and the dissemination of their application areas should be increased.

- Seminars, trainings and workshops on the Baghdadi construction technique should be taught and disseminated.

- The Baghdadi construction technique can be used as a part of the original design in modern buildings. The use of modern structures together with different and traditional techniques should be preferred because of both the continuity of the technique and the many positive effects of the technique on the structure.

- The use of the Baghdadi construction technique should be encouraged, and sustainability should be gained by preserving the examples in existing buildings and making repairs in accordance with the original.

- The use of the Baghdadi construction technique should be encouraged, and sustainability should be gained by preserving the examples in existing buildings and making repairs in accordance with the original.

- Touristic routes should be created by the relevant institutions for the visitors of the city in order to promote and keep the houses with traditional construction techniques in the Suriçi region alive.

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Paper Number: 34

Structural Damages Detected on Adobe Buıldings In Huseynik (Ulukent) District In Elazıg Province 'Faik Bey Mansion Example'


Oktay EKİCİ[1], Nursen IŞIK[2]

[1]Dicle University, Diyarbakır/ Türkiye
[2]Dicle University, Diyarbakır/ Türkiye

[1]ekiciokty23@gmail.com
[2]isikcn@gmail.com

ABSTRACT

Elazig province is one of the important settlement centers of Anatolia with its historical and cultural richness. The city, which has hosted many civilizations throughout history, has been preferred due to its location and fertile lands and has been the center of life for many civilizations. Harput is one of the most important residential areas of the city where traditional life is maintained and one of the oldest jades in Anatolia. There is a castle belonging to the Artuqid period in Harput, which is located on a high part of the city and is called a neighborhood today. The campus, which spread inside the castle and on the hill slope, disintegrated over time and moved towards the Elazig plain.

Hüseynik was one of the villages attached to the Harput sanjak in the 16th century [13]. With the transformation of Elazığ into the city center, Hüseynik gained the status of a neighborhood under the name Ulukent. Hüseynik (Ulukent) Neighborhood, located in the northwest of the city, is located in the high position of the city and has been the center of life for many civilizations living in the past. During the period of these civilizations, various structures were built in order to meet their needs such as shelter, worship and defense. Some of these structures were severely damaged or completely demolished and could not reach the present day. Most of the structures that have survived to the present day are traditional houses and are partially used today.

Hüseynik houses were built similar to the traditional house typology of Elâzığ. Traditional houses, which are made of stone, wood and adobe materials, are usually two or three storeys. One of the houses in Hüseynik (Ulukent) Neighborhood is Faik Bey Mansion on Dağ Street.

Faik Bey Mansion was built in 1911 with the traditional construction technique and with adobe as the main construction material, with a Ground +1 storey. In the adobe building, auxiliary materials such as stone, wood and binding mortars were used. The building, which was registered in 2014, is empty and not used for a long time. Today, the building has had structural problems due to neglect and external effects.

In this study, a field study was conducted in order to determine the structural problems and damages in the adobe wall and other structural elements in Faik Bey Mansion located in the Hüseynik (Ulukent) District of Elâzığ. Existing structural problems were determined through observational determinations in the field study and these problems were documented with current photographs. It is aimed to create a preliminary study for possible repair applications related to the structure by presenting evaluations and suggestions for the damages determined by the study.

Keywords: Structural Damage, Hüseynik, Adobe, Faik Bey Mansion

1. INTRODUCTION

Traditional buildings are an important and valuable part of the cultural and architectural heritage in human history. These structures have survived to the present day by carrying the traces of the past and are still standing by challenging the passage of time. Although many different materials have been used in the construction of these historical buildings, adobe material has been an important option that humanity has often preferred in building construction throughout history.

The reasons for the importance of adobe, which has been used since ancient times and is an important building material, are that the soil and water that make up its content can be easily supplied from the building site and that its preparation is practical at the building site [9]. Adobe has been a building material that has been used for about 90 centuries and has been responding to the shelter needs of humanity since the early ages [4]. When the first settlements of the settled societies are examined, adobe material is encountered in the time period when natural materials such as stone and wood were not available. Egyptians, Assyrians, Hittites, Sumerians are societies that build buildings using adobe building materials. When we look at the architecture of Egypt and Ancient Greece, adobe was a pressure-oriented material and pioneered materials such as stone and brick [3]. Some people around the world continue to live in houses built using mud brick. These and similar structures are generally located in rural settlements [10].

Hüseynik (Ulukent) Neighborhood, which is located in the city center of Elâzığ and has a deep-rooted historical background, contains many historical mudbrick structures built with the traditional architecture of the city. Some of these structures, most of which are traditionally built houses, continue to be actively used today.

These structures, which reflect the traditional architecture and culture of Elazig, have been exposed to various influences and deformations for many years. Some houses were destroyed as a result of damage to their carrier systems. It is of great importance to carry out damage assessments in order to ensure the transfer of these structures, which we inherited from the past, to future generations in their most original form and to prevent their extinction. In this study, the structural problems and damages in Faik Bey Mansion, which is one of the adobe buildings in the Hüseynik (Ulukent) District of Elâzığ, have been observed by making evaluations and suggestions.

2. HISTORY OF ELAZIG PROVINCE HÜSEYNIK (ULUKENT) NEIGHBORHOOD

The province of Elazig and its environs (districts) have been a permanent settlement area from the Paleolithic Age to the present and have hosted many different cultures throughout its history. It has been an area of interaction of the different cultures it has hosted. The province of Elazig, whose history dates back to ancient times, became a region that gained importance with the arrival of the Turks in Anatolia [2].

With its castle built during the Urartian period, Harput provided serious protection for the people of the region against external influences. The strategic location of its location compared to the surrounding settlements has caused many states to desire to own this area. The wide and fertile lands it has also created a reason for the occupation of the region at any time. These positive opportunities of Harput reveal the reason why it changed hands many times throughout history. The limited space the city has has caused the streets to be narrow. The city, whose lands are all on a hill, started to slide down with the filling of these areas. Thus, the city grew towards the south of Harput and today's neighborhoods, especially Hüseynik, were formed (Figure 1) [7].

Figure 1. Hüseynik (Ulukent) Neighborhood Location [16]

As a matter of fact, in 1883, Mehmet Reşit Pasha was appointed as the provincial governor to the region for the purpose of reforming the tribes in the eastern provinces and saw that Harput was unsuitable for further development. He had a headquarters built in the Çöteli hamlet of Hüseynik village (Ulukent), located in front of the slope between Harput and the plain, and ordered the reconstruction of other official institutions. Thus, the first core of the city of Elazig was formed [11].

The name of Hüseynik village, which is one of the central neighborhoods of Elazig today, was changed to "Ulukent" during the Republican era. During the First World War, the village of Hüseynik, where the 102nd Regiment was based, gained fame with a song that started with the words "I left Hüseynik on the road" [15].

3. ADOBE BUILDINGS IN HÜSEYNIK (ULUKENT) NEIGHBORHOOD IN ELAZIG PROVINCE

In Hüseynik (Ulukent) Neighborhood, located in the center of Elâzığ, many historical buildings reflecting the traditional architectural style of the city were built. Some of these structures have survived to the present day, and most of them are traditional houses.

Hüseynik houses are examples of traditional Elazığ houses dating to the late 19th and early 20th centuries. These houses were built during the Ottoman Period and reflect the local architectural style of the city. Hüseynik (Ulukent) Neighborhood is the region where traditional houses are most concentrated.

In the traditional houses of Hüseynik (Ulukent), mudbrick was used as the main building material. The easy availability of adobe material in the region and its suitability for climatic conditions have been an important factor in the preference. The ground floor walls were used especially as plaster on the upper floor walls of the houses made of stone, the bay windows and walls, and the exterior. Bagdadi walls were created by using adobe together with wood material.

With their settlements on the sloping area and narrow streets, Hüseynik houses have similar characteristics with Harput houses [7]. Traditional houses in the Hüseynik Köyiçi region are generally two or three stories high. The third floors appear as basement floors formed due to the slope of the land in the buildings or as the floors where the resting areas are located on the top floor. Houses facing the main roads generally have a direct entrance from the street, while the houses located inside are entered from either a courtyard or a garden [8]. Most of the traditional houses built in Hüseynik Neighborhood are covered with earthen roofs.

4. FAIK BEY MANSION LOCATION AND HISTORY

The building is located in Hüseynik (Ulukent) Mahallesi Köyiçi campus. The building built on the plot of Dağ Sokak 1656 is a ground+1 storey mansion (Figure 2). The inscription on the ceiling of the building, which belongs to Miri Ümera Hacı Muharrem Pasha, states that it was built in 1911[1].

Figure 2. Location of Faik Bey Mansion [16]

4. FAIK BEY MANSION ARCHITECTURAL FEATURES, MATERIAL USED AND CONSTRUCTION TECHNIQUE

4.1. Architectural Features

Faik Bey Mansion consists of ground+1 floor. The mansion has a distinction between harem and selamlık. Built on a sloping land, the mansion has a plan scheme surrounded by a high-walled courtyard. The entrance to the courtyard is provided by a high Cümle gate[2] made of cut stone. There is an Eyvan[3] and Ahır-Merek[4] sections separated by a stone arch on the ground floor of the building. A part of the courtyard was covered and a roof was formed, but today this part has been largely demolished. There are two stairs that provide access from the ground floor to the upper floors. One of these stairs is located in the iwan and is separated from the courtyard section by a stone arch. This staircase leads to the harem section on the upper floor. The other staircase in the courtyard is positioned adjacent to the stone arch and provides the transition to the selamlık section on the upper floor (Figure 3).

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[1] Karakaş, S., Elâzığ Geleneksel Konut Kültürü. Yüksek Lisans Tezi, Selçuk Üniversitesi Fen Bilimleri Enstitüsü Mimarlık Anabilim Dalı, Konya, 2008.

[2] **Cümle Gate:** The main entrance of a large building; main gate (in old large buildings) portal [6].

[3] **Eyvan:** It is a plan element at the entrance of the building in traditional Hüseynik houses.[8].

[4] **Ahır-Merek:** The barn, which is an inseparable part of Elazig houses, is rectangular in plan and areas with animal feeders. The edge of the barn and the adjacent marquees are used as haylofts. Winter food, grass and hay of animals are stored here. [14].

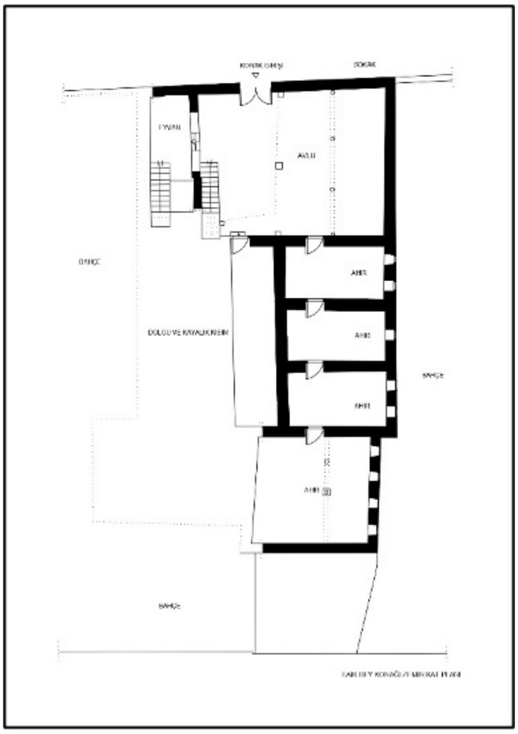

Figure 3. Faik Bey Mansion Ground Floor Plan[7]

In the first floor plan of Faik Bey Mansion, there are sofa, kitchen, toilet, bathroom and room sections. There are rooms, toilet and storage areas around the sofa in the greeting section, which is reached by the stairs in the courtyard. The wall of the sofa section facing the courtyard was protruding and formed a Şahnişin[5]. From this section, it is possible to pass to the checkers in the courtyard (Figure 4).

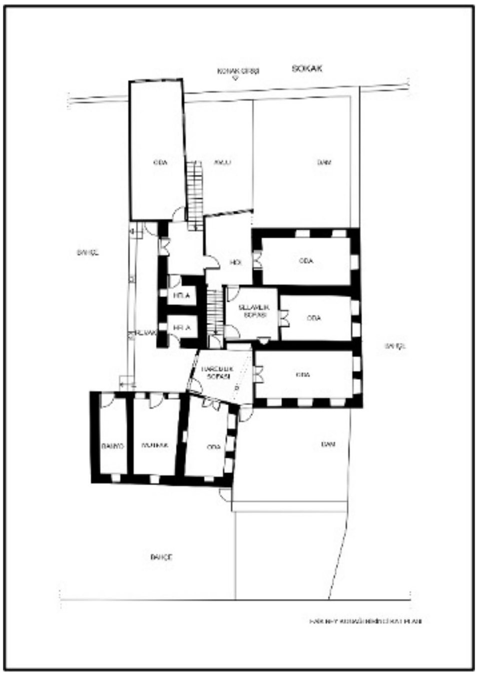

Figure 4. Faik Bey Mansion First Floor Plan [7]

[5] **Şahnişin:** One or more of the rooms on the upper floor of the building in the form of a Cumba [7].

In the Selamlık section, there is a wooden staircase used to pass to the mansion room. The mansion room seen in the old photographs of the building has not survived (Figure 5).

In the Selamlık section, there is a wooden staircase used to pass to the Köşk Room[6]. The mansion room seen in the old photographs of the building has not survived (Figure 5).

Figure 5. The old photograph of the destroyed Mansion Room of Faik Bey Mansion [7]

Due to the difference in elevation with the stairs in the iwan section of the mansion, access to a portico section at the upper floor level is provided. There are wooden columns on stone pedestals in this section. At the end of the portico, there are kitchen and bathroom parts. Access to the harem section of the building is provided from the harem hall, which is reached from the portico. The harem hall is divided into two parts by a wooden arch. From here, transitions to the harem rooms are provided. A door in the haremlik hall leads to the roof section in the south of the building. Today, most of this section has been demolished.

4.2. Construction Materials Used and Construction Technique

Stone, wood and adobe were used as building materials in Faik Bey Mansion. While stone material is used in the ground floor load-bearing walls and arches of the building, wood and adobe materials are used in the upper floor walls and floors. The building was built with the masonry construction technique and the bagdadi wall construction system was used on the upper floor walls. The protrusions and carrier columns in the falcon parts of the building are made of wood.

5. IDENTIFIED STRUCTURAL PROBLEMS IN FAIK BEY MANSION

Faik Bey Mansion is a house built in a traditional style, which has survived for a long time since its construction date and has been exposed to various influences and interventions in this process, and its structural problems have arisen (Figure 6). The building, which was not used for a long time, was left empty due to neglect and abandonment, and the existing structural problems increased. According to the information obtained from the residents of the neighborhood residing in the region, the building has been looted many times and the building has suffered serious damage. Recent earthquakes around the region have also affected the structure and caused damage.

[6] **Köşk Odası:** These are the rooms on the last floor of the buildings. These are private rooms with a view from the mansion room, located alone on the floor they are on [8].

Figure 6. Faik Bey Mansion East and South facades (2023)

The building is surrounded by a high courtyard wall. Rubble stone, cut stone, adobe and wood materials were used on the walls of the courtyard. The mudbrick walls of the empty and unused building have suffered material losses, axial shifts and weathering damage over time. In the building, the original mudbrick walls were completed with brick materials, with unqualified interventions in the parts destroyed by the users. For this reason, due to unqualified interventions on the adobe walls, the structural integrity has deteriorated, increasing the existing damages. The walls of the courtyard were covered with sheet material and structural problems and damages occurred on the walls due to load irregularities. It has led to an increase in structural and stylistic deterioration in the mudbrick walls and wooden beams, which are vulnerable to external influences. (Figure 7).

Figure 7. Structural damage observed on the courtyard walls of Faik Bey Mansion (2023)

There were losses in the façade walls of the building made of adobe material and unconscious interventions were applied to these parts by the building users. Irregular load distributions occurred on the facade walls, which were completed by using materials and techniques contrary to the original. Due to the discontinuities in the load-bearing facade walls, damage such as axis shifts, cracks and joint discharges have occurred. In the old photographs of the building, it is observed that there is a section called the pavilion room in its original form and designed to protrude. Today, almost all of this section has been destroyed by demolition. Remains of wooden flooring and carrier element belonging only to the protruding part of the mansion room have survived to the present day. Deflection, deformation, decay, color change and material losses have occurred in the wooden elements located here (Figure 8).

Figure 8. Structural damages observed on the southern facade of Faik Bey Mansion and the remains of the Köşk Room (2023)

The floor of the courtyard section of the building is covered with stone material (Figure 9). Due to the collapse of the roof of the building and the walls of the courtyard, rubble deposits appeared in the courtyard. The reinforced concrete columns in the courtyard made by the users of the building caused damage to the ground.

Figure 9. Damages observed in Faik Bey Mansion courtyard flooring and stairs (2023)

A part of the courtyard of the building was covered and a roof section was formed. The roof section, which is accessible from the first floor, was built using wooden carrier elements. In this section, the damages due to material losses accelerated the collapse of the structure. Due to the unqualified interventions of the users, the construction system was changed with reinforced concrete columns. (Figure 10). Due to improper combinations between reinforced concrete columns and wooden material, collapses in the roof section caused damage to the walls by making reinforced concrete inserts adjacent to the building walls. Material losses and decays in the original wooden elements have caused discontinuities and collapses in the carrier system.

Figure 10. Structural damages and unqualified reinforced concrete annexes observed in the roof section of the Faik Bey Mansion courtyard (2023)

There is an iwan section separated from the building courtyard by a stone arch. The iwan can be reached by climbing the stairs from the courtyard. Weathering and joint losses occurred in the stone arch in the iwan. There are deteriorations due to processing and darkening on the mudbrick walls, which are thought to be due to the interventions of the users. It was also observed that there were material losses in the stone pavements on the courtyard floor (Figure 11).

Figure 11. Structural damage observed in the Eyvan section of Faik Bey Mansion (2023)

In the iwan, there is a staircase made of stone material that provides access to the first floor. Slips on the stair axis and wear on the step surfaces have occurred. There are deformations, color changes and rot in the wooden elements used in the ceiling covering of the iwan section. The floor on the stairs has collapsed (Figure 12).

Figure 12. Damages observed on the stairs and ceiling tiles in the iwan section of Faik Bey Mansion (2023)

There is a barn section on the southwestern façade of Faik Bey Mansion, the top of which is used as a roof. Today, there are material losses in this section and most of it has been demolished (Figure 13). In the surviving walls of the barn section, the ceiling floor of which was completely destroyed, separations and cracks occurred. There are deformations and losses in the wooden beams inside the walls.

Figure 13. Structural damages observed in the barn and roof section of the southwestern facade of Faik Bey Mansion (2023)

The top cover of Faik Bey Mansion is an earthen roof. Inclined roof additions were made by the users using tile and sheet materials instead of the earthen roof (Figure 14). These additions, which were made against the original, created an unbalanced load distribution on the foundation and walls of the building and caused damage. In some sections, walls were built with unqualified materials in order to provide the roof slope and segregation damage was created on the load-bearing walls.

Figure 14. Faik Bey Mansion's non-original roof application and its structural damages (2023)

There is a Şahnişin (cumba) on the east side of the building, facing the street. Intense material losses are observed on the exterior of this section (Figure 15). Due to plaster spills, wooden material and mud-brick fillings were exposed on the bagdadi walls of the şahniş section. There were deformations, darkening and rot damage on the wooden elements on the walls where weathering and cracks occurred. Deflection was observed in the flooring and wooden carriers of the falcon. Slips and deformations have occurred in window spaces and wall axes. Instead of some destroyed wall sections, fillings were made with materials contrary to the original and the integrity of the walls was damaged. Abrasions and surface deformations have occurred on the original soil pavement of the section of the Şahnişin.

Figure 15. Structural damages observed in the interior and exterior parts of the bay window on the eastern façade of Faik Bey Mansion (2023)

On the first floor of the building, there is a sofa in the form of a Şahnişin(Cumba) (Figure 16). This section is supported externally by reinforced concrete columns and beams made by the users of the building. Serious damage has occurred in this part with unconscious user interventions and some of it has been demolished. Material losses and deformations in the wooden elements of the bagdadi wall are observed in the section of the falcon facing the courtyard. Axle shifts on the walls of the sofa have caused deformities in the window spaces.

Figure 16. Structural damage observed in the bay window of the hall facing the courtyard of Faik Bey Mansion (2023)

Deep structural cracks occurred in the adobe walls of the sofa section. There are cracks and material losses on the walls due to the loss of the properties of the binding materials. Due to the lack of insulation in the ceiling tile, moisture-related deterioration and moisture damage have occurred on the walls. Stone coating was used on the floor of the sofa section. There were losses in the stone materials used and abrasions on the floor covering surface (Figure 17).

Figure 17. Structural damage observed on the wall and floor of the sofa facing the courtyard of Faik Bey Mansion (2023)

There are wall and floor damages in the selamlık sofa of the building (Figure 18). There were plaster spills and cracks on the sofa walls. There is an opening in the wall that opens to the sofa at the entrance. Cracks appeared on the bottom and walls of the opening and surface deterioration occurred. Decomposition in the stone covering materials that make up the floor of the Selamlık sofa, deformations, darkening and deflection occurred in the wooden elements on the ceiling floor of the Sofa.

Figure 18. Structural damage observed in the greeting hall of Faik Bey Mansion (2023)

There are two rooms in the selamlık section of the building. The floor of the greeting room facing the courtyard is covered with wooden material. Discontinuities have occurred on the floor surface due to the deterioration of the wooden covering elements. On the adobe walls in the room, decompositions are observed along the wooden elements due to the movement of the ground. There were plaster spills, cracks, leaks and slips on the walls. There are losses in the wooden elements on the ceiling of the room (Figure 19).

Figure 19. Structural damage observed in the room facing the courtyard in the Selamlık section of Faik Bey Mansion (2023)

In the second room in the selamlık section of the building, plaster spills and slips occurred on the mudbrick walls. There were ruptures and material losses in the wooden elements on the wall niche and on its surface, as well as leaks and moisture damage on the wall where the room windows are located, due to water leaks in the upper floor. Cracks and splits have occurred in the corner joints of the walls and the wooden elements on the ceiling floor. Material losses, decompositions and deformations have occurred in the wood coating. (Figure 20).

Figure 20. Structural damage observed in the second room in the Selamlık section of Faik Bey Mansion (2023)

There is a unique wooden arch inside the harem hall of the building. There are decomposition in the wooden elements of the arch, deformations and losses in the stone materials on the floor and decomposition in the wooden closet section in the sofa. Plaster spills, cracks, blistering and surface deterioration occurred on the adobe walls in the sofa. (Fig. 21).

Figure 21. Structural damage observed in the harem hall of Faik Bey Mansion (2023)

Wooden covering was used on the floors of the rooms in the harem of the building. Coverings were removed from place to place, resulting in material losses and decompositions. There are plaster spills and moisture damage on the adobe walls, slips on the wall axes and splits along the wooden elements. Deep cracks and collapses occurred in the wall-laying joints due to soil mobility (Figure 22).

Figure 22. Structural damages observed in the harem rooms of Faik Bey Mansion (2023)

In the kitchen section of the building, ceramic coatings were made using unqualified materials by the building users and the kitchen counter was removed. Plaster spills on the kitchen walls, material losses and cracks, and unqualified intervention by the users on the floor covering, and the original structure of the screed has been damaged. In the wooden beams in the kitchen, deformations, deflections and separations have occurred (Figure 23).

Figure 23. Structural damage observed in the kitchen section of Faik Bey Mansion (2023)

There are axis slips, plaster spills, cracks and weathering and collapses on the bathroom walls of the building (Figure 24). The demolished wall sections were completed by the users with materials contrary to the original, causing discontinuities in the adobe walls, which have a load-bearing feature. Deflection has occurred on wooden beams due to soot and darkening due to use. There were deformations in wooden flooring and joinery elements.

Figure 24. Structural damage observed in the bathroom section of Faik Bey Mansion (2023)

There is a portico on the north side of the building. The top of this section is covered with a wooden ceiling covering supported by wooden columns resting on stone pedestals. The wall of the portico facing the garden was raised by the users of the building, using materials contrary to the original; plinth and wooden columns remained inside the add-on wall and were damaged. There were plaster spills and cracks on the walls facing the portico of the building. Surface deterioration and abrasions have occurred on the portico flooring. There are decompositions, cracks and deformations in the wooden elements and columns in the upper cover of the portico (Figure 25).

Figure 25. Structural damages observed in the portico section of Faik Bey Mansion (2023)

6. CONCLUSION AND RECOMMENDATIONS

Adobe building material is an important building material that continues to be used from past to present. Throughout history, adobe, wood and stone materials, which have been preferred for their easy supply, natural material and simplicity in construction techniques, have been frequently used in traditional buildings. In our country, examples of traditional buildings made with adobe materials are common.

Hüseynik (Ulukent) Neighborhood of Elazig province is a historical settlement area where there are examples of mudbrick structures built with traditional architecture and style. The traditional houses in Hüseynik (Ulukent), one of the first established neighborhoods of Elazig Province, where mud brick is used as the main construction material, are actively used. However, some of the traditional houses have been abandoned for various reasons and exposed to external influences. Structural problems have occurred in empty and unused traditional houses, due to neglect and unqualified interventions in the past, and some houses have been completely demolished and destroyed over time.

It is important and necessary to preserve and transfer the traditional houses, which are a part of our cultural heritage and carry the traces of the past, to the future. Faik Bey Mansion is one of the traditional houses made of mud brick, which should be passed on to future generations with its original architecture and layout. The building has been registered and the restoration project process continues. Existing structural problems and damages in the building have increased due to neglect and external effects that have been left empty for a long time.

In this study, a field study was conducted to determine the current state of Faik Bey Mansion, and the current state of the building was determined by observational determinations. The current condition of the abandoned building, which has structural problems and damages, has been documented with photographs. Some spaces of the building, whose structural problems and damages have increased over time and which are at risk of collapse, could not be entered. It was concluded that if restoration and repair interventions are delayed, the collapse of the structure is inevitable. In this direction:

• Restoration and restitution projects of the building should be completed as soon as possible and the current state of the building should be recorded.

• With the unqualified interventions made by the users in the past, the materials that are not suitable for the original architecture should be removed without damaging the structure.

• The contents of the building should be determined by analyzing the original material.

• In the sections where material losses are detected, completions should be made with original materials.

• The destroyed parts of the building should be rebuilt with reference to its original architecture.

As a result of the study, it is thought that if the recommendations are implemented, the life of the building will be extended and it will be transferred to future generations in its original form. In addition, the study will serve as a reference for further research and studies and will contribute to the promotion and tourism of Hüseynik (Ulukent) Neighborhood, which is one of the important centers today with its traditional architecture and urban scale, by giving the building a new function.

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Re-Functioning of Tunceli Tozkoparan Primary School, A Republic Period Educational Building


Ebru Nalan Ceylan, Gizem Nur Özcan
Munzur University, Tunceli
ebrunalanceylan@munzur.edu.tr
gizemgungor@munzur.edu.tr

ABSTRACT

In the 1940s, as in many cities of our country, there are school buildings in Tunceli, which were designed under the influence of German architects. These school buildings located in the city were generally built in the villages. The use of these educational buildings, which were designed according to the needs of the period, decreased with the occurrence of migration from village to city throughout the country, also in Tunceli. Towards the end of the 20th century, they completely lost their functions As an example of these buildings in Tunceli, the primary school building in Tozkoparan village of Pertek district is considered. The reason why this building is the subject of the study is that unlike other school buildings built in the same period in the city, this building was built with a mixed system using stone and adobe. This primary school building, which was built as a single-storey masonry structure in this village, where there are usually two-storey mudbrick buildings, is in a very neglected condition today, like other primary school buildings built in the same period in the city. It is thought that this primary school building in the village, where there are traditional buildings compared to other villages in the city, the population is relatively higher, and which also houses one of the most important mounds (höyük) in the city, should be preserved as both a traditional building example and a heritage of the Republic period and transferred to future generations. For this reason, it is suggested that the building be re-functionalized within the framework of a plan that will serve the common use of the village people and conserve and promote intangible cultural heritage values by evaluating other potentials in the village.

Keywords: Cultural assets, conservation, traditional building, republic period heritage

1. INTRODUCTION

As in many cities of our country, school buildings designed by German architects were also built in Tunceli in the 1940s. In Tunceli, these buildings are generally located in the villages and are in the form of building groups consisting of primary education, secondary education, teacher housing and toilet units. These buildings, which were used for educational purposes when they were built, are now either opened to the use of villagers or left idle and unused. In this study, the school building built in the 1940s in Tozkoparan village of Pertek district of Tunceli province was discussed. The history of the building was researched from written and oral sources, its location in the village, its importance, its functions until today and its changing architectural features depending on these were evaluated. After these evaluations, a survey was taken to determine the current use of the building's physical features and verbal interviews were held with the villagers. As a result of these determinations, suggestions were made for the building to be repaired, re-functioned and take an active place in village life, taking into account its architectural features and importance.

2. MATERIAL AND METHOD

In this study, Tozkoparan historical village school will be considered as a singular building example. In line with the information obtained from the field study, the original architectural features of the building, its current situation, structural problems will be conveyed and suggestions will be made for its repair and re-functionalization. While making these suggestions, the decisions of the Tozkoparan village rural guide suggested in the study titled "From Traditional Texture To Rural Design Guide: The Case Of Tunceli-Tozkoparan Village" will be taken into consideration. The re-functional proposal of the primary school building will be made based on this design guide on a texture scale.
The materials required for the field study, which lasted approximately 3 months; Drawing paper, pencils, cameras and laser meters were provided. In order to make field work easier, road routes have been determined and field work has started. The survey of the school in Tozkoparan Village was taken, its plan was drawn and photographs were taken. As a result of oral interviews with the village people and people who studied at this school, that is, the primary users, the historical information of the places, their functions, the lost architectural elements of the building and the deteriorations in the structure were determined. Thus, the field work has been completed. When the writing phase of the study began, the findings were synthesized and the results were expressed as photographs, text, tables and maps.

3. REPUBLIC PERIOD PRIMARY SCHOOL BUILDINGS

The most important struggle of the Republic Period was over poverty and ignorance. Between 1923 and 1950, 75% of the country's population lived in villages and 80% of these villages did not have schools, caused the staff who founded the Republic to start the 'Enlightenment Movement' from the villages.

In the Construction Department, which was established by the Ministry of Education and staffed by local and foreign architects, typical projects were designed taking into account the traditional building materials of the region. The projects in question were sent to all over the country and were built with the management of teachers working in the villages and with the help of local people. These buildings, which are described as the architectural heritage of the Early Republic, are very important in terms of their spread in line with schooling efforts and especially in terms of being public buildings built with the help of the village people.

Since 1930, when primary education policies were shaped and efforts to build schools began in the villages that constitute the majority of the population, city and village schools built according to different types of projects are rarely seen, and the majority of them are seen to be idle and neglected.

It will be examined through the example of Tozkokaran village primary school in Pertek district of Tunceli province, which is a reflection of the educational policy practices of the Republic between 1923 and 1950, aiming to raise the Republic of Turkey to a level of contemporary civilization. Information was received from Tunceli Provincial Directorate of National Education that 495 village/district primary schools in 8 districts are closed and 19 village/district primary schools are open [1]. Tozkoparan village primary school is also among the closed schools.

In the literature studies, it has been stated that studies on the field of education in the Early Republic period generally focus on the history of educational and pedagogical developments of the Ottoman and Republican periods, but the sources give little space to the physical effects of these developments, especially on school buildings. In addition, it has been stated that due to the loss of the project archives for schools by the ministries and the lack of status documents regarding the school buildings built, it is difficult to reach the school projects and designers designed in the Early Republican Period [2]. Similarly, in this study, detailed information about the project, designers and history of Tozkoparan village primary school could not be found. Information about the history was obtained from the village people.

It has been observed that most of the schools built in Tunceli villages were built as typical projects in various cities of Anatolia in the same process, with the financial support and labor force of the villagers. Today, with the changes in the education system, the transition to a mobile education system and the beginning of migration from villages to cities, these village schools have largely lost their function. It will be a very important step to re-function these idle educational buildings and make them available to the public.

There are several publications that are main sources on the subject of Early Republican Period Educational Buildings. The first type of project source prepared by the Exercise Bureau (Tatbikat Bürosu) is the work called "Elementary School Plans Album" prepared in 1933. In this work, type projects designed for the construction of school buildings and teachers' houses, which include design elements specific to traditional and rural architecture, are included, with the construction materials within the possibilities, at minimum cost.

In the work titled New School Hygiene (Yeni Mektep Hıfzıssıhhası), prepared by M. Cemal in 1930, the location of the buildings to be built and what type of materials should be used in terms of lighting and heating were explained [3]. The book includes information such as the fact that schools should not be far from students' homes, that the main facade of the school should face the village road, and that especially classrooms and break areas should be located on facades that receive plenty of light. It also includes detailed information about the number of floors, wall thicknesses and the materials and techniques to be used. According to the book; Village schools will be built as a single storey, wall thickness will be 45-50 cm, wooden material will be joined with a tenon without using nails in the flooring, and the roof will slope to both sides.

The work titled "Village School Building" dated 1937 contains information about typical projects and what materials and techniques the school buildings should be built with. This work includes typical projects planned to be built in the villages where teachers will work after the Village Educators Law. The book titled "City, Town and Village Primary Schools affiliated to the Primary Education Directorate and Some Information About These Schools", published by the Ministry of National Education in 1966, is also one of the main sources.

The doctoral thesis titled "A New Approach for Dening the Conservation Status of Early Republican Architecture, Case Study: Primary School Buildings" prepared by Fatma Nurşen Kul in 2010; is very important as it is one of the first studies examining village schools in Izmir [4]. Again, in the article titled "Early Republican Period Primary School Buildings" prepared by the same author in 2011, she talks about these less known building types of architecture.

During the early Republic period, many studies were carried out in line with educational policies parallel to the new system. In order to ensure that the nation-state consciousness, which is tried to be created in line with these education policies, is established in the social sphere, importance has been given to the design of primary school buildings and the construction of schools. Thus, primary school buildings of different scale, plan type and architecture were built according to the characteristics of the regions. At this point, Ernst Egli and the Exercise Bureau (Tatbikat Bürosu) have a significant role.

It can be seen that primary education policies have been shaped since 1930. Focusing now on the problems in rural education, school construction has begun in all villages in order to educate the village people, who constitute the majority of the country's population. During this period, city and village schools were built according to projects designed in various types. The fact that the departments dealing with school construction have lost the archives of the projects and that there is no inventory information about the schools built since the establishment of the Ministry of National Education, makes it impossible to reach such projects and designers designed during this period [5].

However, information about typical projects can be obtained from the "Elementary School Plans Album", one of the typical project resources prepared by the Exercise Bureau (Tatbikat Bürosu) in 1933. According to the information in the book:

Before the construction of the school, for the land selection, the area where the playground and the building will be built will be selected as sandy land that will quickly absorb mud and rain, the land will be open, surrounded by trees and the air quality will be high. The front of the school building will be placed facing the village road; Buildings, rooms and classrooms will be positioned so that evening or morning sun can enter. There will be solid soil in the foundation. It should be such that solid soil can be reached by excavating 1-1.5 meters. In order to protect the foundation of the building from frost, the foundation must be excavated at this depth. The soil material resulting from the foundation excavation should either be thrown out of the school grounds or used in the ground leveling process.

When the projects carried out in the same period are examined, it is seen that school toilets and teachers' houses were also considered as separate buildings in addition to the school building. Type projects were produced both together with the teacher's house and separately, and they were drawn in different types according to the building materials. When we look at the example of a village school with one classroom made of adobe, we see that the main building is functional as two different units, a veranda is placed in front of the classroom on the right wing of the main mass plan, and the unit that functions as the teacher's house is separated by a corridor (Figure 1). The space located to the left of the corridor and connected to the teacher's house was used as a living area. It can be seen that the rooms in the teacher's house, the entrance, bedroom, kitchen, animal pen, chicken coop and toilet were planned in detail [6].

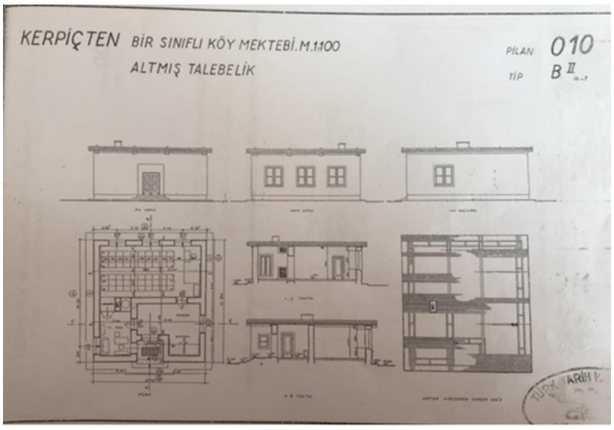

Figure 1. A Village School with a Classroom of 60 Students Designed by the Construction Bureau and Required to be Built with Adobe Material (From the Primary School Plans Album)

Despite the successes in the first ten years of the Republic, according to 1935 population data, there were 26 thousand villages in the country with a population of less than 400. In the first ten years of the Republic, 5401 village schools were built and the majority of them were located in villages with a population of more than 400. According to the Education Law of that period, although the costs of schools built in cities belonged to the state, it was the village people's responsibility to build schools in villages and cover their expenses [7].

In the book titled "Village School Building" dated 1937, which includes type project schools designed to be established in the villages where teachers will work after the adoption of the Village Educators Law, we learn that three different types of projects were designed according to the climate for the village school consisting of one classroom. In the plan of the one-class village school project, we see that a lodging for the instructor and a room for the village board are designed (Figure 2). In the book, technical details about the suitable location for the School, facade location, foundation and building materials, as well as quantity survey tables, are also added to the projects [5].

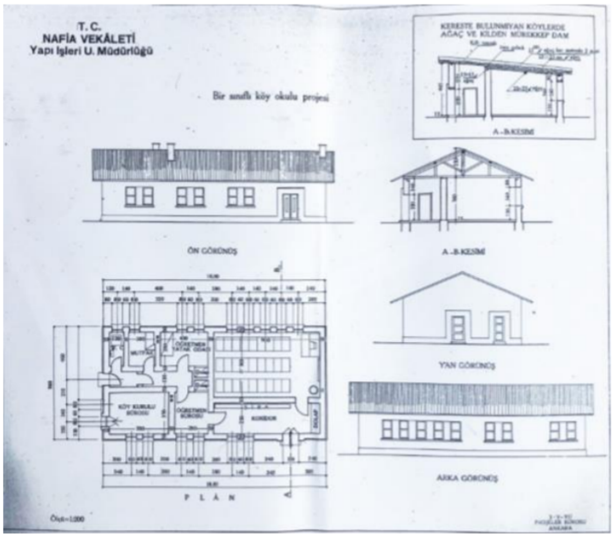

Figure 2. One-Class Village School Project (Kul, F.N, 2011)

Architect Margarete Schütte-Lihotzky and her husband Wilhelm Schütte, who worked at the Ministry of Education Implementation Bureau in the following years, through Bruno Taut in 1938; They were invited to Istanbul because of their expertise in school designs. Margarete Schütte Lihotzky worked as an architect at the Ministry of Education for approximately 10 months between 1938 and 1939. Schütte-Lihotzky produced type projects for schools in Turkey, inspired by her work in the Soviet Union. With the appointment of the Ministry of Education, she worked on village school type projects that would be easy to implement and inexpensive, using accessible materials for the villages in the country. In her memories published in 1939; she touched upon the importance of regional and material conditions for buildings designed with materials such as wood, adobe, brick or crushed stone [8].

"The architecture of village schools should be fully harmonized with the local landscape and the appearance of the village. However, the school building, which will serve as an important cultural center in a small settlement today, should be emphasized in a way that reveals this feature. In this sense, the color element plays the most important role rather than the form, roof or facade of the building [8].

Based on the literature, it is seen that Tozkoparan primary school was built in line with the educational planning and architectural understanding of the period, in harmony with the general appearance of the village and in accordance with the typology of general educational buildings of the period. In addition, as mentioned, the school served as an important center in a small settlement such as a village.

3.1 Concept of Cultural Heritage

Culture and cultural heritage are the resources of societies; In this sense, works that reflect culture are expressed as witnesses that show future generations the dates when these works appeared. Preserving the cultural heritage of societies also means, in a way, conserving human history [8], [9]. For this reason, traditional buildings that constitute cultural heritage should be protected as symbols of the common past of societies and transferred to the future.

3.2 Function Concept

"Function means the demands determined by the requirements and their programming" [10]. Architecturally, function means the suitability of building units for their purpose. The purposes and ways of usage of building elements constitute the function. Both spatial and formal features of the building are formed in order to meet user requirements. The fact that the elements of the building are capable of meeting the needs shows the suitability of the building for its function. The concept of function also refers to a ranking of parts of the building for different purposes according to use. This ranking becomes more important in terms of suitability for function as building usage functions increase. This ranking shows the suitability of the building for its intended use and function.

When we look at the definition of function as "refunctionalization", we see that the issue has a different dimension and requires a more detailed examination than building a new building. It is necessary to examine the compliance of the existing structure with refunctioning or the suitability of the new function with these behaviors.

3.2 Concept of Refunctionalization

Refunctioning is the arrangement of the existing building by changing it to include new uses and activities within the structure. It is the process of changing the function of the existing structure by producing new solutions with the same or different functions according to the requirements of the building to be redesigned [11]. It is the functional obsolescence of buildings that lose their original function. In these cases, the existing building can be modified and repurposed for reuse. This change of function provides the opportunity for the reuse of the existing building.

The historical primary school building in this study was designed and built as a school building in the 1940s. Today, it has lost its function and remains idle. Restoring and reusing the building is important in terms of cultural sustainability, apart from the economic benefit it will provide in terms of construction time and construction cost, as it has been built in the memory of the region by using traditional methods in its time.

4. HISTORY AND ARCHITECTURAL FEATURES OF THE BUILDING

The historical village school building is located in Tozkoparan village of Tunceli Pertek district. When we look at Tunceli in general, there are very few examples of textures where traditional buildings coexist. Tozkoparan village stands out in the city with its combination of traditional adobe houses (Figure 3).

The historical primary school building of Tozkoparan village is the only educational building in the village built with the adobe construction technique and was built collaboratively by the adobe masters in the village. In this respect, the building is both a singular example of the traditional texture of the village and a symbol of its common culture. Today, a part of the building is used to meet the storage needs of the villagers, and its use for this purpose damages the structure (woodshed - dirty and neglected - indoor cooking etc). In addition, the other part of the building was used as a barn. Similarly, there are problems in this section due to lack of maintenance. This part is currently idle. The fact that there is not even a door in this part of the building has a negative impact (uncontrolled use from outside and adverse weather conditions) There is a general lack of maintenance problem.

The historical primary school building in Tozkoparan Village, known to have been built in the first years of the Republic, served as education and lodging until 1981, and then only as lodging. In order to be converted into a lodging, the classroom section was divided into rooms with adobe brick walls. The building has not been used since 1996. Next to the school building, as the need in the village increased in the following periods, a kindergarten building, a primary school building and a lodging building were built with stone materials. Along with these buildings, there are two-storey adobe houses around the area, which turned into the education center of the village. Today, the historical primary school building "As well as the other educational buildings in its vicinity, it is not used and is idle.

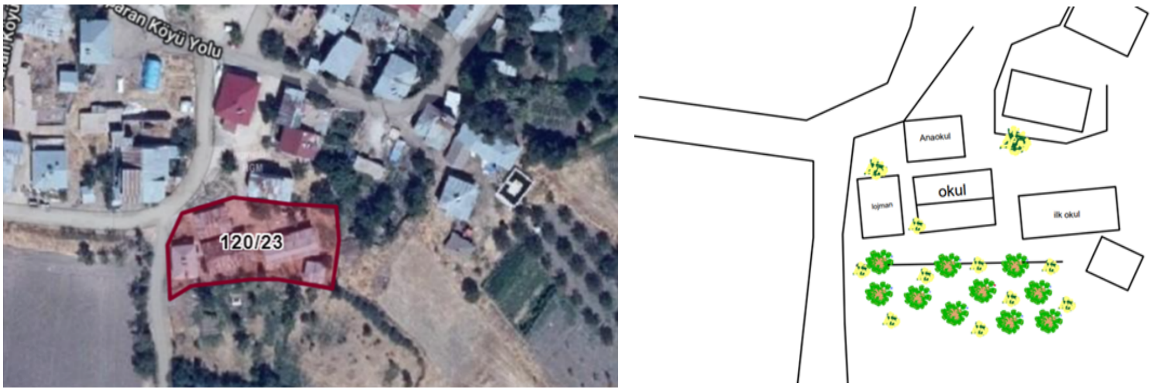

Figure 3. Location and surroundings of the building

The building is approximately 10m x 6m in size and was built as a single-storey masonry stone. The inner and outer stone walls of the building are 50 cm thick, and the mudbrick inner partition walls, which are thought to have been added later, are 20 cm thick. The interior sides are plastered with soil and the exterior with a cement mixture. The ground floor, where the living spaces are located, is approximately 25cm above the natural ground level and covered with wood. The roof of the building is in the form of a very steep gable roof with a slope of approximately 50%. The eaves height is 2.50 m and the ridge height is 4 m. The roof covering was made with a wooden truss system and placed on load-bearing walls. As can be seen from the sections, in addition to the original stone walls, some rooms were divided and used in line with increasing space needs. There is a fireplace as a unique architectural element in the building (Figure 4).

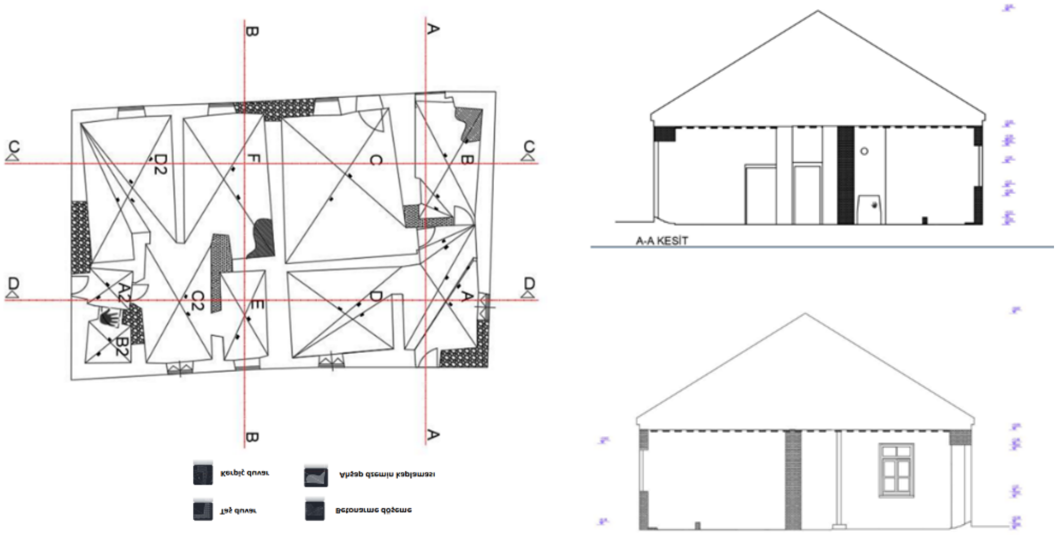

Figure 4. Plan and sections of the building

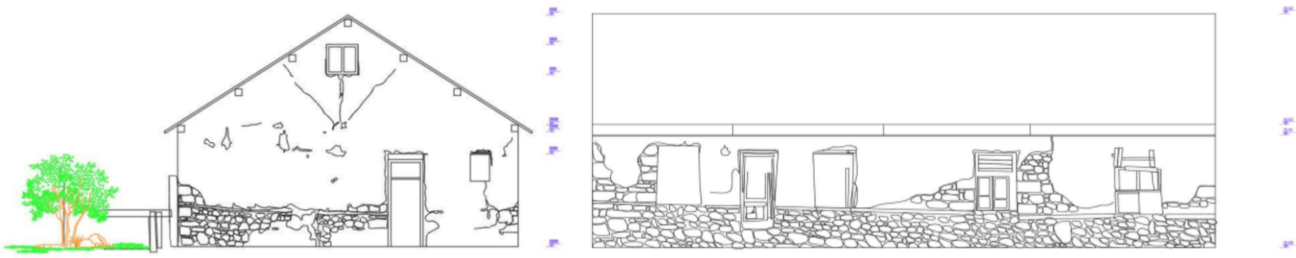

Figure 5. East and south elevations of the building

Figure 6. Outdoor images of the building

Figure 7. Interior images of the building

5. CONCLUSION AND RECOMMENDATIONS

The historical primary school building of Tozkoparan village is the only educational building in the village built with the adobe construction technique and was built collaboratively by the adobe masters in the village. In this respect, the building is both a singular example of the traditional texture of the village and a symbol of its common culture. Although adobe masters still live in the village today, it is noteworthy that there is no adobe and adobe building production. Based on this problem, the study proposes that the building can be repaired and continue its life, and that it can be saved from being idle and reused with a function that can display its original architectural features.

The building must first be restored to its original accessible state and unqualified additions must be removed. Some windows and doors are closed. It needs to be cleared of these attachments and interventions. Afterwards, the necessary maintenance and repairs should be carried out with original - traditional materials and techniques whenever possible. Then, the structure should be given a function that can serve common and continuous use. Thus, continuity in protection must be ensured. This function can be a sales-presentation area related to the villagers' handicrafts and local production.

In this context, the relationship of the building with the Tozkoparan mound and the square in the village was established. The mound (höyük), the village's traditional handicrafts and adobe production were considered as potential. Considering these potentials, the primary school building has been proposed for multi-purpose use. It was deemed appropriate to use it as an exhibition and gathering place, especially for adobe workshops to be held during the summer period when the tourism season increases, to host the production and exhibition of traditional handicrafts (cacım), and to be used in events related to the mound (höyük). In addition, since this historical building was considered as a potential value in the design guide proposed for the village, a walking route was planned between the building, the city square and the mound, which will contribute to the promotion of the village (Figure 8).

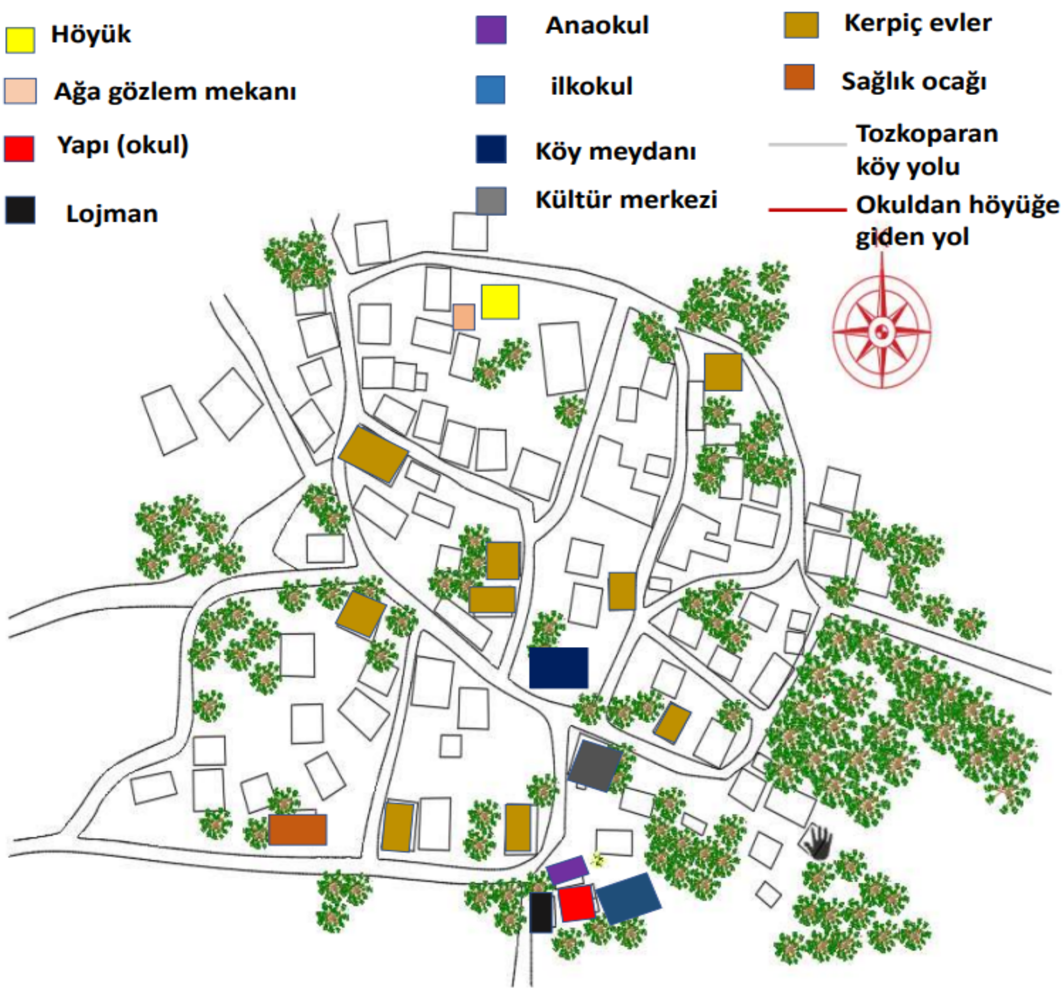

Figure 8. Village layout and routes

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Paper number: 40

The İmportance of Recognizance of "Creative Practice" on The Way of Traditional Architecture Conservation

(By reviewing the practice of conservation and restoration in the historic Fenai house)


Farzane owlia*, Seyed Hadi Razavi**
*M.A. in conservation and restoration of historical monuments and sites, Yazd, Iran
**M.A. in restoration and conservation of historical cities and landscapes, Yazd, Iran
farzaneowlia@yahoo.com
hadirazavii@yahoo.com

ABSTRACT

In the continuity of historical architecture, new architecture can or must carry the values and worthiness of the land's culture. To build such architecture, we, as architects, must learn first. In order to learn, one must study the historical architecture in which preservation, conservation, and rehabilitation of historical monuments and sites are striking proceedings. An aspect of the study process on historical architecture, which is mainly neglected, is ''practicing to learn''.

Practicing is a way of institutionalizing a value within the person who holds or believes in it. Although it has its own costs, without practicing, we wouldn't be able to continue if we say not the most, but one of the most efficient kinds of architecture through efforts for building in human history.

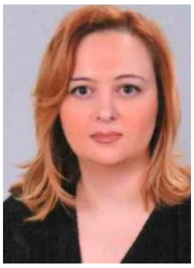
This article will present a sample of practicing building, following traditional earthen architecture in fields of preservation, restoration, and construction, Reviews the earthen architecture in the historical city of Yazd and comment on some worthless experiences which could have been prevented by mentioning.

Recent rebuilding and restoration performed in a historical house named Fanaei house (Yazd-Iran) are briefly described, emphasizing the criteria and techniques adopted and arising from the traditional architecture.

Keywords: Conservation, Traditional Architecture, Creativity, Practice And Learn, Fanaei House.

Paper Number: 41

A Review of Vernacular Material Selection in Educational Buildings in the Context of Sustainable Architecture

Ülkü Şimşek Şengül, Özlem Tüz
Mersin University, Mersin

ulkusimsek@mersin.edu.tr
ozlemtuz@mersin.edu.tr, ozlemtz@yahoo.com

ABSTRACT

Sustainability in architecture has emerged intending to make designs that will meet the needs of people by minimizing the damage to the natural environment. Sustainable architectural design is design that respect people and the environment, do not harm natural resources, are compatible with the climate, consume less energy and use recyclable materials. Traditional architecture, on the other hand, is the climate and topography of the geography they are located in. It has emerged with the use of local building materials, which are compatible with the characteristics of the society, reflect the beliefs, traditions and life culture of the society, together with the past knowledge. In the studies on sustainable architecture, it can be said that there are similarities between traditional architecture and sustainable architecture and when it is examined, it is understood that the basis of the sustainability criteria is based on traditional architecture. Building materials, which are one of the main criteria in sustainable architecture and traditional architecture, have an important place in terms of energy consumption of buildings, conservation of natural resources and environmental health. Therefore, in this study, traditional building materials will be examined within the scope of sustainable architecture.

Sustainability is not just about the design of buildings. As the main purpose of sustainability, leaving a livable ecosystem to new generations will only be possible by raising young generations consciously. The impressions that the places in the schools leave on the children will affect their sensitivity to the environment. For this reason, raising awareness in the concept of sustainability should be one of the most important goals in education. In this study, it is aimed to reveal the relationship between the use of traditional materials and sustainability with examples from the world and Turkey, by examining the educational buildings that stand out with the use of traditional materials and design by considering the principles of sustainable architecture.

Keywords: Sustainability, Sustainable Architecture, Traditional Architecture, Traditional Materials, Sustainable Educational Buildings.

1. INTRODUCTION

In the last decade or so, academic interest in the sustainability of traditional architecture has increased noticeably. While incremental academic studies differ in their thematic scope and methodological approaches, what these studies have in common is the idea that those involved in the development of sustainable architecture can (and indeed should) learn from traditional architectural practices. The idea is that in an age of many environmental challenges, traditions have long been associated with their natural environment. This more 'sustainable' approach is thought to contain what needs to be learned for those involved in contemporary architectural practice [1].

The paradox of this view is that the continuity of most traditional structures is today in grave danger. All over the world, traditional structures appear to be in decline and are often underestimated, abandoned, neglected or demolished. At least by many, these buildings, which are outdated and associated with poverty, are constantly being replaced by architectural models that support more modern, international technologies, materials and forms [2,3,4]. Interestingly, these declining vernacular traditions are sometimes described as those that embody important practices for sustainable design. For example, the wind towers of the Middle East are good examples of this paradox. To many researchers, these represent the complex, advanced nature of traditional passive cooling strategies [2], but today these strategies are hardly used by those in the region. Instead, they use electro-mechanical cooling systems.

On the one hand, although traditional architecture is abandoned for some reasons, on the other hand, those who understand that sustainable architecture passes through traditional architecture are trying to blend with today's architecture. It is considered important that the overlap between sustainable architecture and traditional architecture, especially in educational buildings, gives children the opportunity to learn about protecting nature and giving the least damage to the environment by experiencing it.

The healthy development of children is affected by many factors, as well as the structural features of the building. For this reason, it is becoming more and more important that educational buildings have sustainable features. Some of the American and European countries have made it mandatory to provide sustainable building features related to educational buildings with laws and regulations. Special emphasis is placed on various issues in order for educational structures to be certified. These are sufficient daylight, color choices, energy efficient design, better indoor air quality, acoustic comfort in the classrooms, buildings being a teaching tool at the same time, sharing the building facilities with the people in the immediate vicinity, durability, and the selection of local materials that do not harm health. The most important reason for focusing on these issues is that the users of these buildings are children. In this study, local material selection, which is one of the most critical principles, will be discussed. This subject, which is one of the principles of traditional architecture, constitutes the scope of the study.

In this context, educational buildings, which stand out with the use of traditional materials and designed by considering the principles of sustainable architecture, were examined by the literature review method. In the study, it is aimed to reveal the relationship between the use of traditional materials and sustainability by examining examples from the world and Turkey, and to provide resources for applications to be made within the framework of educational structures.

2. LITERATURE REWIEV

Materials are essential for construction, but they cause significant environmental impacts, especially those whose production is high energy intensive. In the past, due to lack of technological solutions capable of producing more advanced materials and to transport them over long distances, materials used in vernacular constructions had low-tech profile and were restricted to those available on sites. These were mostly natural, had low processing, low embodied energy and consequently reduced environmental impacts. Some studies explaining this relationship were examined.

Fang, Ying (2014), his paper addresses the relation between Portuguese vernacular architecture and locally sourced materials. To assess the contribution of these materials for sustainability, a comparison

with industrial materials at level of environmental indicators was established. According to they, taking into consideration that traditional materials are closely related to local conditions and have significantly less environmental impacts and embodied energy than current construction materials, their use means a potential to reduce impacts throughout the life-cycle of buildings, in a "cradletograve" approach. Thus, to achieve sustainability, architecture should seek integration between tradition and contemporaneity, using the best of both in technologies and materials. [5].

Zhai and Previtali (2010), their papers investigated the energy efficiency performance of traditional building materials. Considering special building traditions seen in ancient vernacular architecture as an approach to improving building energy performance is a worthwhile endeavor. For instance, the simulation indicates that using vernacular materials, such as, earth walls and thatch roofs, will improve the performance of buildings. The energy-saving value of integrating vernacular building attributes into contemporary construction practices will be much broadly manifested when other building criteria (e.g., cost effectiveness and safety) can be evaluated simultaneously. [6].

Desideri et.al. (2012) their studies examines the sustainability principles of educational buildings. It also tries to explain the relationship between sustainability and local material. It is thought that the study on educational structures in Nigeria will contribute to other studies in this field in the country. [7].

3. CONCEPTS OF SUSTAINABLE ARCHITECTURE AND VERNACULAR ARCHITECTURE

In this section, the concepts of sustainable and traditional architecture will be explained. Within these concepts, the title of building material will be examined. The relationship between material selection in traditional architecture and sustainable architecture will be explained.

3.1. Sustainable Architecture

"Sustainable architecture is all of the activities to create structures that are environmentally friendly, use energy, water, materials and the area they are located in, and protect the health and comfort of people, giving priority to the use of renewable energy sources, taking into account future generations, in the conditions and in every period of its existence." [8]. In another definition, sustainable architecture is "an approach to increase the availability of natural resources to architectural design that minimizes food or resource consumption" [9]. An architect should make a decision by considering the environmental effects of the building he designed in all processes from the design stage. In this direction, sustainable building design is made with certain criteria. These criteria are:

• Structural asset creation
• Increasing the quality of life
• Being comfortable and aesthetic
• Ensuring the acquisition of residential property for the poor segment of the society • Supporting mass production processes
• Does not prevent biodiversity
• Least impact on the environment
• Being light, reliable and healthy
• Resilience in the face of changing environmental and social situations
• Local construction, maintenance, repair and safe disposal
• Easily recyclable or reusable at the end of its service life
• Effective use of energy and materials
• The materials used are safe [7,8].

Material is an important criterion in the construction of sustainable architecture, considering its impact on the environment in all life cycle processes. The basic principles of this criterion are:

• Local materials
• Materials with the least environmental impact
• Materials that reduce the urban heat island effect

• Low emissivity materials
• Materials with low formation energy and reducing energy consumption in fieldwork • Materials that reduce water consumption and pollute water less in fieldwork
• Durable materials
• Materials produced from renewable resources
• Materials reworked for use in construction
• Least processed materials
• Recyclable or potentially recyclable materials
• Materials purchased from manufacturers through product take-back programs • Use of certified wood
• Materials that avoid toxic chemicals or by-products [10,11,12,13].

Building Material in Sustainable Architecture

Sustainable structure can be defined as a system that has the characteristics of a process that will exist continuously, without any deterioration in the properties of the existing material, without any reduction in the material that feeds it [14]. Sustainable building materials are materials that consume the least amount of energy during their use, do not harm the environment and human health during the acquisition, processing, use, maintenance-repair and waste generation of raw materials [15]. Sustainable building materials, in other words, green building materials are materials that do not harm the environment and that raw materials sensitive to the limits of exhaustible resources are used effectively in their production. In the selection phase of building materials, in addition to criteria such as good performance, quality, aesthetics and cost, sustainability criteria are also expected to be met. sustainable materials;

• Since they do not contain toxic components, they are not harmful to human health.
• They can be recycled or reused.
• They do not cause harmful effects to the natural environment after their functions are finished.
• They are obtained from local sources and producers.

The life cycle of the building covers the period from the extraction of the raw materials to be used for the construction to the demolition. The life cycle of a structure can be classified into three phases. This cycle is classified as pre-construction period, construction period and post-construction period. Especially when choosing a building material, features such as aesthetics, cost and performance should be taken into account, while at the same time life-cycle criteria should be considered [16,17].

3.2. Vernacular Architecture

The word 'tradition', which is the English and French equivalent of the word 'tradition', is derived from the Latin word 'tradere', which means 'transfer, transmit'. The word means 'culture-related and inherited from previous generations' and accumulated/accumulated experiences and their continued use'. Paul- Alan Johnson defined tradition as 'the transmission of knowledge over time in the form of facts, beliefs, sayings, rules and customs' [18]. Traditional architecture can also be defined as the whole of human- nature-culture, which produces the most appropriate solutions to environmental conditions and reflects the living culture, stemming from the direct relationship and experience of people with their environment throughout history [19]. These types of buildings are shaped over time, not according to a specific person or view, but according to the common beliefs and lives of the society, and are made anonymously by local owners and masters in the region, not by private architects. Necati Şen, for traditional architectures, 'Multi-doped, unidentified architects, one of which is the influence and rooting of the other.

[20,18]. Social customs and traditions, lifestyle, customs and beliefs; physically, the ground-topography, wind, solar radiation, air movements, temperature, humidity, vegetation, local materials have an important place in the shaping process of these works. For example, the climate,

which is a determining factor in shaping the architectural envelope and providing interior comfort, is effective in terms of the direction, shape, facades and materials to be used of the building [21]. The fact that traditional buildings have an inward-looking space arrangement through inner courtyards or that all of the spaces are outward-facing is related to climatic conditions. The exterior surfaces of the buildings, both the wall thicknesses and the window and door openings on the wall surfaces have been developed in the form and dimensions that will allow the heat loss/gain and natural ventilation to be provided under the necessary conditions. Rain, snow and wind resistant roof formations and eaves sizing are distinctive features of many traditional architectures [18]. Traditional architectural products, shaped in accordance with the characteristics of the place and climate, offer many unique solutions.

Material in Vernacular Architecture

Ecological systems that are formed by the mutual relations of the living things in a certain area and the inanimate environment that surrounds them and that are continuous are called 'ecosystems'. In order for the living things that are part of the ecosystem to survive, the existing ecological balance must be preserved. In this respect, the rational use of resources and the importance of nature-friendly design for the environment and ecology are better understood. Mankind, who has been in constant interaction with the environment he has been in since the first day of his existence, was initially under the influence of the environment he lived in, but over time he began to organize the environment according to himself; He gradually used materials such as stone, wood and plants, which he used naturally until the agricultural period, by shaping them.

Local materials seen throughout the world can be grouped under the title of soil (adobe, brick), wood (chestnut, bamboo, reed, etc.) and stone (valzer quartzite, stone gabions, etc.). Traditionally, the type and application technique may vary depending on the characteristics of the place. Among these, soil- based materials are frequently used in many regions, especially in rural areas. Local, cheap and easy to produce; In addition, properties such as heat storage are among the reasons for the preference of soil material [22]. The properties of adobe and brick, which are frequently used among soil-based materials, are similar. In addition to carrying the basic properties of the soil material, the differences are that the adobe is dried with sunlight without consuming energy, and the brick is fired in an oven with a temperature of 900 oC. In addition, brick is molded and shaped under pressure, and adobe is produced by placing it in molds with human power without the need for such a process [23].

These applications, which required manpower, have been left behind due to the technological opportunities that have developed in the industrialization process that has continued from the 19th century to the present, and new products that are not in nature have been developed. With the Industrial Revolution, many new materials such as steel, aluminum, glass, plastic have been used. These materials, most of which are foreign to nature and take many years to dissolve spontaneously, damage the ecosystem in parallel with the amount of waste they create in the environment [24]. Today, while people are trying to create new policies and take measures to improve the deteriorated environment and natural living conditions, on the other hand, they try to ensure naturalness in their own environment and life. Perhaps this is why the interest in traditional architecture and materials has increased in recent years. For example, a large number of studies are currently being conducted on mudbrick, which was used extensively in pre-industrial buildings [25].

4. VERNACULAR MATERIAL AND ITS IMPORTANCE IN SUSTAINABLE ARCHITECTURE

The importance of material selection for sustainable architecture has been mentioned above. In this section, the relationship between traditional materials and material selection in sustainable architecture will be examined. At this point, first of all, the concept of the life cycle of materials should be explained. Life-cycle assessment (LCA-life cycle assessment) is an environmental impact estimation method that covers the entire life cycle of structures, including extraction of raw materials, processing, production of building components, use of structures, and end-of-life [26]. As it can be understood from this definition, the extraction and processing of the raw material, its use for the building and the energy consumed throughout its life and its impact on the environment are very important. This constitutes one of the main subjects of sustainable architecture. Traditional materials are generally natural materials that are extracted from the region where they are located and processed in the region, which are compatible with the environment. The proximity of traditional materials to the area where the building will be built will also eliminate the transportation problem. The energy to be spent during transportation will also be minimized. In this respect, the relationship between sustainable architecture and traditional material selection is increasing.

Traditional materials such as wood, earth, sand, stone, clay, bamboo, adobe, straw are also environmentally friendly as they do not contain chemicals or are minimally processed. They comply with the criteria of sustainable materials: least harmful to human health, having the least environmental impact, reducing the urban heat island effect, low emissivity, reducing energy consumption in fieldwork and low formation energy, reducing water consumption in fieldwork and polluting water less, durable, Renewable Materials that are produced from resources, reprocessed for use in construction, Least processed, recyclable or have the potential to be recycled.

5. SUSTAINABILITY IN EDUCATIONAL BUILDINGS

It is seen that the importance of sustainable design has been emphasized in the studies in recent years in which the environmental conditions desired for schools have been defined. It is thought that a healthier and productive environment can be created for children within the framework of the definitions in terms of the use of daylight, clean air, and the use of low-polluting materials in school buildings where sustainable design principles are adopted. The schools are thermally comfortable; contact with fresh air, daylight and scenery; have acoustic conditions that support learning; providing sports facilities; able to use the environment as a learning resource; able to obtain good drinking water; providing social opportunities that support friendship and social development; It is emphasized that it should be designed in a way that is sensitive to individual safety. With the definition of sustainable school, the dimensions of energy and water conservation, minimizing waste, avoiding potential pollutants, protecting and supporting natural life, using financial resources effectively, respecting people's participation are discussed [27].

Providing the necessary fresh air for thermal comfort, especially in the classroom environment, is associated with the use of traditional materials. Reducing airborne chemicals with low-emission materials is important for the physical and mental development of children.

Use of vernacular materials in educational buildings

Providing the necessary fresh air for thermal comfort in educational buildings, especially in the classroom environment, is associated with the use of traditional materials. Reducing airborne chemicals with low-emission materials is important for the physical and mental development of children. For this reason, in this study, some examples of buildings using traditional materials will be examined.

Table 1. Rural School Pivadenco [Url-1].

TITLE	Rural School Pivadenco
LOCATION	ŞİLİ
YEAR	2020
ARCHITECT	Duque Motta & AA , MAPAA
AREA	417 m²
MATERIAL	Wood frame, volcanic stone and metal cladding

DESIGN: The design of the building is associated with the old productive sheds and materials of the area, but reinterpreted from a contemporary perspective, using metal cladding, wooden structure and local volcanic stone from the area. Its location aims to organize the land by providing 3 spaces with different uses, a public square that emphasizes the idea of being open to the community and allows events and meetings, a playground and sports area for children, and educational areas [url-1].

In addition, energy efficiency and thermal comfort were considered for the school. It is defined that the central area also functions as the thermoregulator of the building in winter and summer through 3 elements. These three elements are as follows:

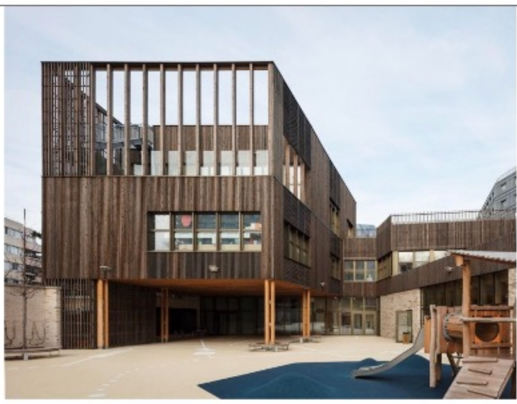
• Skylights to capture indirect natural light from the north in summer and direct sunlight in winter to gather warmth,
• Concrete walls as a thermal mass that absorbs this heat during the hours of sunlight and distributes it throughout the rest of the day; and
• A cross ventilation system that significantly reduces the indoor temperature in summer.

Table 2. Montessori School [Url-2].

TITLE	Montessori School
LOCATION	İSPANYA
YEAR	2019
ARCHITECT	Gradolí & Sanz
AREA	1842 m²
MATERIAL	Terracotta-based perforated brick and wood

DESIGN: The focal point of the design of the building has been to have flexible spaces that can change and grow according to needs. When desired, there is an environment interaction with the classes that open out. For this, we come across a three-dimension reminiscent of the fan form. Considerable attention has been paid to the heavy use of materials with a smaller ecological footprint: terracotta and wood. Concrete was used only in the foundations, while steel was used in individual columns and balustrades. There is no plaster work, suspended ceiling or suspended floor, paneling. Everything is visible. In this way, it can be understood how the structure works, how the materials are assembled and how it is built. [Url-2]

Table 3. Jeanne d'arc Nursery School [Url-3].



TITLE	Jeanne d'arc Nursery School
LOCATION	FRANSA
YEAR	2019
ARCHITECT	Atelier Desmichelle Architecture , La Architectures
AREA	1753 m²
MATERIAL	Ahşap karkas, volkanik taş ve metal kaplama

DESIGN: The project was designed using a low carbon approach. Therefore, all materials are selected from bio-based and geographically sourced material. As the building is part of the passive design certification, sunlight is optimized, reducing heating needs and using a high-performance cladding and dual-flow ventilation system. [Url-3] Attention is drawn to the use of traditional materials by using wooden walls and terracotta bricks.

Table 4. Initiative Rising Star School [Url-4].

TITLE	Initiative Rising Star School
LOCATION	ZİMBABVE
YEAR	2023
ARCHITECT	Ingenieure ohne Grenzen
AREA	2552 m²
MATERIAL	Brick

DESIGN: It's hard to believe that the new school building is completely handmade. About 600,000 bricks were laid by masons, and only a few technical devices assisted the construction. [url-4]

Table 5. Elementary School in Santa Cruz de Villacuri Community [Url-5].

TITLE	Elementary School in Santa Cruz de Villacuri Community
LOCATION	PERU
YEAR	2022
ARCHITECT	Atelier Ander Bados, Betsaida Curto Reyes
AREA	760 m²
MATERIAL	Brick, wicker, wild cane and wood

DESIGN: The understanding of 'it comes from the community that understands its environment as valuable' has created the design concept. The common point of all constructions is the use of uncoated materials to be economical. The materials are used as they are; exposed brick, exposed concrete, wicker, reed and wood. . The intimacy of the material in its natural state helps the community more identify with the school and feel more respected by the local construction methods. Wild cane and wicker, which are local and traditional materials, are the unifying elements in the project. They are used in the closing, shadow and segmentation functions. [url-5]

Table 6. Gangouroubouro Primary School [Url-6].

TITLE	Gangouroubouro Primary School
LOCATION	GÜNEY AFRİKA
YEAR	2013
ARCHITECT	LEVS MİMARLIK
AREA	295 m²
MATERIAL	Hydraulic compacted earth block (HCEB)

DESIGN: The walls are constructed with newly developed and locally produced hydraulic compacted earth blocks (HCEB) in alternating strips. It sets the rhythm of the facades and provides a cool interior climate. The porch with stone rows on both sides forms the wide terrace of the school. The roof is made of overlapping steel sheets, each overhanging 1 meter, creating extra shadow areas. The mass of the roof is transferred to the buttresses by means of thin steel shaft profiles. Poligny beams run throughout the classroom rooms, creating a free floor surface [url-6].

Table 7. The Rajkumari Ratnavati Girl's School [Url-7].

TITLE	The Rajkumari Ratnavati Girl's School
LOCATION	HİNDİSTAN
YEAR	2021
ARCHITECT	Diana Kellogg Architects
AREA	-
MATERIAL	Sandstone

DESIGN: Rajkumari Ratnavati Girls' School is a school that will serve more than 400 girls from kindergarten to grade 10 living below the poverty line living in the mystical Thar Desert region of Jaisalmer in Rajasthan, India, where female literacy has reached only 32%. Since the GYAAN Center was designed for women by a woman, Kellogg looked at cross-cultural feminine symbols when starting the design process. In particular, a structure consisting of three ovals was designed to represent symbols of power, femininity and the power of eternity. Rajkumari Ratnavati Girls' School is made entirely of local hand-carved Jaisalmer sandstone by local craftsmen. Using local materials has helped reduce carbon emissions. The elliptical shape of the structure also creates a cooling airflow panel, helping to bring out the sustainability aspect. [Url-7]

6. CONCLUSIONS

Sustainability means that while meeting the needs of the present, the needs of future generations are also considered. According to this, ecological structure emerges as a structure that makes use of the environment and nature while fulfilling the standards and human expectations required for modern life, but does not harm it, and even helps to preserve the ecological balance. traditional residential areas; climate and topography etc. in their geography. They are areas that are compatible with the characteristics of the society, reflect the beliefs, traditions and life culture of the society, and are created by the use of local building materials together with the past knowledge. In studies on sustainable architecture, it is stated that there are similarities between traditional architecture and sustainable architecture, and when sustainability criteria are examined, it is based on traditional architecture. It is known that the use of local materials, especially in traditional architecture, is of great importance in sustainable architectural design principles. For this reason, revealing the relationship between traditional material selection and sustainable architecture has been one of the aims of the study.

However, the idea that all problems will disappear with sustainable building design or traditional architecture should not be accepted. As the main purpose of sustainability, leaving a livable ecosystem to new generations will only be possible by raising young generations consciously. In this context, raising awareness in the concept of sustainability should be the most important goal in education.

It is seen that the importance of sustainable design has been emphasized in the studies in recent years in which the environmental conditions desired for schools have been defined. It is thought that a healthier and productive environment can be created for children within the framework of the definitions in terms of the use of daylight, clean air, and the use of low-polluting materials in school buildings where sustainable design principles are adopted. The schools are thermally comfortable; contact with fresh air, daylight and scenery; have acoustic conditions that support learning; providing sports facilities; able to use the environment as a learning resource; able to obtain good drinking water; providing social opportunities that support friendship and social development; It is emphasized that it should be designed in a way that is sensitive to individual safety. Providing the necessary fresh air for thermal comfort, especially in the classroom environment, is associated with the use of traditional materials. Reducing airborne chemicals with low-emission materials is important for the physical and mental development of children. For this reason, some examples of buildings using traditional materials were examined in this study. As a result of these examinations, it is possible to say that today's architecture is oriented towards traditional building materials. It is seen that the use of brick, wicker, wild cane, wood and adobe is common. These educational structures contribute to sustainability and creating comfortable and healthy educational spaces for children with their environmental compatibility.

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Paper Number: 42

Biologically Improved Rammed Earth Blocks-BIRE Blocks-as the Keystones of a Contemporary Design and Production System

Fatime Mermerci[1], Fulya Akipek[2], Büşra Aktürk[3], Tuğrul Yazar [4], Hatice Gülen[5], Muammer Özbek[6]

[1,2,4] Istanbul Bilgi University, Department of Architecture
[3,6] Istanbul Bilgi University, Civil Engineering Department,
[5] Istinye University, Faculty of Engineering and Nature Science,

fatime.mermerci@bilgiedu.net, fulya.akipek@bilgi.edu.tr , busra.akturk@bilgi.edu.tr, tugrul.yazar@bilgi.edu.tr , hatice.gulen@istinye.edu.tr; muammer.ozbek@bilgi.edu.tr

ABSTRACT

This paper covers the intermediate results of the three-year research project, which aims to define a sustainable life-cycle process for designing and fabricating biologically improved rammed-earth blocks. The research is based on three primary methods such as (1) laboratory tests, (2) design and fabrication of earth blocks in the factory, and (3) prototype construction.

In this research, it was aimed to test the performance of different bio-stabilized earth mixtures by creating recipes to enhance some properties of the earthen blocks, i.e., weight, durability, or shrinkage parameters. In the scope of the laboratory tests, physical and mechanical properties of the mixes, which are formed by incorporating biological ingredients into the Alker recipe, were determined. The mixes produced with agricultural plant waste, such as peanut shells and rice husks, and also with the bacteria will be optimized during the block fabrication process in the factory.

In the scope of the design and fabrication process, the block types, components, and wall patterns that perform as massive walls, textured walls, or perforated walls were identified. The block design and layout strategies are expected to create various spatial qualities for different scenarios. The whole design and fabrication process planned via the life-cycle assessment approach is studied by the process diagram. This diagram enables the recognition of simultaneous and interrelated processes and also serves as a guide for sustainability issues.

This shift from the university laboratory tests to the factory production process entails standardization of the material, automatization of some tasks during block production, and some refinements through design. In conclusion, the fabrication process of the BIRE Blocks will be compared with traditional, on-site rammed-earth wall construction processes in order to evaluate it as a contemporary design and production system.

Keywords: Rammed earth, Fabrication, Compressed Earth Blocks (CEB) , Bio-stabilizers, Life Cycle Assessment (LCA)

Paper Number: 43

Conservation Problems of Traditional Adobe House in Kırşehir Kayabaşı Neighborhood


Özlem Sağıroğlu Demirci [1],
Olcay Türkan Yurdugüzel[2]

[1] Gazi University, ANKARA
[2] Yozgat Bozok University, YOZGAT

[1]osagiroglu@gazi.edu.tr
[2]olcay.turkan@yobu.edu.tr

ABSTRACT

Using traditional construction methods, adobe structures, which are environmentally friendly and sustainable practices, are examples of traditional rural architecture of settlements. The most widely used and oldest material in Anatolia during the construction process, adobe is the material that produces the largest number of buildings. The number of adobe houses, which are widely used in the center and rural areas of many settlements, varies according to the settlement and usage situations. The adobe housing are defined as qualities worthy of protection, as the buildings that show the characteristics of the rural texture begin to set the agenda as a necessary value to be protected.

In this study, adobe houses located in Kırşehir were chosen as the study area. It has been determined that while some of the adobe houses are actively used, some houses are out of use. It has been determined that the houses that have been out of use for different reasons have been damaged at a level that cannot be used in the process and are on the verge of extinction. In this context, it is aimed to determine the protection problems of adobe houses in Kırşehir Kayabaşı Neighborhood, which are damaged at different rates. Suggestions for the solution of these problems are presented by grouping the damages of the used and unused houses. In the development process of the city, ideas that can be tried to be produced within the scope of protecting and using adobe houses.

Keywords: Kırşehir, Kayabaşı Neighborhood, Adobe House, Conservation Problems

1. INTRODUCTION

Rural architectural examples can be defined as a collective ensemble of structures that prioritize the expression of cultural traces embedded in the settlement's social life. They are shaped and formed based on physical environmental characteristics and are influenced by environmentally conscious processes, regional materials, techniques, and craftsmanship. Preserving and comprehensively evaluating architectural products produced based on these criteria, in conjunction with sociocultural values and spatial narratives, holds significant importance [1]. The rural architectural fabric, which is shaped by regional materials, techniques, environmental data, and cultural characteristics, plays a crucial role in defining the uniqueness and authenticity of the settlements [2, 3]. To ensure the continuity of the cultural footprint, it is crucial to consider the sociocultural attributes embedded within the built environment, the use of materials, the construction techniques required by the regional building culture, and the transmission of traditional knowledge and experiences, as they collectively shape the identity and value of the settlements [4].

It is worth mentioning that structures and settlements shaped using regional materials such as adobe have gained recognition for their sustainable practices. With the looming threat of depleting energy resources, energy usage, conservation, and management have become key concerns spanning various disciplines, including the construction sector. The escalating levels of energy consumption throughout the production, utilization, and decommissioning processes of buildings have raised concerns regarding environmental harm. In order to achieve energy conservation, create environmentally friendly and sustainable structures, it is essential to utilize local materials in construction, adopt eco-conscious energy utilization, consumption, and management practices, and employ region-specific construction techniques. Rural architectural examples, where the prominent use of local materials takes precedence, are deemed worthy of preservation within the discipline of architecture. Adobe structures, being one of the most prevalent instances of rural architecture, not only demonstrate environmental friendliness and conservation in energy consumption but also provide quality living environments that cater to appropriate usage conditions. The absence of production facilities required for material production, environmentally sensitive utilization, lack of necessity for separate insulation materials, economic viability, eco-friendliness in recycling processes, and energy efficiency of the building envelope all make adobe a significant material in the preservation of the natural environment [5]. The advancement of technology has led to increased energy consumption within the construction sector, resulting in environmental pollution that the ecosystem cannot sustain. Decisions regarding environmental conservation, the utilization of renewable energy sources, waste management, and sustainability have driven designers and practitioners to adopt environmentally conscious choices. Consequently, the prioritized decisions of designers and implementers entail ensuring comfort conditions, utilizing minimal and renewable energy sources, and employing eco-friendly material usage [6]. Consequently, adobe, as a building material, has garnered attention in numerous countries with varying levels of development and has been subject to extensive research and investigation [7, 8].

The chosen research area, Kayabaşı Neighborhood in Kırşehir, boasts numerous adobe houses and exhibits rural architectural characteristics. Additionally, it is situated in close proximity to the city center. The city features various neighborhoods with examples of adobe housing. However, the rapid deterioration process and the expectation that a substantial majority of these structures will soon become inaccessible due to their proximity to the city center have motivated the decision to focus on this area for study purposes. The number of adobe houses, which contribute to the traditional fabric of the settlement, has decreased over time due to diverse practices associated with the city's developmental progress, and this decline continues. At present, some structures that represent a distinct fabric, facade, and spatial composition specific to rural housing are still actively utilized, while others remain unused or are only occupied during specific periods. The preservation of these houses, although unregistered, is deemed essential due to their significant cultural, social, and technical features, which reflect the era to which they belong and contribute to the continuity of the cultural footprint. Thus, the aim of this study is to facilitate the continued use of adobe houses while preserving their architectural qualities. Within this context, the research endeavors to identify conservation issues relating to active or inactive adobe houses, which are influenced by various factors such as sociocultural, socioeconomic, environmental, and others. In addition to documenting the physical deterioration process of the unused houses, the study aims to evaluate the impact they have on the social fabric of the neighborhood. Categorizing the conservation issues of these structures under distinct headings and generating ideas for potential solutions are integral to enhancing the transformation and spatial qualities of the settlement. Despite the lack of official registration, the cultural, social, and technical features encapsulated within these structures make them worthy of preservation as they perpetuate the cultural footprint of their respective era. The absence of academic studies focusing on the significant examples of rural housing within the city and the imminent risk of these structures vanishing underscores the significance of this study.

2. PRODUCTION AND CHARACTERISTICS OF ADOBE

Adobe, a construction material commonly used in Anatolia, has been employed for thousands of years due to its distinctive production technique. The selection of soil material for adobe, the utilization of straw as a binding element, the fermentation process, pouring the mixture into molds, and subsequent sun drying are the key steps that contribute to the material's uniqueness [9]. There is a diversity of binding materials used in adobe production across different regions of Anatolia. These materials include plant stems, fibrous plant residues, gypsum, lime, wood ash, salt, wool, hair, and others [6].

The production method and energy consumption associated with the construction material used are of paramount importance for maintaining ecological balance. Emphasizing sustainability, the dominant principle in construction and utilization, depends on the energy expended throughout the design, implementation, usage, and end-of-life processes of a structure. In this regard, adobe stands out as an environmentally friendly material, requiring minimal energy consumption during production, application, and usage. Its contribution to energy conservation can be observed during transportation from the production site to the construction area, as well as through appropriate design decisions concerning material utilization [10]. Moreover, the thermal storage capacity of adobe during the usage phase contributes to indoor comfort conditions by regulating humidity and purifying the air [11]. The material's ability to easily integrate with the environment, lack of waste generation, and potential for reuse even after the completion of its life cycle further accentuate its prominence as an ideal building material [12, 10, 13].

Various methods exist for producing building elements with adobe. The brickwork method involves pouring adobe mixture into wooden molds and stacking the obtained bricks on top of each other to construct the building. This method is the most widely employed in Anatolia. The pounding method, known as "dövme" in Turkish, refers to the production of elements by pouring adobe mud into prepared molds and compacting it through pounding. This technique offers advantages such as ease of construction, time efficiency, and achieving smoother surfaces. In the wood-framed infill method, vertical and horizontal wooden elements are incorporated within the walls, along with adobe bricks, to provide structural support. This method is another prevalent approach to adobe construction in Anatolia. The spraying method, akin to the technique used in concrete technology, involves applying adobe mud onto prepared reinforcement or mesh and applying a finishing plaster. This method is applied to non-load-bearing elements [10].

3. KAYABAŞI NEIGHBORHOOD ADOBE HOUSES

The exact founding date of Kırşehir, a medium-sized settlement situated along the Ankara-Kayseri highway in Central Anatolia, remains unknown. Based on findings from archaeological excavations, the city is known to have originated in the Early Bronze Age. Over its history, Kırşehir has been influenced by several civilizations, including the Hittites, Phrygians, Persians, Macedonians, Kingdom of Cappadocia, Romans, and Byzantines [14, 15]. The architectural style and material usage similarities found in excavations at Kaman Kalehöyük, Yassıhöyük, Kültepe, Alacahöyük, Alişar, and Boğazköy indicate that these sites belong to the same era [16, 17, 18].

The geographical location of the city has significantly shaped its cultural, social, and physical development throughout history. The earliest available information about the city dates back to the 12th century. After changing hands multiple times during the Seljuk Empire and the Beyliks period, Kırşehir was eventually granted to the Karamanoğlu Beylik following the Battle of Ankara [14, 15].

The city is situated in a continental climate zone and occupies an area that can be considered moderately sloping. Reflecting the characteristics of the Central Anatolian region, the city generally features sparse forested areas and steppe vegetation.

The research area chosen for this study is Kayabaşı Neighborhood, which is within walking distance of Cacabey Square, the city center, and located to the west of the square (Figure 1). The adobe houses to be examined as examples in this study represent the regional housing fabric of the city. However, due to technological advancements and changes in construction materials and techniques, the buildings constituting the city's housing stock have shifted towards reinforced concrete frames and brick/masonry construction methods. This transition has accelerated the decline and potential disappearance of adobe houses, which embody the characteristics of the local culture. Adobe houses, which are more prevalent on the city's periphery, are scarce in the central area and its immediate surroundings.

Figure 1. Location of Kayabaşı Neighborhood (Yandex Maps)

An evaluation was conducted to assess the original floor plans, facade details, and architectural features of the dwellings in Kayabaşı Neighborhood, taking into consideration the potential deterioration and interventions they have undergone. The focus of the fourth section of the study was to identify issues related to the conservation of these dwellings that could compromise their inherent qualities. By examining the current state of the structures, particular attention was given to visible interventions and alterations that have affected the spatial configuration and usage patterns shaped by the city's inhabitants.

The houses in Kayabaşı Neighborhood predominantly comprise single or two-story structures constructed using adobe infill between wooden frames. The use of stone masonry is observed up to the sub-base level, while the upper sections feature adobe or wood materials. To mitigate damage caused by adverse weather conditions, the mud plaster applied to the houses is commonly made of clay. The majority of the houses possess gardens of various sizes, although a few examples without gardens can also be found. These houses can be positioned within the garden, facing the road directly, or set back from the road. Consequently, access to the house can be through the garden or the porch. While most of the houses are arranged in a detached manner, a small number are attached to neighboring structures and front-facing the road.

The garden walls of the houses are typically constructed using the stacked technique, incorporating adobe material and featuring an additional layer of brushwood and soil to enhance privacy. The brushwood, locally known as "çalpı" is obtained from tree branches and shaped longer than the height of the garden wall, preferably using thorny branches. By vertically placing the brushwood, it acts as an eave, providing protection against factors that may disrupt the privacy of the dwelling, such as human and animal intrusion. The layer of soil added on top of the brushwood creates a barrier, preventing its detachment from the wall.

Houses with interior courtyards are equipped with ancillary spaces such as bread ovens, stables, coal storage areas, and poultry houses. In single and two-story examples, the courtyard can accommodate one or two rooms in each direction, while an asymmetric layout is also possible, with one side of the courtyard featuring a single room and the other side housing two rooms. In two-story houses, the ground floor is primarily utilized for service areas, while the living spaces are located on the upper floor. Within the garden, various features can be found, including wells, hearths, outdoor toilets, and fountains. Residents engage in agricultural activities, utilizing their gardens for cultivation and preparing winter provisions such as tomato paste and dried vegetables/fruits. Each house incorporates a "dip kiler" space, used for food storage, designed with insulation appropriate for preserving food. Accessible from inside the house, the "dip kiler" is connected to the residential areas by an "ön kiler" space, which can open either into the house or the garden.

The facades of the houses often feature open or closed projections. These projections, not adhering to a specific typology, can be categorized as single projections emphasizing the entrance axis, projections on both sides of the entrance axis, or projections positioned to the right or left relative to the entrance axis. The design of door and window openings on the facades varies in proportion. Room windows tend to be nearly square or rectangular, while the windows flanking the entrance door are vertically oriented and take on a rectangular form. Buildings with entirely wooden frames typically lack decorative elements such as ornamentation, moldings, or architraves. The roof predominantly comprises pitched roofs, with a few examples featuring hip roofs. In some cases, the roof extends to create an overhang above the entrance, or a triangular pediment is applied. There are also instances where the entrance area is defined without an overhang, as the wall recedes from the facade.

4. CONSERVATION ISSUES FOR ADOBE HOUSES

The adobe houses in Kayabaşı Neighborhood, characterized by their rural architectural qualities, face significant challenges in terms of conservation. These challenges can be categorized as socio-economic and socio-cultural issues, as well as issues arising from natural conditions and user-related factors. These challenges significantly contribute to the deterioration and loss of the original fabric and qualities of these houses.

Among the *socio-economic and socio-cultural challenges*, the abandonment of houses holds particular significance. It is believed that users prefer modern construction systems and materials over adobe houses. Factors such as the perception of contemporary constructions being more durable and capable of providing superior comfort may influence user preferences. Additionally, changes in the traditional neighborhood culture, leading to a weakening of neighborly, kinship, and community relationships, can also contribute to the abandonment of adobe houses. The requirement for annual maintenance and repair, which incurs additional costs, can only be fulfilled based on the economic capabilities of users. Consequently, it is observed that users opt to leave their adobe houses and choose to reside in new dwellings, repurposing their old houses as secondary residences or storage spaces. The complete abandonment or inappropriate utilization of adobe houses impedes the maintenance and repair efforts, hastening the process of deterioration. During the course of this study, it was determined that some abandoned structures had deteriorated into ruins. Moreover, the presence of unused houses within a region can contribute to social decline, leading to areas of social deterioration.

Figure 2. Examples of abandoned houses (Author's Archive)

Figure 3. Examples of ruined houses (Author's Archive)

It is possible to offer some assessments regarding the reasons why users continue to inhabit these dwellings. Within this context, reasons such as the sentimental value of the house as a family heirloom, its advantageous location within the city providing transportation convenience, or the lack of economic means to purchase a new dwelling may compel users to continue living in adobe houses.

Adobe material possesses numerous advantageous properties; however, it is also susceptible to *deterioration due to natural factors*. Moisture and water-related issues can pose significant problems and damages to adobe structures. The use of stone as the building material up to the sub-base level in adobe constructions primarily aims to prevent water from the ground and water ingress from damaging the structure. Additionally, the presence of wood material in adobe houses accelerates the deterioration process caused by water and moisture. Rain and snowwater coming into contact with the body walls can result in erosion and surface disintegration. The need for regular renewal, maintenance, and repair of the mud plaster applied to adobe walls can be considered a challenge in terms of usability. In many unused houses identified during the study, it is believed that plaster failures, erosion, wear, and fragmentation of the body walls occur (Figure 4). The lack of intervention or incomplete surface repair leaves the surfaces vulnerable to water and moisture issues.

Figure 4. Erosion and plaster repairs on body walls (Author's Archive)

Cracks and damages in adobe walls due to temperature variations can also occur. In Kayabaşı Neighborhood, cracks observed on the wall surfaces can be attributed to the expansion and contraction resulting from temperature changes. Furthermore, the holes and cavities found in the building walls are believed to be caused by rodent damage.

One of the *human-related conservation issues* concerning adobe houses involves proposed solutions to meet additional space requirements, which can be defined as user needs. It can be stated that additional wet areas are identified in the houses in Kayabaşı Neighborhood. These areas are primarily toilets, bathrooms, and kitchens. The incorporation of these areas into the houses to meet comfort conditions may lead to decisions that disrupt the original floor plans of the houses (Figure 5). Moreover, the use of different materials such as bricks, blocks, or cement for these additions creates problems associated with the integration of different materials.

Figure 5. Later added spaces and application of concrete plaster (Author's Archive)

The execution of maintenance and repair interventions by individuals lacking knowledge and experience in adobe techniques and practices can result in irreversible damage to the structures. The use of materials during interventions that harm the original materials can shorten their lifespan. Additionally, many examples can be found where adobe wall surfaces are coated with concrete plaster (Figure 5). This application, aimed at reducing the burden of yearly plaster renewal, is considered another practice that harms the adobe material. It is possible to suggest that surfaces experiencing plaster failures and not receiving any intervention will have a shorter lifespan, being exposed to harsh climatic conditions.

The replacement of window and door frames, which define the original facade character of the houses, with widely used and perceived as more comfortable materials, is a common occurrence in the study area. Furthermore, interventions that alter the balance between solid and void on the facade by closing doors and windows can also have a negative impact on the original facade character (Figure 6).

Figure 6. Change in frame material, damage caused by paint and inscriptions on the facade (Author's Archive)

The lack of awareness among urban users who have not reached a sufficient level of consciousness regarding the need to preserve these structures as rural architectural heritage can hinder their preservation. Consequently, problems caused by users on the building facades can be discussed. Paint, inscriptions, and other practices carried out by uninformed users, as well as the installation of unqualified additions, can be considered as applications that negatively affect the facade character (Figure 6). Furthermore, the lack of sensitivity from local government, non-governmental organizations, and universities regarding the preservation of architectural heritage within the city is viewed as a negative aspect in terms of sustaining these values.

5. EVALUATION AND CONCLUSION

The adobe houses in Kayabaşı Neighborhood in Kırşehir face damage due to factors such as the city's development process and changing user preferences. The disappearance of these houses over time will hinder the understanding of the era and cultural structure they represent by present and future generations. Short-term usage or abandonment of these structures is one of the most significant obstacles to their preservation. To prevent the destruction of these houses due to user preferences or financial interests, it is considered necessary to make decisions regarding their registration or inclusion in conservation practices. This would allow for alternative uses of abandoned houses. It is believed that comprehensive preservation decisions implemented for the entire neighborhood or even on a city scale would be effective in ensuring the continuity of cultural heritage. Additionally, to maintain the continuous use of the houses, users need to be informed about the cultural significance of these structures as necessary heritage. This way, the value of preservation and a sense of ownership can be effectively conveyed to users.

To preserve adobe houses, it is necessary for various institutions and organizations such as local government, non-governmental organizations, and universities to implement practices and actions that raise awareness about these structures. It is also considered crucial to convey the concepts of preservation and cultural heritage from an early age, starting from early education levels. With an increased level of knowledge among users, it is believed that the repetition of human interventions on the structures would be avoided. It is also believed that raising awareness of these structures' cultural value would prevent damages caused by unqualified additions, changes in floor plans, and the use of different materials.

The active use of houses in the study area can be matched with regular maintenance and repair of the structures. By addressing natural issues, such as resolving moisture-related problems, the lifespan of the structures can be extended. It is also suggested that changes to the structures should be carried out by practitioners who have knowledge and experience in adobe construction techniques. Despite not requiring specialized craftsmanship, being aware of the deformations that interventions and the use of different materials can cause in existing structures is believed to be effective in their preservation and continuity.

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Paper Number: 44

Experimental Study on Thermal and Mechanical Characteristics of Compressed Earth Block Stabilized with Cement


Negin Baseri[1], Nariman Farahza[2]

Art and architecture school, Yazd University, Yazd, Iran

n.baseri@stu.yazd.ac.ir

n_farahza@yazd.ac.ir

ABSTRACT

Considering the increased usage of compressed earth blocks as a modern earthen material in the construction industry, it is imperative to have an understanding of their efficacy. Therefore, this research highlights the impact of compacted pressure during production and the amount of cement content on both the strength and heat conductivity of compressed earth blocks. The result of the experimental study indicates that increasing the cement content and compaction pressure significantly improves the strength of the compressed earth blocks. The maximum strength of 13.3 Mpa was achieved by adding 5% cement with a compaction pressure of 20 Mpa. However, the minimum strength was recorded at 5.3 Mpa, which was fabricated without the use of cement and compacted at 10 Mpa. Based on the results, it can be concluded that the amount of cement has a negligible effect on the thermal conductivity of the specimens. Conversely, the compaction pressure significantly impacts the heat transfer of the compressed earth blocks.

Keywords: Compressed Earth Block, Compressive strength, Thermal conductivity, Cement stabilizer

1. INTRODUCTION

During the last few years, there has been growing attention to the use of materials with low environmental impact, low cost, and more accessibility in the world. This interest has caused many investigations to replace environmental materials with modern materials.[1, 2] Accordingly, the use of earthen materials, which is one of the oldest and most extensive buildings in human history, has become exceedingly popular. These materials, which require a simple construction method, are made from local materials, and provide pleasant thermal properties.[3, 4]

Traditional earthen materials like adobe have limitations when it comes to the needs of modern engineering constructions. To address this, a new generation of earthen structures, including compressed earth block (CEB), has been developed to improve the prior earthen materials based on the needs of engineering constructions.[5] Compressed Earth Blocks are made by compressing wet soil in a mold and do not require complex equipment.[6] The compaction process enhances the quality and performance of the blocks, and making them stronger and more durable blocks compared to adobe.[7, 8]

The inclusion of clay enhances the soil's cohesive properties, and binding its components together. Nonetheless, Compressed Earth Blocks (CEBs) are vulnerable to degradation due to environmental factors, particularly precipitation. Soil stabilization techniques have been increasingly used to enhance the strength and durability of soil, which alters its properties and improves its engineering performance.also, it is defined by three methods, mechanical stabilization, corrects soil granulation by adding soil, stabilization with additives and stabilization with compression. [9]Bahar et al [10] examined the impact of various techniques on the mechanical properties of soil blocks. The findings show that a combination of compaction and cement stabilization was an effective approach to increase earthen block strength. Compressed earth block are commonly stabilized with cement due to its widespread usage. Adding a small amount of cement to CEBs can enhance their strength. Amoud et al [11]found that when water is added to cement, it forms hydrated compounds that fill up empty spaces in the mixture. This leads to a considerable improvement in the mechanical strength of the product and enhances its overall quality. Elisabete et al[12] confirmed through their experimental study that the durability and thermal conductivity of the compressed earth blocks directly deponds on the quality of the soil particle size distribution, level of compaction pressure during construction and the raw materials composition.

Our research, examine the impact of compaction as well as cement content on compressed earth blocks during production and analyzing performance of CEB.The object is to achieve optimal thermal and mechanical characteristics in compressed earth blocks for use in buildings.

2. MATERIALS AND METHODS

Compressed earth blocks are a contemporary version of molded earthen bricks that are compressed by hand-operated or hydraulic machines. It can be molded into various solid shapes such as bricks, bricks with holes, or interlocking blocks. Compressed Earth Blocks are often made using manual presses that utilize leverage to ensure proper compaction. In order to maintain consistency across all blocks and mixes, this research utilized machine-produced blocks. The hydraulic jack is equipped with a pressure gauge, allowing for precise input pressure for every fabricated block. All of the specimens were produced using hydraulic pressure. Fig1, illustrates the experimental device for manufacturing test specimens including a metal mold and a hydraulic press for soil compaction.

Figure 1. Specimens preparation procedure

The soil used for fabricating the CEB specimens was collected from the region of Yazd, Iran. Based on the assumption that soil characteristics may differ within various areas, the Atterberg limits and the particle size of the soil were investigated. Before production, ASTM D422 [13] was used in order to classify the soil based on its particle size distribution, as shown in Fig. 2.

Table 1. Atterberg limits of local soil

D_{30}	D_{60}	Gravel	Sand	Silt	Clay
0.0031	0.15	0%	47%	25%	28%

Table 2. Atterberg limits of local soil

Plasticity limit (PL)	Liquidity limit (LL)	Plasticity Index (PI)
9.5 %	22 %	12.5

The obtained grading curve was compared with the particle size range recommended by CRATerre (Centre de Recherche en Architecture en Terre). Fig. 2 demonstrated that the grading curve of the used soil is between the lower and upper limits given by CRATerre, indicated the soil is acceptable for CEB without any modifications. As shown in Table 1, the soil can be classified as a moderately plastic silt type CL according to the USCD (Unified Soil Classification System).

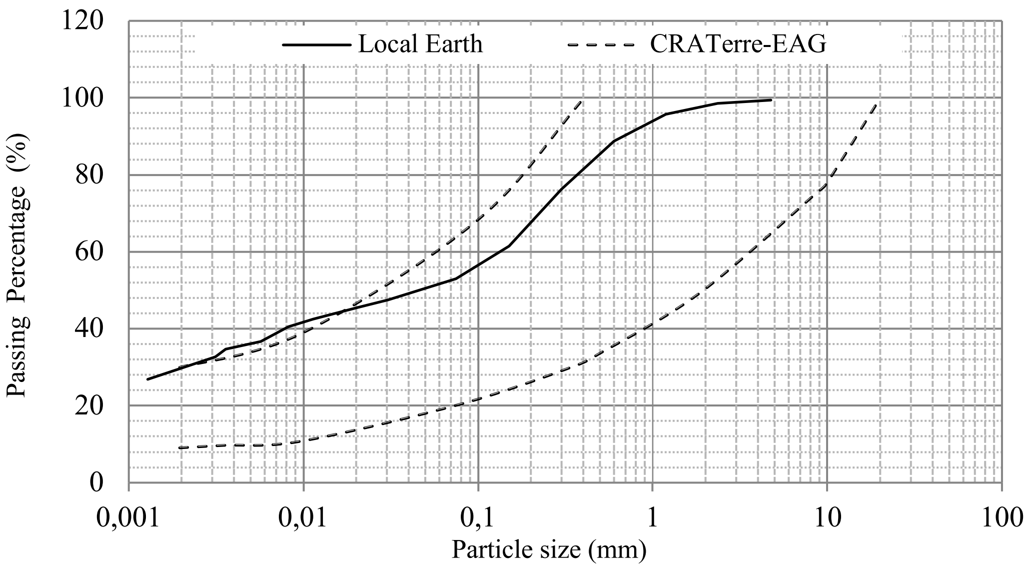

Figure 2. Distribution of soil particle size

At first, the local soil was air-dried for block production. Then, the lumps were manually broken down and sieved using a 10mm screen to remove any unnecessary particlesThe soil is sieved and dried in an oven at 105°C for 24 hours before mixing with water.The mixing procedure of CEB was done first by dry mixing the cement and soil until it became consistent and uniformly distributed and then sufficient water added to it. The materials were weighed precisely before molding and compaction. The soil were placed into the cubic-shaped mold and then compressed using a hydraulic press. (Fig.1). After compaction, the specimens were removed from the mold and cured for 28 days. Half of the time, the blocks were coated with a plastic cover to simulate wet curing. After removing the cover, the block was left to dry for another two weeks.

Table 2. Specimen specifications

Type	Pressure (MPa)	Cement (%)	Size	Nnumber
C0-P20	20	0	5 * 5 * 5	3
C3-P20	20	3	5 * 5 * 5	3
C5-P20	20	5	5 * 5 * 5	3
C5-P10	10	5	5 * 5 * 5	3

Compressed earth block construction has few globally recognized standards. Direct compression testing is the most effective way to obtain valuable information about the strength of CEB. Uniaxial compression tests were performed on 28 days aged cubic samples ($5 * 5 * 5\ cm^3$) by the electronic universal testing machine.

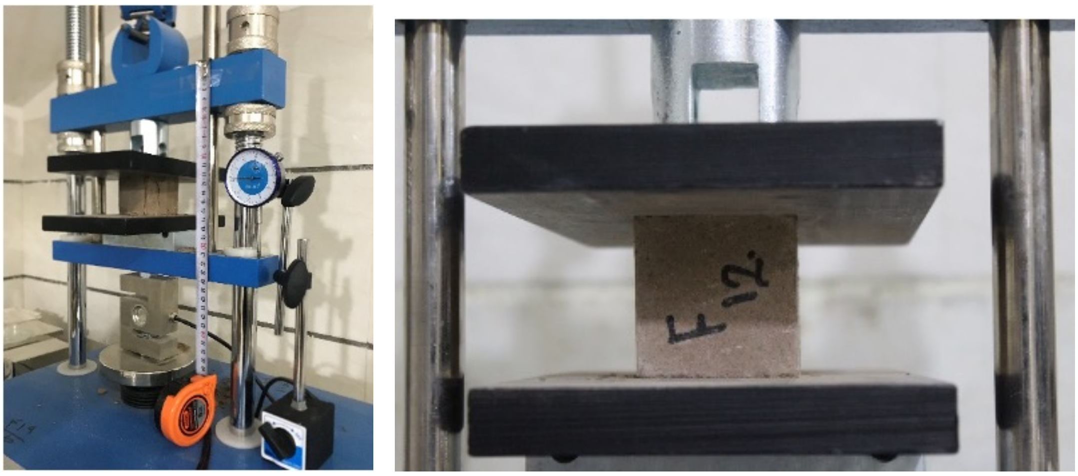

Figure 3. Uniaxial compression testing of cubic samples

The thermal conductivity was measured by using a WL-376-thermal conductivity device. The WL 376 device is used to measure the thermal conductivity of non-metallic building materials according to DIN 52612. An electric heating mat is used to heat up the hot plate. Water cooling is used to achieve the low temperature in the cold plate. Sensors measure the temperatures at the cooling water inlet and outlet, as well as in the center of the plate. The temperature for the hot plate above the sample and the cold plate underneath are set in the provided software. A temperature control system keeps a constant temperature. The experiment was conducted by taking five measurements and then calculating the average value to report. Before measuring, the flatness of the specimens was checked to ensure proper contact with the sensor.

3. RESULTS AND DISCUSSION

3.1. Compressive strength result

The dry compressive strength and density of the compressed earth block are presented in Table 3 There are four series of samples, categorized by the level of compaction pressure applied during production and the amount of cement used. In each series, 3 specimens were prepared, and the specimens were tested after appropriate curing and drying in the laboratory for 28 days. The tests were repeated for each specimen in the series.

Table 3. Mechanical test results

Type	*Mean.density* $(\frac{kg}{m^3})$	*No.*	*Compressive Strength (Mpa)*
C0-P20	1898	1	13.4
		2	12.8
		3	13.8
C3-P20	1914.5	4	8.89
		5	7.99
		6	9.67
C5-P20	1920	7	5.43
		8	5.70
		9	5.02
C5-P10	1861.5	10	6.21
		11	6.92
		12	6.77

The mean dry density was approximately between 1861.5 to 1920 $(\frac{kg}{m^3})$. Among the series of specimens tested, the highest strength is associated with C5-P20, while the lowest strength is related to C0-P20.The strength of the cement samples has shown a notable increase, which can be attributed to the ongoing pozzolanic reactions. The compressive strength results of the compressed earth block samples are shown in Fig. 4.

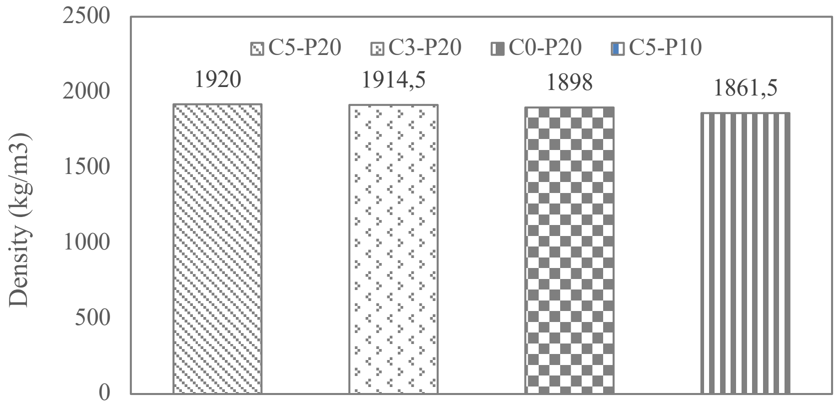

Figure 4. Comparing the mean density of samples

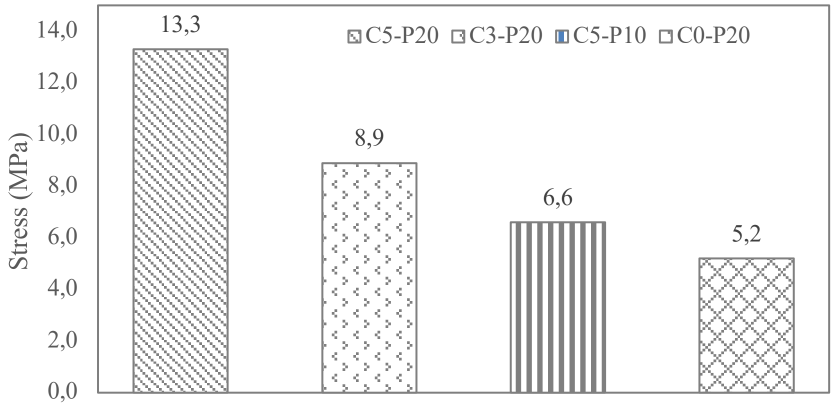

Figure 5. Comparing the compressive strength of samples

3.2. Heat conductive result

The table 4 summarizes the results of the thermal conductivity test and related density for the compressed earth blocks after 28 days.It shows heat transfer values at temperatures spanning from 30 to 80℃.The values of the thermal conductivity coefficient varied between 0.3004 and 0.5638 ($\frac{W}{mK}$). The most effective impact observed on thermal conductivity was the compaction pressure during the production. As the compaction pressure is increased, a corresponding increase in thermal conductivity is observed. This phenomenon occurs due to the presence of air voids, which reduce thermal conductivity.

Table 4. Thermal conductivity test results

Type	*Mean.density* ($\frac{kg}{m^3}$)	*Tempreture* (℃)	*Thermal conductivity* ($\frac{w}{mk}$)
C0-P20	1898	30	0.3253
		40	0.3458
		50	0.3526
		60	0.3662
		70	0.3799
		80	0.3935
C3-P20	1914.5	30	0.4390
		40	0.4551
		50	0.4713
		60	0.4874
		70	0.5035
		80	0.5196
C5-P20	1920	30	0.4522
		40	0.4856
		50	0.4968
		60	0.5191
		70	0.5414
		80	0.5638
C5-P10	1861.5	30	0.3004
		40	0.3206
		50	0.3273
		60	0.3407
		70	0.3542
		80	0.3676

Cement content affects a material's thermal conductivity and porosity by hydration. the cement's hydration causes the clay particles to polymerize and the microstructure to be filled. Analyzing changes in porosity from cement variations helps us understand the relationship between these factors. Figure.6 illustrates thermal conductivity of specimens.

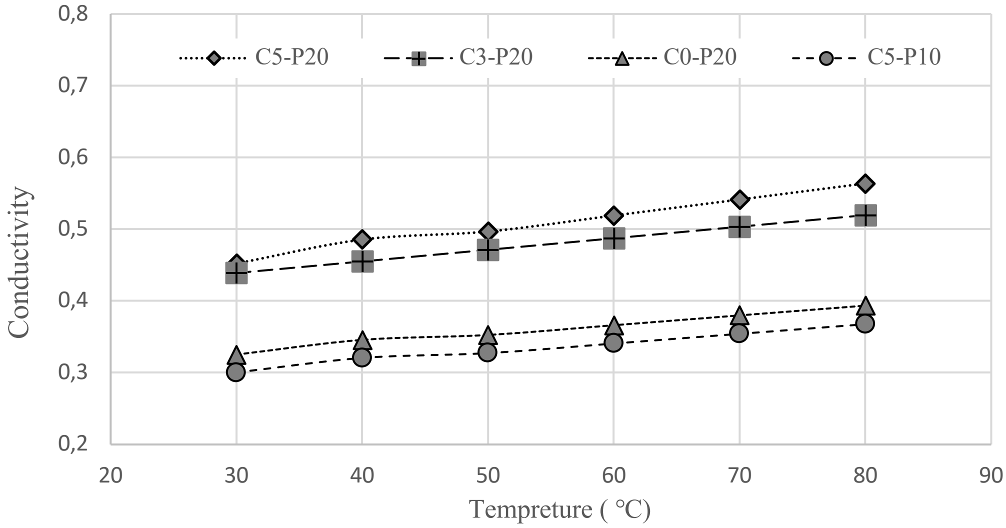

Figure 6. Thermal conductivity test results

4. CONCLUSION

Raw soil is a sustainable construction material due to its low cost and global availability. The study examines the effect of cement content and compaction pressure on the mechanical and thermal properties of compressed earth block production. Various CEBs were evaluated and compared. Based on the research, the following conclusions have been made:

- By increasing cement content, the density of blocks increased, and enhancement in compressive strength can be seen obviously.
- The compaction pressure is directly related to the density and strength of the specimens.
- It has been demonstrated that the strength of blocks is significantly influenced by their cement content and density.
- The results demonstrated that the addition of cement led to a slight increase in the thermal conductivity,
- There was no statistically significant correlation between the thermal conductivity and the amount of cement present.

This pilot study is the first step towards exploring the behavior of the CEB constructions and promoting energy efficiency in the earthen buildings for thermal and environmental purposes.

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Paper Number 45

Measurement of Architecture Students' Knowledge and Awareness Regarding the Use of Adobe



Ebru Arslan[1], Sibel Akan[2] Olcay Türkan Yurdugüzel[3]

[3]Yozgat Bozok University, Yozgat

ebruarslann52@gmail.com
sibelakanmimar@gmail.com
olcay.turkan@yobu.edu.tr

ABSTRACT

Adobe, one of the earliest building materials, has been extensively employed throughout history in various structures, serving different purposes. This natural, sustainable, 100% recyclable, and waste-free material is commonly utilized in traditional settlements. Its numerous advantages, including healthiness, affordability, ease of production using local resources and basic tools, as well as energy efficiency and minimal release of harmful gases such as CO2, enable adobe to be readily manufactured in many regions of Anatolia.

This study aims to evaluate the knowledge and awareness levels of architecture students enrolled in the Architecture Departments of Yozgat Bozok University and Dicle University regarding adobe materials. The adequacy of the information provided in the building materials courses within the architecture curriculum will be examined in relation to students' professional competencies. Furthermore, an endeavor will be made to determine the current utilization areas and techniques associated with adobe materials, ultimately shedding light on the contemporary usage staus of this traditional building material.

The identification of the advantageous and disadvantageous characteristics of a building during its pre-construction phase, period of use, and periods of non-use has been requested. Additionally, the adequacy of the architectural education process has been investigated by comparing the responses of first and final-year students to a survey on adobe materials and structures. This study aims to contribute to the architecture curriculum and provide recommendations based on the data obtained from the survey results.

Keywords: Architecture student, adobe, Bozok University, material knowledge

1. INTRODUCTION

The utilization of local materials refers to the incorporation of materials obtained from a region's natural resources into the construction of local structures. The selection of these materials is generally based on their compatibility with the geographical, climatic, and cultural characteristics of the region. The use of local materials can provide various advantages in architectural contexts. Among these local materials, adobe stands out as one of the oldest building materials, having been used since prehistoric times. Adobe, as a natural material, is typically produced by mixing clay, sand, water, and organic fibers. This mixture is then poured into molds and dried in the sun or specialized drying areas to obtain adobe material (Yardımlı, 2021, pp. 10-11).

The historical development of adobe usage reveals its adaptability to the local conditions and resources of a particular region. However, overall, the use of adobe has decreased with the development and widespread adoption of modern construction materials. Preferences for materials such as concrete and steel have limited the utilization of adobe. Nevertheless, there has been a recent increase in interest towards sustainability and local values, leading to a resurgence of popularity for local materials like adobe and an increased usage in certain regions. This trend is of great importance for the preservation of traditional methods and the reevaluation of local architectural heritage.

This study aims to examine the level of competence achieved by students in the architecture department in relation to the knowledge imparted through the building materials courses included in their curriculum. Specifically focusing on courses aimed at enhancing students' material knowledge, the study seeks to assess the adequacy of the information provided to students regarding adobe materials. The research will evaluate the students' general knowledge levels concerning the usage areas and techniques of adobe materials. Furthermore, the study will investigate the contemporary usage status of traditional adobe materials, with a particular emphasis on determining the level of knowledge regarding the usage areas and techniques, thus examining the contemporary utilization of traditional materials.A survey evaluation method will be employed for students from different academic years enrolled in the Architecture Departments of Dicle and Bozok Universities. This method will measure the students' knowledge levels concerning adobe materials and assess the adequacy of the material-related courses in their educational process. The collected data and subsequent analyses will demonstrate the contributions of the building materials courses to the students' professional competencies and provide insights into the impact of adobe materials on determining their contemporary usage status.

This study contributes to the field of architecture by assessing the competency levels of students in relation to adobe materials, examining their knowledge levels and the effectiveness of material-related courses. The findings will help enhance the architecture curriculum, with a focus on promoting sustainable and traditional building materials like adobe. Ultimately, the study aims to enrich architectural education and promote the utilization of adobe materials in contemporary construction practices.

2. HYPOTHESES OF THE STUDY:

Hypothesis 1: The knowledge level of students in the Department of Architecture at Dicle and Bozok University regarding adobe materials increases as they progress through their educational process. It is posited that as the educational process advances, students' professional perception and competencies develop, leading to an augmentation in their knowledge and understanding of adobe materials.

Hypothesis 2: Courses focused on adobe materials not only support students' professional competencies but also foster the promotion of the contemporary use of adobe materials. Through the evaluation of contemporary examples showcasing the utilization of adobe, these courses encourage students to embrace adobe as an alternative material. Furthermore, these courses facilitate the generation of diverse design decisions and practical applications that endorse the integration of adobe materials in design and implementation classes, thereby stimulating creative ideation.

3. OBJECTIVE-SCOPE-METHOD

The aim of this study is to determine the knowledge level of students regarding adobe materials within the scope of the building materials courses included in the curriculum of the department. In this context, the study will evaluate the students' knowledge level regarding the current applications and techniques of adobe materials, as well as the adequacy of the courses during their educational process. The study aims to contribute to and provide suggestions for the curriculum of the architecture department based on the data obtained from the survey.

Furthermore, the study will measure the knowledge level of students at Dicle and Bozok University regarding adobe materials. This knowledge level will be evaluated through a survey encompassing topics such as the characteristics, applications, advantages, disadvantages, and construction methods of adobe materials. Thus, the general knowledge level of students regarding adobe materials will be determined, and their progress during the educational process will be analyzed.

To evaluate the adequacy of the courses during the students' educational process, their opinions on various topics such as course content, teaching methods, use of materials, and learning experiences will be collected and analyzed. This assessment aims to determine the level of support provided by the courses in enhancing students' professional competencies and their acquired knowledge regarding adobe materials.

The survey study was conducted among students from different classes at Dicle and Bozok University's Department of Architecture. A representative random sample was selected from various classes and courses to ensure inclusion and representation of the general population. The survey included questions covering topics such as the characteristics, applications, advantages, disadvantages, advantages and disadvantages during construction and non-use phases, and construction methods of adobe materials. The survey includes various question types, such as multiple-choice questions, open-ended questions, or rating scales, to measure the students' knowledge levels. Additionally, the survey includes questions that provide feedback on the adequacy of the courses during their educational process. The analysis examined how the students' knowledge levels regarding adobe materials changed according to their class levels.

The participation in the survey was based on voluntary basis. During the data collection process, privacy and anonymity principles were ensured. The collected data were evaluated using statistical analysis techniques. The study employed methods such as literature review, data collection, data analysis, sample selection, and survey implementation to assess the students' knowledge levels of adobe materials, the effectiveness of the courses, and the contemporary use of adobe materials. The survey used in the study was prepared using the Google Forms platform.

To evaluate the academic aspects of the courses in the selected universities, the course information packages were thoroughly examined. The objectives, learning outcomes, topic headings, textbooks and references, assignments, and exams of the courses were analyzed to investigate the scope and suitability of the courses. The opinions and feedback of the students regarding the course content are expected to be an important source in academic evaluations. Comparing the course contents of two universities offering similar programs or courses can also be an evaluation method. This can assist in assessing the competitiveness of the course and its compatibility with other programs.

It is anticipated that the obtained data and analysis will reveal findings that support the objectives of the study. These findings will be utilized to evaluate the students' knowledge levels of adobe materials, the effectiveness of the courses, and the contemporary use of adobe materials. This study aims to provide valuable insights into the significance and impact of adobe materials in the architectural education process.

4. FIELD STUDY

4.1 Analysis of the Position of Adobe Material in the Architecture Curriculum of Dicle and Bozok Universities

The undergraduate curriculum of architecture faculties in Turkey can vary from university to university and program to program. However, considering Turkey's traditional architectural heritage and local building techniques, we can say that adobe material holds significant importance in architectural education in Turkey. There are many historical and traditional structures constructed with adobe material in different regions of Turkey. Therefore, architecture faculties in Turkey often include the use of adobe material in their curriculum with the aim of teaching local architectural traditions and building techniques. In courses such as building materials, building physics, etc., adobe material is regarded as an important component, especially in programs focused on local architectural traditions and sustainability. Below are some general information about the inclusion of adobe material in the content of certain courses, its impact on students, and its effectiveness:

1. Courses within the Scope of Building Materials and Technologies: This course aims to introduce architecture students to different building materials and teach their usage techniques. Adobe material is included in this course, providing students with information about its characteristics, advantages, disadvantages, and construction techniques. This enables students to understand the potentials of adobe material and evaluate its usage.
2. Courses within the Scope of Building Physics: The building physics course focuses on the physical aspects of architectural projects, such as energy efficiency, thermal insulation, acoustic performance, and natural lighting. Due to the potential of adobe material in terms of sustainability and energy efficiency, it is also addressed in this course. Students are informed about topics such as the thermal performance, heat storage properties, and natural ventilation of walls made with adobe material.
3. Courses within the Scope of Restoration and Conservation: This course deals with the analysis, restoration, and conservation of historical and traditional structures. As there are numerous adobe buildings within Turkey's rich historical heritage, adobe material holds significant importance in this course. Students are taught about restoration techniques, material analysis, and conrvation strategies specifically related to historical structures constructed with adobe material.

Overall, the inclusion of adobe material in the curriculum of architecture faculties aims to enhance students' understanding of traditional building techniques, sustainable construction practices, and the preservation of architectural heritage in Turkey.

The subject of the study involves conducting a comparative analysis of the course contents of the Architecture Faculties at Dicle and Bozok Universities. Through survey studies conducted with students, the aim is to understand the position and effectiveness of adobe material in the curriculum of these two universities.

Table 1: Comparison Of The Courses On Building Material Of The 1st Semester

1ST SEMESTER	**UNIVERSITY OF DICLE**	**UNIVERSITY OF BOZOK**
COURSE TİTLE	BUİLDİNG MATERİALS I	BUİLDİNG MATERİAL
CREDİT - ECTS	2 - 2	2 - 3
COURSE TYPE	Required Course	Required Course
COURSE CONTENT	Teaching the technical performance characteristics of building materials. Understanding the production, classification, and architectural applications of natural stone, artificial stone, primary metals, other metals, glass, and fired clay building materials.	Defining the mechanical, physical, and technological properties necessary for the recognition of building materials; highlighting the fundamental differences among materials classified based on material science principles and explaining the materials included in each group (minerals, natural stones, fired clay materials, wood, aggregates, binders, concrete, metals, plastics, and glass); and introducing the functional materials used in construction based on the basic performance criteria required by building components.
COURSE OBJECTİVE	The instruction in architecture education involves imparting knowledge of the general characteristics and concepts pertaining to relevant building materials, introducing these materials, providing information on their rational utilization within structures, and cultivating a systematic approach and research proficiency when making decisions regarding the selection of building materials in architecture.	Teaching the general characteristics and concepts related to relevant building materials necessary for architectural education, introducing building materials, providing information about rational utilization methods in construction, and imparting system logic and research skills in the context of decision-making regarding the selection of building materials in architecture.

LEARNİNG OUTCOMES OF THE COURSE	-Grasps the internal structural characteristics of building materials at a general level. -Learns the technical features of building materials at a general level. -Understands the internal structural and technical characteristics of the mentioned types of building materials. -Learns at a general level where the mentioned types of building materials are used in architecture. -Grasps the relationship between the mentioned building materials and architectural impact at a general level. -Understands the position and importance of the mentioned building materials in architecture.	-Defines the materials used in construction and describes the production methods of building materials. -Describes the chemical, physical, and mechanical properties of building materials. -Determines the usage purposes of building materials in architecture. -Acquires the skill to detail materials in terms of building elements, building systems, and overall structure.

Table 2: Comparison Of Building Materials-Related Courses İn The 2nd Semester

2ST SEMESTER	UNIVERSITY OF DICLE	UNIVERSITY OF BOZOK
COURSE TİTLE	BUİLDİNG MATERİALS II	INTRODUCTİON TO BUİLDİNG INFORMATİON
CREDİT - ECTS	2 - 2	2 - 3
COURSE TYPE	Required Course	Required Course
COURSE CONTENT	Teaching plastic building materials, natural wood, engineered wood, binders, mortars, paints, building joints and jointing materials, concrete building materials.	This course includes the explanation of basic concepts related to construction, building materials, building components, building elements, and the general characteristics expected from structures. It also covers the classification of buildings based on their functions, materials, structural systems, and ownership. Additionally, it includes topics such as the relationship between the building and the ground, soil investigations, excavation, and foundation works. Furthermore, it discusses the explanation of the relationship between materials and the structural system
COURSE OBJECTİVE	Providing education on the general characteristics and concepts of building materials necessary for architectural education, introducing building materials and providing information about their rational use in structures, and developing an understanding of the system logic and research effectiveness in case of making selection decisions related to building materials in architecture.	The aim is to provide a definition and classification of structures, introduce and explain the basic building elements starting from the structure-ground relationship, and transfer the fundamental concepts related to building, architecture, and building technology in light of scientific and technical knowledge.
LEARNİNG OUTCOMES OF THE COURSE	- Understand the relationship between technological development, architectural development, and building materials. - Learn about different types of building materials and related concepts. - Grasp the logic of classifying building materials. - Understand the specific internal structural and technical characteristics of the described types of building materials. - Gain a general understanding of the relationship between different types of building materials and architectural impact. - Comprehend the role and importance of the described building materials in architecture. - Recognize that building materials are an element of the "external environment, structure, building element, building material, detail" system, and that choices made regarding building materials will impact the entire system.	- Learn the definitions and concepts in the field of architecture, as well as the classification of buildings. - Gain knowledge about architecture, building science, materials, and structures. - Describe the characteristics of building elements and their application areas. -Acquire the ability to conduct research in the field of architectural design and translate the findings of analysis into design solutions.

	- In line with this, make choices in selecting building materials by considering the concepts of "needs, system, types of building materials, characteristics of building materials, detail solution, and optimization" together.	

Table 3: Comparıson of Courses Related To Buıldıng Physıcs And Envıronment

	UNIVERSITY OF DICLE	UNIVERSITY OF BOZOK
COURSE TİTLE	PHYSİCAL ENVİRONMENT CONTROL STUDİO	BUİLDİNG PHYSİCS AND ENVİRONMENTAL CONTROL
SEMESTİR	6st Semester	3st Semester
CREDİT - ECTS	3 – 3	2 – 3
COURSE TYPE	Required Course	Required Course
COURSE CONTENT	Control of Climate Elements, Control of Light, Control of Sound	Natural and built environment data (such as heat, water, wind, sunlight, sound, atmospheric effects, etc.) will be evaluated to examine the physical environmental impacts in the context of ecology and sustainability. Within this scope, the concept of the physical environment and elements of building physics, the purpose and scope of solar effective regulation, heat transfer paths in building envelopes, measures related to heat exchange in building envelopes, general information on heat and moisture, thermal conductivity of building materials, condensation, fundamental principles of energy-efficient building design, architectural acoustics, the domains of building acoustics and room acoustics, sound and noise, sound propagation and transmission, principles of noise control, optimization of heat, moisture, and sound insulation in building envelopes constitute the content of the course.
COURSE OBJECTİVE	To provide a healthy, comfortable, and sustainable environment, the aim is to equip individuals with the fundamental knowledge, concepts, principles, and skills to regulate the built environment by controlling the physical environmental elements.	The aim is to inform the students about the evaluation of physical environment and building physics issues in relation to ecological balances, considering natural and constructed environment data for fundamental building elements such as foundations, walls, floors, and stairs, either for an existing structure or a structure subject to design. This evaluation encompasses mechanical effects, heat, moisture, sound, lighting, and physicochemical effects in a general sense.
LEARNİNG OUTCOMES OF THE COURSE	- Defines the basic concepts related to the physical environment.. - Explains the design variables associated with the constructed environment that are effective in controlling the physical environment. - Describes the factors that need to be considered in the design of the constructed environment for controlling the physical environment.. - Organizes the built environment in accordance with the requirements of the physical environment. - Differentiates design strategies and techniques related to the constructed environment. - Critically evaluates alternative solutions for controlling the physical environment developed in the constructed environment.	- Learns the principles of evaluating data related to the built environment. - Develops solution proposals for thermal and acoustic comfort. - Understands the importance of shaping the building and building envelope based on comfort requirements and gains the ability to generate appropriate solutions. - Recognizes the significance of site selection in building design in terms of climate, acoustics, natural lighting, and physicochemical effects, and gains the ability to establish and develop the relationship between the natural and built environment.

When we look at the architecture program at Dicle University, it can be observed that students are introduced to adobe material in the Building Materials course in the first semester of the first year. In this course, students acquire knowledge about the properties, advantages, disadvantages, and construction techniques of the material, which is further addressed as part of the local architectural traditions in the mandatory Building Materials 2 course in the second semester. Topics such as traditional adobe construction, wall construction, and connection details are taught. A sustainability-oriented approach can be assumed, thus associating adobe material with energy efficiency and natural ventilation topics. In the second semester of the third year, in the mandatory course called Environmental Control Studio, which focuses on physical environment control, it is also possible to address the thermal performance, heat storage capacity, and natural lighting aspects of adobe material, considering the learning outcomes of the course. In the Restoration and Conservation courses, given Dicle University's rich historical heritage in the region, the emphasis on restoration techniques, material analysis, and conservation strategies related to adobe material is also significant.

In the architecture program at Bozok University, it is observed that students are introduced to adobe material in the Building Materials course in the first year. The course teaches the physical, mechanical, and chemical properties of the material, its production methods, and its use in architecture, thus establishing the relationship between building, material, and design. In the second semester of the first year, the Introduction to Building Knowledge course may also cover the placement of adobe material in the context of building knowledge, materials, and structures.

In the field of Building Physics, compared to Dicle University, the Building Physics and Environmental Control course is included in the curriculum earlier at Bozok University. In this course, it is possible to address the thermal performance of adobe material, insulation, natural ventilation, and energy efficiency aspects.
In the Restoration and Conservation courses, the knowledge of materials is supported by focusing on topics such as restoration techniques and conservation strategies related to adobe material.

4.2 Survey Evaluation

When examining the architecture program at Dicle University, it is observed that students are introduced to adobe material in the Building Materials course in the first semester of the first year. In this course, students acquire knowledge about the properties, advantages, disadvantages, and construction techniques of the material. The information gained by the students regarding adobe material is further addressed in the second semester under the mandatory course titled Building Materials 2, where it is integrated as part of the local architectural traditions. Topics such as traditional adobe construction, wall construction, and connection details are taught. It can be considered as an approach with a focus on sustainability. Therefore, it is likely that adobe material is associated with topics such as energy efficiency and natural ventilation. In the second semester of the third year, in the mandatory course called Environmental Control Studio, the learning outcomes of the course suggest that the thermal performance, heat storage capacity, and natural lighting aspects of adobe material may also be addressed. In the Restoration and Conservation courses, considering the rich historical heritage of Dicle University in the region, the focus on restoration techniques, material analysis, and conservation strategies related to adobe material is also significant.

In the architecture program at Bozok University, it is observed that students are introduced to adobe material in the Building Materials course in the first year. The course teaches the physical, mechanical, and chemical properties of the material, its production methods, and its use in architecture, thus establishing the relationship between building, material, and design. In the second semester of the first year, in the Introduction to Building Knowledge course, it is also possible to teach the position of adobe material in the context of building knowledge, materials, and structures.
In the field of Building Physics, compared to Dicle University, the Building Physics and Environmental Control course is included in the curriculum earlier at Bozok University. In this course, it is possible to address the thermal performance of adobe material, insulation, natural

ventilation, and energy efficiency aspects.In the Restoration and Conservation courses, the knowledge of materials is supported by focusing on topics such as restoration techniques and conservation strategies related to adobe material.

5. EVALUATION AND CONCLUSION

The impact of adobe material on students is important in terms of raising awareness about sustainable building materials and local construction techniques. Teaching the use of adobe material in traditional structures will help students better understand the local architectural heritage and encourage them to think about sustainability in their future projects.
Based on survey studies and an analysis of the curriculum of both universities, it can be said that students have a good understanding of adobe material to a large extent. However, it is observed that the level of knowledge is not sufficient due to a lack of practical application and hands-on experience, as indicated by the results.

There is sufficient awareness regarding the waste generation, energy conservation, and recyclability of adobe material in different processes related to its design, use, and end-of-life stage. The survey results also indicate that students have been provided with the necessary information about the disadvantages of the material in these processes.

Both universities offer the advantage of introducing students to adobe material in the first semester. This will allow students to relate the theoretical knowledge they acquire about the material to the spaces they experience in the later years. However, it has been identified as a deficiency in professional education that students do not have the necessary skills for the practical application of adobe material throughout their undergraduate studies.

The insufficiency of practical education alongside theoretical knowledge is a frequently discussed issue in architectural professional education. It is believed that having experience and knowledge about the application techniques, methods, and processes of materials will enhance the quality of architectural education. In order for students to gain proficiency in adobe material, it is suggested that they participate in practical applications, workshops, or site visits alongside theoretical knowledge in their courses.

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Kerpic'23 – Gain Information from the Traditional Earthen Architecture
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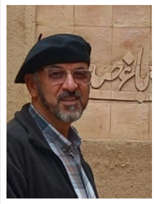
Contemporizing knowledge from historical buildings (case study: Farahza's house in Yazd, Iran)



Nariman Farahza
Assistant Professor, Faculty Member of Architectural Department, Department of Architecture, Faculty of Art & Architecture, Yazd University, Yazd, Iran
narimanfarahza@gmail.com

Sara Alidoost
Master Student of Energy & Architecture, Department of Architecture, Faculty of Art & Architecture, Yazd University, Yazd, Iran
eps4129@gmail.com

Fatemeh Norouzi
Master Student of Energy & Architecture, Department of Architecture, Faculty of Art & Architecture, Yazd University, Yazd, Iran
fatemehnorouzi94@yahoo.com

ABSTRACT

The purpose of preservation and restoration of historical buildings is their revitalization and reuse in order to meet contemporary functional requirements while learning from these valuable buildings for the design and construction of new buildings. The lived experience in various historical spaces of Yazd city, especially being present in the historical space of the School of Art and Architecture of Yazd University, meets the functional requirements of the fields of architecture, urban studies, and art quite well. It has also inspired some of the professors and students to contemporize historical achievements and experiences and use them as a model in their studies, designs, and constructions. These items include the modeling of geometry and general design of the building, proportions, materials and construction details, decorations, facades, climatic solutions, and green space.

This article introduces a residential house as a case study in the new urban context of Yazd city, which has contemporized the historical models. Some of the interesting models used in this house include the general design, the contemporization of the windcatcher, the cellar, and sun shading louvres on the façade, which were partly influenced by the simultaneous design and construction of this house with the restoration of the historical complex of Hojat Abad Vazir. These items, along with historical cases will be further examined. it is worth mentioning that the habitants are relatively satisfied by the building's functional relations and thermal comfort in the harsh climatic conditions of the hot- arid region of Yazd city.

Keywords: Contemporizing, historical buildings, Farahza's house, Yazd

1. INTRODUCTION

Iran is a vast country that is known for its diverse climate. Iranian architecture has been influenced by various factors, including the climate, geography, local materials, and cultural beliefs[1] making it a valuable knowledge treasure passed down from previous generations that must be preserved and passed on to future ones. In the past, vernacular buildings in various regions of Iran were designed and constructed based on an understanding of natural resources and local experience. This resulted in structures that were naturally compatible with their climates and harsh environmental conditions. However, with advancements in technology and easy access to fossil fuels, this aspect of architecture has been neglected, leading to numerous climatic issues such as global warming and environmental pollution in modern times. Therefore, the topic of passive and low-consumption buildings has increasingly become important worldwide, promoting countless efforts and studies in this regard.

The historical architecture of each city is a valuable treasure of climatic design solutions uniquely suited to that city. The historical context of Yazd City, with its hot-arid climate, has maintained its efficiency and livability due to the richness of urban planning and architecture that is compatible with the climate. Traditional buildings in this city incorporate various climatic elements, including wind catchers [3, 4], central courtyards [5], Cellars [6], Talar, Peristyle [7], Hozkhaneh, vegetation, and materials [8]. Despite numerous studies on the climatic analysis of these elements, only a limited number of contemporary buildings have been constructed by integrating them. Therefore, the present study investigates and presents an example of a contemporary residential building in the hot-arid climate of Yazd that incorporates some of these passive elements to save energy, reduce fossil fuel use, and create thermal comfort.

2. CASE STUDY

The case study is a residential building located in the new context of Yazd city. This city is situated at latitude 31.89 and longitude 54.35 [9] and experiences hot and dry summers, as well as cold and dry winters [10]. According to the Köppen-Geiger climate classification, Yazd city falls under the hot desert climate zone (BWh). According to surveys conducted for a period of 10 consecutive years (from 2010 to 2019 AD), the average rainfall was 0.12 millimeters, the maximum amount of precipitation was 20.9 millimeters, and the average relative humidity was 26% [11].

2.1 Building Architecture Analysis

The building under study was designed by Dr.Farhaza and his wife, who are both residents of the house. According to the couple, this house is the result of their academic and professional experiences, as well as their familiarity with traditional and vernacular architecture in the Yazd City. The principal concept of the House is to utilize past architectural climatic experiences in present architecture, while also emphasizing fluidity in spaces for perception and movement. These two factors have played a significant role in creating various spatial qualities.

This building, with an area of 325 square meters, was constructed between 1999-2002 and consists of two basement floor and a ground floor, and one mezzanine floor. The ground floor features a living room, drawing room, bedrooms, kitchen, bathroom, and parking 'Fig 1'. The basement floor comprises a living room, bedrooms, Hozkhaneh, guest suite, kitchen, and bathroom 'Fig 2', while the first mezzanine includes the master bedroom facing the Hozkhaneh and an office room situated on the parking space 'Fig 3'. This building has unique architectural features, including the following:

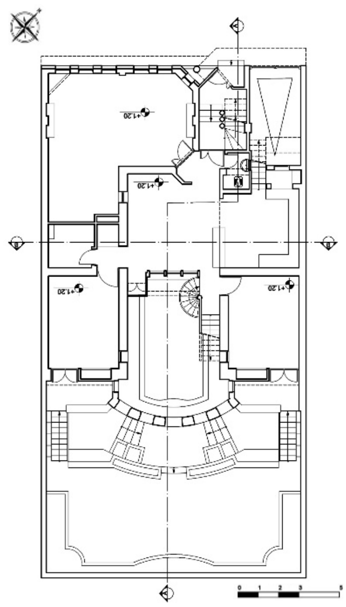


Figure1. Ground floor plan

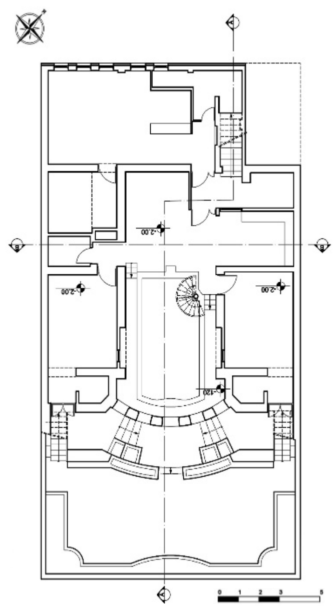


Figure2. Basement floor plan

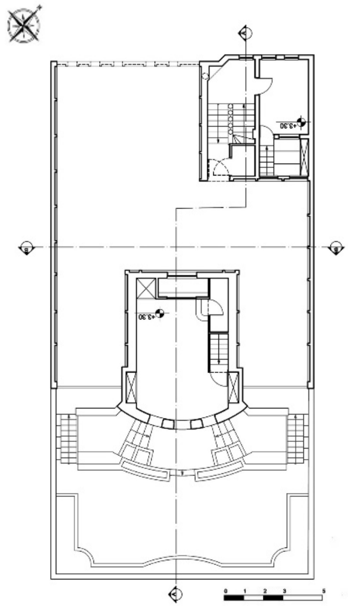


Figure3. Mezzanine floor plan

1. Considering the appropriate relationship between the Hozkhaneh and the master bedroom with the living room and courtyard in terms of visual and perceptual aspects 'Fig 4'.
2. The pure geometry of spaces includes strong structural geometry in the building due to the observance of the 4,4,5 and 5,5,5 modules 'Fig 5' and appropriate circulation in different spaces.
3. Diversity in different spatial qualities such as the Hozkhaneh, courtyard and living room, as well as contrast in external façade while maintaining an overall unity in the building 'Fig 6'.
4. The house's flexibility and ability to adapt its existing spaces for various functions, for instance the functions of the room positioned on the parking lot which can serve as an office, library, bedroom, or housemaid's room.

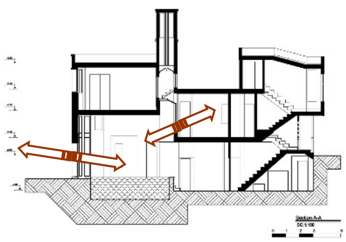


Figure4. Relation between the Hozkhaneh with living room and courtyard

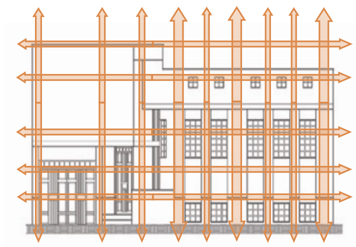


Figure5. The Motion and structural geometry in the main facade of the house

Figure6. Diversity in the materials of the facade facing the street and various movements

2.2 Climatic Considerations for Building Design

The study of the architecture of Yazd, a hot and arid climate city, has revealed that climate played a significant role in the design of houses. Historical architects incorporated various climatic solutions to achieve human thermal comfort, focusing on improving sustainable architecture despite limited access to modern technologies. The mentioned case study was designed to integrate contemporary and historical architecture, taking inspiration from the restoration efforts of the Hojat Abad Vazir historic complex.

The Hojat Abad Vazir complex is located in the city of Meybod, in the province of Yazd. It was built in 1298 AH (Hijri Ghamari)'Fig 7'. Its combination of intelligent architecture and structure, along with solving climatic concerns and the beautiful natural light flow in the building, are among its remarkable features. The complex is a two-story building, with the ground floor elevated three steps above the garden level. The plans of the complex are illustrated in 'Figs 8 and 9'. The complex is oriented northwest-southeast for use in spring and summer so that the west facade faces the prevailing wind direction. In addition, three sides of the building face the garden so that it can take full advantage of both the garden view and the prevailing wind 'Figs 10 and 11'. The presence of a Horno above the Hozkhaneh's dome and two courtyards on the first floor have had a desirable effect on creating air circulation and ventilation during summer. The adjacent spaces to these courtyards on the first floor, as well as the Hozkhaneh, have openings towards them so that the wind can pass through the building, promoting air circulation and ventilation in the Hozkhaneh and other areas 'Fig 12'.

Figure7. A perspective of the Hojat Abad Vazir Complex

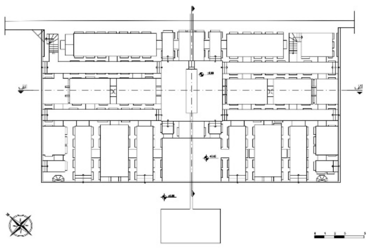


Figure8. Ground floor plan

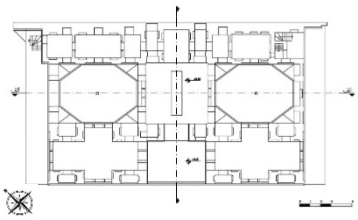


Figure9. first floor plan

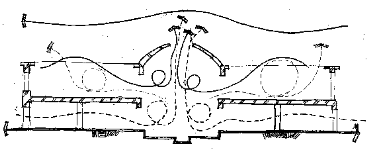


Figure10. Air flow and natural ventilation in the cross section of the Hojat Abad Vazir Complex

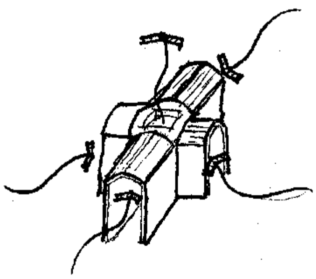


Figure11. Illustration of the effect of building openings and Horno on creating natural ventilation

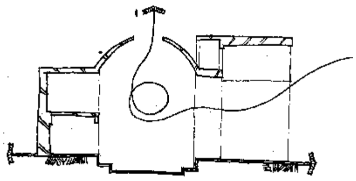


Figure12. Depiction of air flow and natural ventilation in the cross section

The house has been designed with a particular focus on past architecture and vernacular technology while considering the four factors of thermal comfort: temperature, humidity, air flow rate, and radiation. The aim is to use these factors in a modern and contemporary way. However, it should be noted that meeting the increasing cooling needs in an environmentally friendly manner is inherently more challenging than meeting heating needs. This is because any form of energy can easily be converted into heat, and even the body and home equipment naturally produce heat in the absence of active heating systems. Therefore, a building that can effectively respond to the increasing demand for cooling in such climatic conditions would be highly desirable.

To achieve passive cooling in this house, a four-sided Windcatcher 'Fig. 13' and a pool have been designed at its center (Hozkhaneh). Together, they create comfortable conditions for indoor spaces, such as the living room 'Fig. 14'. In fact, the placement of the pool at the center of the courtyard, along with the Windcatcher, has created relatively suitable temperature and humidity levels within the house through evaporative cooling. The basement floor, which is located at a lower level than the ground and connected with the Hozkhaneh and the Windcatcher, serves as a summer sitting area that benefits from the breeze passing through 'Fig. 15'. This arrangement not only utilizes the Earth-sheltering Technique but also takes advantage of the ventilation provided by the Windcatcher and the Hozkhaneh. The courtyard has also been designed to utilize the specific heat capacity of the Earth as a thermal mass, like the basement floor, and to maintain a balanced temperature throughout the year.

Figure 13. Internal partitions of Windcatcher

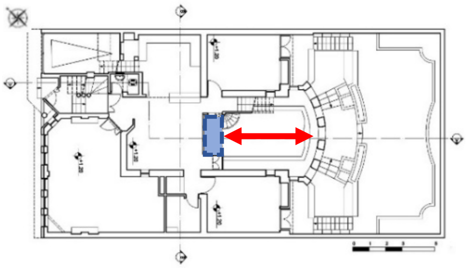


Figure 14. Relationship between Windcatcher, Hozkhaneh, and indoor spaces

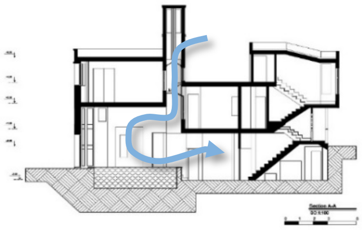


Figure 15. The connection between the basement floor and the Windcatcher and Hozkhaneh at the lower ground level

With the recent increase in average temperatures, there is a need to improve the performance of Windcatcher. Combining Windcatcher with water spraying results in the air passing through the Windcatcher being cooled by evaporative cooling. After absorbing heat from the air through a phase change, water accompanies the cooled air, resulting in a comfortable environment with balanced temperature and humidity levels. 'Fig. 16'. The designed Windcatcher consists of porous bricks at its head, sprayed with water in a controlled manner by adjustable valves 'Figs. 17 and 18'. To conserve water, gutters have been designed around the head of the Windcatcher so that used water can be collected and returned to the source by a pump for reuse 'Figs. 19 and 20'. Given the water scarcity problem in Yazd City, the Windcatcher can still function even when the pool in the Hozkhaneh is empty. The Windcatcher begins to function when the windows of the living room are closed, and the air inside the Hozkhaneh begins to heat up due to the wide glass surface, causing it to rise upward 'Figs. 21-23'. The suction of warm air by the Windcatcher leads to fresh air entering from the other side, resulting in the cooling of indoor spaces such as the living room and the master bedroom 'Fig. 24'. During winter, the Windcatcher channel is closed from the inside by a metal gate, and the warm air from the Hozkhaneh is directed inside by opening the living room window 'Figs.25 and 26'.

Figure 16. Water spray on porous bricks

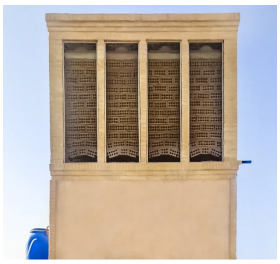


Figure 17. A new design of Windcatcher

Figure 18. Water spraying pipes

Figure 19. The gutter beneath the porous clay bricks facilitates the return of water to its source.

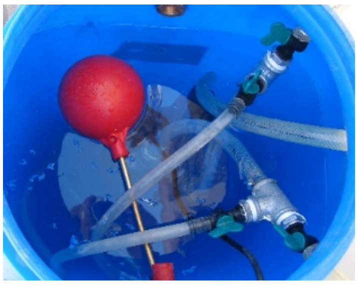


Figure 20. Water pump components

Figure 21. The interaction between living room, Hozkhaneh, and Windcatcher

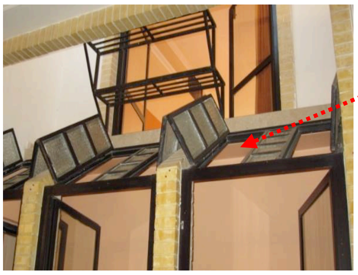


Figure 22. The Living room windows facing the Hozkhaneh

Figure 23. The Living room windows facing the Hozkhaneh

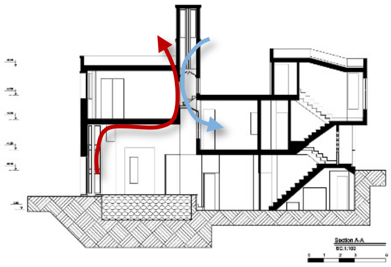


Figure 24. Windcatcher mechanism in summer

One way to cool down a space is to prevent or reduce heat transfer into the indoor environment. Using materials with high heat capacity delays the entry of heat from the outside environment and ensures that heat accumulated during the day in the walls warms up the house during the night as the outside temperature decreases. Therefore, this house has used bricks with relatively high heat capacity. Additionally, due to intense radiation, insulation (thatch) has been used to reduce heat transfer from the ceiling to the interior. The use of double-glazed windows in this house is also one of the factors that has led to the reduction of heat transfer into the indoor space 'Fig. 27'.

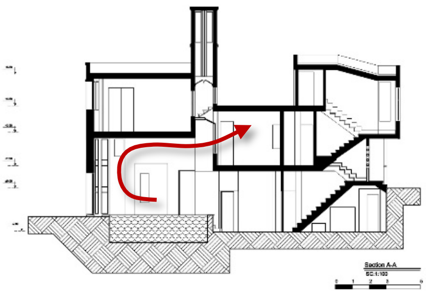


Figure 25. Windcatcher mechanism in summer

Figure 26. Windcatcher metal gate

Figure 27. The type of double glazed windows incorporated in this house

Utilizing appropriate solar radiation in the environment is another important factor to consider in the design process. Therefore, in order to maximize solar radiation during winter seasons, the south facade has been designed in a circular shape based on the rotation of the sun 'Fig. 28'. Additionally, placing the courtyard at a lower level than the ground has resulted in a suitable extension of the south-facing windows and consequently achieving maximum radiation. However, to control the amount of radiation during summer months, walls with greater depth have been considered for placing southern windows, and appropriate curtains and shadings have been incorporated 'Fig. 29'. Furthermore, the living room has been positioned away from the southern side due to intense radiation exposure, with the help of Hozkhaneh. To control the radiation on the southern facade, a grapevine trellis has been designed as a deciduous tree to naturally shade the windows during the summer months.

Figure 28. South facade rotation and the placement of windows in the great wall depth

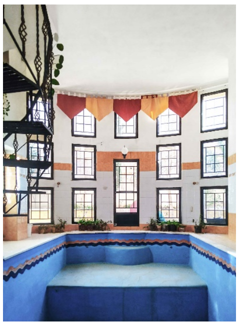


Figure 29. The design of the curtains and shadings

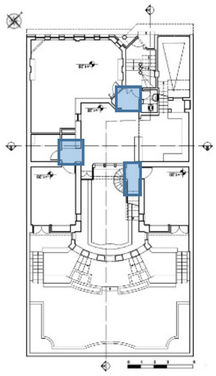


Figure 30. The entry filters

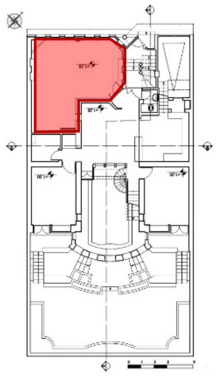


Figure 31. Separation of the drawing room from other areas of the house

In order to facilitate heating and cooling in this house, the interior spaces have been designed modularly, taking low heights into account. The placement of entry filters for different spaces also reduces the loss of heating and cooling loads in these areas 'Fig. 30'. Moreover, to minimize heat loss in the interior spaces, the drawing room with a large area that is used less frequently has been separated from the other spaces and positioned on a side that receives less solar radiation 'Fig. 31'.

3. CONCLUSION

The vernacular buildings in various regions of Iran have naturally been compatible with their climate and harsh environmental conditions. The historical architecture of each city encompasses valuable aspects that have gained more attention today due to numerous climatic issues. Sustainable buildings have become a notable topic worldwide, leading to various studies. The present research aimed to investigate a contemporary residential building in the new context of Yazd City, which incorporates the principle concept of utilizing the past architectural and climatic experiences in present architecture. Among the reasons for selecting this particular building as a case study are its unique architectural features, such as the fluidity of various spaces, appropriate relationships between diverse spaces while considering privacy, pure and suitable geometry of spaces, diversity in different spatial qualities with maintaining overall unity, and the flexibility and adaptability of existing spaces for various functions.

Furthermore, this building is designed with a particular emphasis on traditional architecture and draws inspiration from Yazd's vernacular buildings, specifically the Hojat Abad Vazir complex. These initiatives include: incorporating passive cooling through a four-sided windcatcher along with a water spray system and its connection to the Hozkhaneh, maintaining a balanced temperature by designing a courtyard and Hozkhaneh at the lower ground level due to utilization of the Earth-specific heat capacity, delaying the entry of heat from the outside environment with using materials with high heat capacity and double-glazed windows, incorporation of thatch as insulation to reduce heat transfer from the ceiling, placement of entry filters for various spaces to minimize the loss of heating and cooling loads, facilitation the cooling and heating by designing interior modularly spaces with low height, utilizing appropriate solar radiation during cold seasons through the design of circular south-facing façade based on the rotation of the sun and the extension of their windows, controlling the amount of radiation throughout warm seasons by incorporating walls with greater depth and considering curtains, shadings, and natural shading (a grapevine trellis as deciduous tree).

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Paper Number: 49

The Renaissance of Earthen Building Materials

And Akman
YBE: Building Biology & Ecology Institute
burgazand@gmail.com,
andakman@yapibiyolojisi.org

ABSTRACT

In the regions with high environmental awareness, with the trigger of climate and sociocultural crisis, buildings' carbon footprint, life cycle and embedded energies became some of the most requested performances. Plus, physiological and psychological problems caused by built environments came to the fore more frequently. In this context, the numbers of incentives together with sanctions increased towards de-carbonization, low energy consumption and healthy environment of living spaces.

In this frame, natural building materials, as being mostly the environmental friendly and healthy alternatives, became the necessity for the sustainable transformation of the building sector. Earthen building materials also took advantage from this agenda. Thus, they have diversified and improved their industrial standards especially in Europe. Until recently earthen materials were only known as 'adobe bricks' and their common memory was the 'ruined village house'. However, with contemporary technical developments, we are witnessing the resurrection and awakening of earthen materials.

In this context, the topics that will be covered in the presentation are the followings:

- The variety, features and implementation methods of widely used earth based natural building materials
- The factors contributing to the spread of these materials: Grassroots movements, developing standards and norms, politic mechanisms
- Leading works for the development of the ecosystem on natural building materials in Türkiye
- The industrial production and contemporary architectural applications of earthen based natural building materials

Keywords:
Gebaute beispiele:

- Biyoev
- Ahmet Keskin
- Integration in BAK, z.B. grünes Zentrum Immenstadt

Seit Ihr **Leich**tathleten zu einer **Schwer**bewaffnetten 60'er Feier bereit?
Dann freue ich mich gemeinsan mit Euch ins nachste Jahrzehnt zu rutschen.
Natürlich gerne in Begleitung Eurer besseren Helfte.

Tatort: Grüntenblick Agagthazell.
Am 24.Feb.2023 Freitag ab 19:00 Uhr

Für den leiblichen Wohl mit einem Fass Bier zum anzapfen ist gesorgt.

Paper Number: 50

From Traditional Texture to Rural Design Guide: The Case of Tunceli-Tozkoparan Village


Gizem Nur Özcan, Ebru Nalan Ceylan
Munzur University, Tunceli
gizemgungor@munzur.edu.tr
ebrunalanceylan@munzur.edu.tr

ABSTRACT

Although there are documented traditional mudbrick structures and many academic studies in cities such as Elazig and Malatya, which are close to the province of Tunceli, there are not enough field studies on this subject in Tunceli. This study focuses on the lack of work in the city on the subject and focuses on the production of adobe and the use of adobe in buildings in Tozkoparan Village of Pertek district of Tunceli province.

In the city where traditional buildings are quite scattered, Tozkoparan village creates a unique texture with its earth plastered mudbrick structures. The village was chosen as the study area because of this feature. The plaster of adobe houses was obtained using a yellow soil type from a nearby area. The houses plastered with this soil exhibit a characteristic appearance in the color specific to the area.

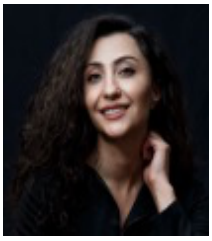
According to the oral interviews with the local people, the settlement in the village first started with a castle located at the foot of the mountain. After the destruction of the castle, the settlement area moved towards the lower levels. The mudbrick masters in the village built the houses with traditional adobe production using adobe blocks 30 cm & 15 cm (analı-kuzulu). Generally, masonry construction system and mixed system were used in the residences in the area. The lower floors of the houses, which were mostly built as two floors, were used for sheltering and storing animals. On the upper floor are the living areas. In addition, houses with a courtyard plan scheme, which is not a common type of plan in Tunceli, were also identified in the area.

Taking inventories of the mudbrick structures in the area is very important for the city of Tunceli, where there is not enough detection work and study about traditional construction systems. After this inventory study, it is aimed to develop conservation plans for the area. While this planning is being made, Tozkoparan Mound, which is still under excavation, will shed light on the past of the region and has a 5500-year history according to current information, will also be considered as an important potential. In addition, it is foreseen that the information to be obtained from this inventory study can be used as a base for the creation of a rural design guide for this city where ecological life is at the forefront.

Keywords: Cultural assets, conservation, traditional building

Paper Number: 51

A Modern Religion House Complex on Adobe Material: Uzundere Djemevi and Sociocultural Center

Zafer Sağdıç, Şule Ertürk
Yıldız Technical University
Slash Architects Founder Partner
zafersagdic@hotmail.com
sule@slasharchitects.com

ABSTRACT

The Uzundere Djemevi and Sociocultural Center project competition, opened in 2017 by the municipality of Karabağ, Izmir. Slash Architects Architecture and Design office started to design the proposal project by asking a fundemental question of how to solve a particularly modest religious place and a sociocultural center connected to it, as it is showing the universal architectural fiction of nourishing by spirituality, and moreover than this as emphasizing the locality as a strong design element by using local material selection to indicate an identity of being simple and humble. Thus, the project was developed for the land located at the far end of Uzundere village and on a very challenging slope on adobe material to emphasized the humbel identity of belonging to the terra-cota/earth. Nevertheless, the project is designed as a modest, lively proposal that appeals to all age groups, while it is faithful to the scale of Uzundere village and as it respects to nature and the general view of the environment, yet it reflects a touch of contemporary look. It is believed by the designer Şule Ertürk that designing an adobe material based Djemevi in the village of Uzundere, where Alevi-specific habits and lifestyles are at the forefront, brought a modest religious place identity to the forefront.

According to the architect of the proposal project, the design of the Djemevi should emphasize the identity of the village and should exist in a location that symbolizes the inhabitants, at the heart of the selected project plot of the municipality. The main religious building of the project complex, which has the function of "Djemevi" is the main subject of the competition as existing in a prominent way at the highest elevation, but on the other hand, it modestly reveals the topography and the surrounding environment. Therefore, it was placed on the plot in such a way as to be in contact with the main geographic issue. The building, where the entrances are constructed from two different levels, the Park and the Djem Square, was reached through the ramps and stairs around. In this way, the Djemevi can take its place in a way that referred to the embracing identity of Alevism. For this reason, squares of different sizes were designed in the project. While the masses containing cultural and social functions generally hide the large square meter needs underground the plot and the functions that will activate the squares are left above the ground. On the other hand, one of the important decision is taken to preserve the effect of the scale and the texture of the village as it could be. The existence of building pairs in that sense are designed to be understood sometimes as hidden objects on the topography, sometimes as slightly exposed spaces and yet sometimes they elevated upwards completely from the ground and made themselves to be read as they are in a present unity. In this context, the paper will focus on the design process of Uzundere Djemevi and Sociocultural Center proposal project design criterias to show why using adobe material is quite significant on this type of space creations even they are seen as contemporary architecture examples.

Keywords: Adobe, Djemevi, Sociocultural Center, humble design, local material, universal sight**.**

1.INTRODUCTION

Uzundere Djemevi and Sociocultural Center by Slash Architects Architecture and Design office is designed as a proposal project design of the project competition, opened in 2017 by the municipality of Karabağ, Izmir. The Project site is located on the far end point of the village area of Uzundere and the proposal project has focused on context criterias of the site at first, such as the geoghraphy and the weather conditions of the location, user identity and the socio-cultural background of the Alevi community. On the proposal project the symbolic values are not highly emphasized and the main focus of the designer Ertürk is to create a humble prayers space on a local material by using traditional techniques, whereas the main design stays on a respectful relation with the proportions of the cozy village scale as having dynamic identity on modern architectural point of view. Ertürk explains that her office started to design the proposal project by asking one main question of "how to solve a particularly modest religious place and a socio-cultural center connected to it, as it is showing the universal architectural fiction of nourishing by spirituality, and moreover than this as emphasizing the locality as a strong design element by using of local material selection to indicate an identity of being simple and humble". In that sense adobe has been selected as the basic material of the project as being a local material which can be produced on traditional techniques as being a humble solution.

To make a design of a prayers space on Uzundere village -where Alevi families are living- brings a point of view of setting the design criterias according to the daily life standarts and cultural necessities of them. The Djemevi Design should emphasis the identity of the village at the hearth of the location as a major symbol of the Alevi community.

2.THE DESIGN PROJECT

Uzundere Djemevi and Sociocultural Center proposal project by Slash Architects Architecture and Design office has the Djemevi building unit at the heart of the project site, which is surrounded by the annex units such as a mensa, a unit which has a multi-functional hall, an exhibition area and an administrative office area, a library, classrooms, a guest house, a unit which has a place for workshops, a traditional cafe, and a funeral house on a hill based project site. Architect Ertürk focused on designing the building complex units on a hill area especially integrated to the land as the principal design criteria. The project site is also designed to have different open-air squares to serve to different functions, such as Djem Square, Hayat (Life) Square, Hak (Creater) Square and Funeral Square. Within them the Djem Square is created to be the main central gathering place of all of them. On both of the sides of a linear ax on which the other squares are located, the annex units of the Djemevi are sited too, whereas the Djemevi itself, is located as the main architectural element of the project on site. The architectural solution of the site can be defined as the best choice to create a prayers space in a building complex in form as if to make perfect design similiar to the village's scale of Uzundere. One of the other dynamics of the project is that the project site has a quite massive density of the tree texture at its South side. Another dynamic is the part of the main project area reserved for the construction of the children's park, which will be located right next to this tree-lined part of the land. Containing these two important dynamics can be seen as the strengthening ability to correctly respond to the use of public space on the project. Therefore, having these two significant public spaces inside of the concept project area has emphasized the public friendly architectural solution of the Uzundere Djemevi and Sociocultural Center proposal project. The design of the main unit of the proposal project, which is the adobe material based eco-friendly Djemevi building unit is created to be emphasized by the identity of the village as a humble and cozy place next to the Alevi village. According to Ertürk "..the Djemevi should exist in a location that symbolizes the inhabitants at first, as being "the heart" unit of the selected project plot of the municipality". The main religious building unit of the project complex in that sense is the "Djemevi", located at the highest elevation of the project site, which modestly reveals the topography and the surrounding environment, too.

Figure 1. Site Plan
Figure 2. Transportation Details on Schemas of the Uzundere Djemevi and Cultural Center Proposal Project.

The main approach strategy is to protect the green area in the park as well as the densely forested heathland. The dense tree texture in the South of the project plot is left to embrace the Funeral Square. At the same time, it creates a strong green background for the Djemevi mass unit. The playground intersects with various pedestrian axes. In this way, the integrity of the green and the pedestrian axes are ensured into a relation among all the units of the building complex. The land orientation has pedestrian transportation axes in a relationship among each other from every level and every view point of the site. The Djemevi is located on the highest elevation in that sense, as the most prominent building unit of the complex site. All other building units sit on other levels, as if to be emphasised their recessive identity against the main building unit, which is the Djemevi.

Figure 3. Entrance Perspective of the Djemevi &
Figure 4. Site View of Uzundere Djemevi and Cultural Center Proposal Project.

The Djemevi is located in the middle of the land as a binding place. There are public spaces to the North, such as workshops, cultural centre, classrooms, guest house. The area in the South is isolated with dense green space. One of the design criteria is that the form of the Djemevi should meet the design criteria that a place of worship should be and that it also provides an appearance, thus it is integrated with nature from a far away point of view. On the other hand, it should also be inviting on the eye of the user, in this context, it sits at the highest level of the site, as it is indicated before. One of the other significant issue of the concept project is that each and every building unit of the proposal project is constructed from adobe material, which is eco-friendly, local and produced on a low cost budget and suitable to be used on the Aegean Side geography, especially during the summer periods where earthquakes have been seen quite often.

3. IMPORTANCE OF USING OF ADOBE MATERIAL IN CONTEMPORARY ARCHITECTURE OF ANATOLIA

In contemporary architecture, the use of locally sourced and sustainable materials has become increasingly important. One of such material is adobe, which has been used in construction for thousands of years and is still widely used in earthquake-prone regions of Anatolia. Adobe is a natural material made from mud, straw and water and is highly resistant to seismic activity. Here are some reasons why the use of adobe material is important in contemporary architecture, especially in earthquake-prone areas of Anatolia.

In a general point of view, adobe is a low-cost, locally sourced material that is widely available in Anatolia. This makes it an ideal choice for construction in rural areas where resources may be limited. In addition, adobe is easy to work with and can be molded into any shape or size, allowing architects to create unique and beautiful structures that are both functional and sustainable.

Secondly, adobe is highly resistant to seismic activity. In earthquake-prone regions of Anatolia, where earthquakes are common, adobe buildings have proved to be more resilient than those made of other materials. Adobe buildings have a unique ability to flex and absorb energy during seismic events, which helps prevent the risk of collapsing and minimize damages done to the structure.

Moreover, than this, the use of adobe in contemporary architecture promotes sustainability and environmental responsibility. Adobe is a natural and renewable material which has low environmental impact. It is also energy-efficient, as it provides excellent insulation and helps to regulate indoor temperatures, reducing the need of artificial heating and cooling systems.

Nonetheless, the use of adobe in contemporary architecture helps preserve traditional building techniques and cultural heritage. In Anatolia, adobe has been used for centuries to construct homes and buildings, and its use in contemporary architecture helps to maintain the region's unique cultural identity.

Thus, the use of adobe material in contemporary architecture is important, especially in earthquake-prone regions of Anatolia. Adobe is a low-cost, sustainable, and highly resilient material that promotes environmental responsibility and cultural heritage. By using adobe in their designs, architects can create beautiful and functional structures that are both resilient and sustainable.

4.CONCLUSION

As a locally sourced and sustainable material, adobe is chosen as the main material of the Uzundere Djemevi and Sociocultural Center proposal project which is designed by the founder owner of Slash Architects, Şule Ertürk B.Arch. As a low-cost, sustainable, and highly resilient material that promotes environmental responsibility and cultural heritage adobe is chosen as the most suitable material to a concept project of the Djemevi and Sociocultural Center proposal to 2017 dated architectural exposition which is organized by the municipality of Karabağ, Izmir. The adobe material mentioned here can give a humble design solution on a cozy holly space design as being highly resistant to seismic activity especially on the geography of Aegean Seaside, where earthquakes could be seen quite a lot during the whole year. On the other hand, the use of adobe in contemporary architecture helps preserve the traditional building techniques and cultural heritage on where the Concept Project of Uzundere Djemevi and Sociocultural Center Complex could be a successful design example of contemporary architectural design that is created by a local and eco-friendly material on traditional techniques. Nonetheless, as being a low-cost, locally sourced material adobe material based Djemevi and Sociocultural Center Complex construction could be affordable by a village community which would like to have a new gathering space at the hearth of their location.

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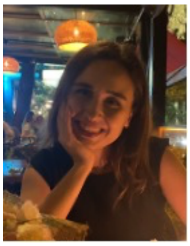
Paper Number: 52

The Changes of Traditional Adobe Residential Texture in Gündüzbey (Malatya) After Earthquakes



Elif Ceren Tay
Yıldız Technical University, Istanbul, Turkey
elifcerentay@gmail.com

ABSTRACT

Malatya is one of the provinces most affected by the 6, February 2023 earthquakes. After the earthquakes, thousands of our citizens lost their lives under the rubble and many of our citizens were injured. All citizens living in the city were affected by the earthquake and most of them had to leave the city. Malatya's building stock was also severely affected by the earthquakes, and many buildings were destroyed or severely damaged. The aim of the study is to investigate the deterioration of traditional adobe houses, which form the texture of the built environment, after the devastating earthquakes and to determine the impact of the change in the building stock on the urban landscape.

The study focuses on the urban landscape of Yeşilyurt district in Malatya. Yesilyurt is one of the historical settlements of Malatya. The examples of civil architecture built in this district in the mid-19th century reflect the characteristic features of Turkish houses in Malatya and form the built environment of Yeşilyurt. Due to these characteristics, Yeşilyurt was designated as an urban conservation area in 2005. A conservation development plan has been prepared for the neighborhood. The case study is the residential and commercial neighborhood of Yeşilyurt, which is designated as an urban conservation area and is located in the commercial center of the city. This area is designated as a historic preservation area in the development plan. Most of the buildings in the study area are two-story adobe buildings that fit into the urban landscape. The architectural style and construction techniques of the houses were developed using local materials. The base of the houses is made of stone, and the walls were constructed with adobe using nogging techniques. While the adobe walls are used as vertical beams in the houses, the wooden beams serve as horizontal beams. Thus, the adobe walls separated the rooms from each other and took over the load-bearing function

Keywords: Adobe, Earthquakes, Built Environment, Malatya, Traditional Turkish house

1. INTRODUCTION

Cities are created through a historical process depending on natural environmental data, climatic conditions, land use, and traditional building techniques [1]. The physical environment of cities is created by buildings. It becomes a texture when new buildings are added to the existing environment. Various processes affect the urban texture [2]. The urban texture is variable; on the one hand, it changes by itself, and on the other hand, it is subject to human intervention [2].

The urban texture is shaped by the social and cultural values of the societies in which it is located. The urban texture is a living structure whose function and character are constantly changing as the social environment changes [3]. Anatolian cities are shaped according to the way of life of the Turkish population. The Turkish house is a form of housing that has been established in Anatolia and Rumelia and has existed for 500 years [4] [5]. It has a design that corresponds to the family life, culture and customs of the Turks. The Turkish house typology was created by adapting the Turkish way of life, which originated in Central Asia, to the Anatolian geography. In the Turkish house, in addition to the spatial arrangement, such as the relationship between the sofa and the room, the facade design and the street connection, the construction techniques and materials are also an important part of the house character. Doğan Kuban states that the main material of Turkish houses in the villages and towns of Central Anatolia is adobe [5].

Many examples of civil architecture in the urban texture of the Yeşilyurt district of Malatya are adobe buildings that were created by adapting Turkish house typology to the geography of Malatya [6]. Most of these buildings were constructed in the mid-19th century without any engineering knowledge. However, the Kahramanmaraş earthquakes on 6th February Malatya hard and the city lost a large part of its building stock.

The aim of the study is to observe the behavior of traditional housing typology, whose main material is adobe, to earthquake loads and to reveal the loss of housing stock and urban morphology due to earthquakes. In the study, the losses that occurred in the historical urban texture of Malatya after the February 6 earthquakes were demonstrated using traditional Malatya houses built with adobe.

2. DEFINING THE CASE STUDY

Archaeological studies conducted in Yeşilyurt district of Malatya show that the history of the district dates back to 4000-3000 BC. The first urbanization in the region occurred in 395-659 AD under Byzantine rule [7]. The first data about the urban structure of Yeşilyurt are the land register entries of 1516 [8]. Yeşilyurt was used as a settlement by the Hittites, Urartans, Roman Empire, Byzantine Empire, Seljuk Empire and Ottoman Empire [9].

The Gündüzbey neighborhood is located 1 km southeast of İlhan Şahintürk Boulevard, one of the main streets of Yeşilyurt [10]. İlhan Şahintürk Boulevard is the main street of Gündüzbey. At the point where the boulevard ends, the social facilities of Gündüzbey and the town square are located. The study focuses on the residential area southeast of the town square. In this context, Pehlivanoğlu Street, Caferoğlu Street, İsmetpaşa Street, 1st Street and Gültek Street, which run perpendicular to the boulevard, and Camikebir Street, which runs parallel to the boulevard, were studied (Figure 1).

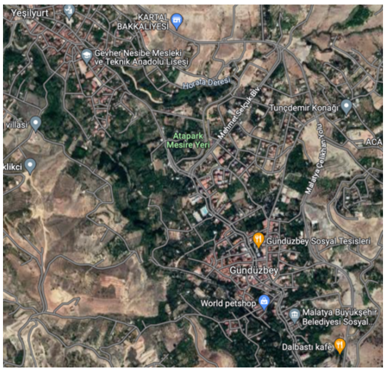


Figure 1. Location and urban texture of Gündüzbey

Most of the buildings in the study area are proprietary buildings. The buildings are traditional Malatya houses of the Turkish house type, built with adobe. The building stock in the study case defines a house typology and forms a morphological region. All buildings were destroyed or severely damaged by the February 6 Kahramanmaraş and February 27 Malatya earthquakes. After the earthquakes, the condition and inventory of the houses were observed, photographed and archived during a technical site visit on May 15 (Figure 2).

Figure 2. Gündüzbey after the earthquake [11]

3. TYPE AS MALATYA HOUSES

Commonalities within the urban texture are referred to as "types." Petruccioli defines a type as "the living sum of all elements at a given time" [12]. The urban design approach that seeks to understand the relationship between buildings of a particular type and the built environment they form is called typomorphology. Typomorphology shows the evolution of the city.

The traditional houses of Malatya were built in the second half of the 19th century. The houses, where privacy is important, reflect the lifestyle of the time [13]. They usually have a two-story floor plan and have a sofa (Figure 3). The main materials are adobe, stone and wood [14] [6]. The houses in Malatya are divided into attached and detached buildings. Attached buildings are directly connected to the street, while detached buildings are connected to the garden [13]. The traditional houses of Malatya have the architectural features of the Turkish house. There are rooms on the upper floor of the two-story houses. The transition to the rooms is provided from the sofas. On the ground floors there are stables, haylofts, cellars, iwans, kitchens and wet areas. In [15] [6] [9].

Figure 3. The traditional houses of Malatya. **Figure4.** Urban texture of Yeşilyurt

The urban texture of Yeşilyurt district, which is one of the ancient settlements of Malatya, consists of traditional houses that reflect the characteristics of local architecture of that time (Figure 4). Yeşilyurt houses, the floor plan types of inner and outer sofas are used together [6]. The main elements of the house are rooms, sofas and stairs [6].

Gündüzbey is one of the oldest neighborhoods of Yeşilyurt. The residential texture of Gündüzbey is an important example of the traditional houses of Malatya. The houses in the study area are two-storied and attached buildings. There are console called ''cumba'' on the upper floor of the houses. The foundations of the houses are made of stone and the walls are made of adobe and built with the hımış masonry technique. Most of the buildings are connected to the street. A small number of houses are entered through the garden.

4. EFFECTS OF THE FEBRUARY 6 EARTHQUAKES ON MALATYA HOUSES

On February 6, 2023, two earthquakes occurred nine hours apart. The epicenters of the earthquakes were located in Kahramanmaraş. The magnitudes of the earthquakes were reported as 7.8 Mw and 7.5 Mw. The tremors of the earthquakes devastated 10 provinces, namely Kahramanmaraş, Gaziantep, Hatay, Adıyaman, Diyarbakır, Şanlıurfa, Malatya, Adana, Osmaniye and Kilis. In the earthquake chain in the region, 36 thousand 187 citizens lost their lives. 108 thousand 68 citizens were injured. The damage assessment surveys conducted after the earthquakes revealed that 232 thousand 632 buildings were immediately demolished or severely damaged according to Murat Kurum, the previous Minister of Environment, Urbanization and Climate Change [16].

Figure 5. Urban texture of Malatya after the earthquake [11]

The urban texture of Malatya was severely damaged by the earthquakes (Figure 5). The Malatya Governor's Office stated that 3,899 buildings were destroyed and 23,968 buildings were severely damaged after the earthquake [17]. After the devastation of the city, the traditional building fabric was examined and the destruction in the region was observed. The causes of damage to adobe houses were evaluated based on the information found in the literatüre [18] [6]. In accordance with the information obtained, the damages present in the field study were listed.

4.1 Fracture at joints

If the walls are not sufficiently connected, they move independently against the earthquake load, and the walls fall off their axis (Figure 6).

Figure 6. Examples of fracture at joints [11]

4.2 Separation of the annex

Damage caused by the detachment of the annex from the main building as a result of earthquake loading (Figure 7).

Figure 7. Examples of separation of the annex [11]

4.3 Collapse due to ceiling load

Damage caused by the separation from the walls of ceilings that are not adequately supported on the walls, the deformation of their geometry, and the consequent overturning of the walls out of plane (Figure 8).

Figure 8. Examples of collapse due to ceiling load [11]

4.4 Complete collapse

In masonry structures, the walls also have load-bearing properties. If the walls are severely damaged under the earthquake load, the structure will collapse completely (Figure 9).

Figure 9. Examples of complete collapse [11]

4.5 Structural cracks

Damage to masonry structures under earthquake loading begins with cracks in critical areas. The cracks grow as the load effect increases. As the cracks open and close, the building absorbs the energy (Figure 11).

Figure 11. Examples of structural cracks [11]

4.6 Formation of void circles

Diagonal cracks form in walls around voids such as doors and windows in walls due to earthquake action (Figure 12).

Figure 12. Examples of formation of void circles [11]

4.7 Damage to the corner

In masonry structures, damage occurs in the vertical direction at the corner joints of the structure as a result of the action of ceiling or roof loads (Figure 13). .

Figure 13. Examples of damage to the corner [11]

5. CONCLUSION

The urban form consists of buildings, parcels and streets. In analyzing the built environment, we start from the buildings, which are the basic cells of the urban fabric. The relationship between buildings and streets can be a starting point for defining the urban fabric. The form of a city is shaped by the social and cultural values of the societies that live in that city. For this reason, the form of a city can only be understood historically.

The traditional houses of Malatya have shaped the Yeşilyurt district in Malatya as a type. The house type in the district has similar characteristics. The houses are attached and have a direct relationship with the street. The floor heights are one floor above the ground. While there is a sofa and rooms on the upper floor, the other rooms are located on the ground floor. In these houses, there are bay windows that relate to the street. The traditional houses of Malatya were built using masonry technique. The main materials of the buildings are adobe, stone and wood.

The chain of earthquakes that occurred in our country on February 6, 2023, with aftershocks still continuing, has been called the disaster of the century. Ten provinces were badly hit by the earthquake and the building stock was severely damaged. Malatya was significantly damaged by the earthquake. In this study, the behavior of the urban texture of Gündüzbey neighborhood in Yeşilyurt district of Malatya in the face of the earthquake is investigated.

In the Gündüzbey neighborhood, Pehlivanoğlu Street, Caferoğlu Street, İsmetpaşa Street, 1st Street and Gültek Street, and Camikebir Street were identified as study areas. The majority of the buildings in the site were constructed of adobe. The buildings were two-story traditional Malatya houses with attached order directly connected to the street. The buildings were severely damaged by the earthquake. The earthquake effects on the adobe buildings in the study site are analyzed under seven headings, their causes explained and exemplified by the buildings on site.

In summary, the traditional houses in the study area make up the urban morphology of Gündüzbey. All of these buildings were severely damaged or destroyed after the earthquake. All the houses in the study area were evacuated. In order for the region not to lose its urban identity and to preserve its morphology, a detailed study should be conducted. The findings should be archived and transferred to maps. The planning studies to be conducted after the earthquake should be carried out in accordance with the existing potential of the region. Planning studies and implementations should be carried out in an interdisciplinary manner. Site data, the location of the ruins, the structural condition of the ruins, and the social and cultural structure of the society in the region should be taken into account when determining interventions in the historic environment. At this point, it is important to ensure the integrity and sustainability of the area.

6. MEMORY

This work is dedicated to the memory of our citizens who lost their lives in the earthquake

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Paper Number: 53

Prosperity in Shirazi Courtyard by Designing a Portico Shading with a Lightweight Structure at Yazd University


Fouzieh Zeinali[1] , Nariman Farahza[2]
[1,2]Yazd University, Yazd, Iran
[1]zeinali.fouzieh67@gmail.com,
[2]narimanfarahza@gmail.com

ABSTRACT

This article is a report of the process of designing and building a light portico shading structure on a historic area surrounded by vernacular adobe houses called "Shirazi Courtyard". This courtyard is located in the historic city of Yazd and is part of the Faculty of Art and Architecture of the University of Yazd. Some traditional houses in the historical context of Yazd such as Lari's house, Rasoolian's house, and Sima Rasoolian's house surround the courtyard of Shirazi. To ensure the prosperity of this courtyard and to make this traditional and historical space more functional for the students, it was necessary to build a shade next to its southwest wall. The wall behind this portico is the Lari Panjdari room with five vertical windows overlooking the Shirazi courtyard. It was necessary to design a shading structure that would preserve and protect the trail southwest of this courtyard from wind, rain, and sunlight. It was also necessary that the structure is very light and have a minimum number of foundations to carry out any intervention on this historic site. This project was defined as the final exercise of the CONSTRUCTION III course for senior BArch students. The result of this exercise was the construction of an early prototype of a structure designed by students. The designed portico was a three-dimensional wooden structure that established a beautiful integrity between the roof and the columns and was covered with fabric between the truss spaces. During this exercise, students experienced the course description with a constructivist learning approach and 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: Shirazi courtyard, adobe architecture, student project, portico shading, construction.

1. INTRODUCTION

This paper is a report on the construction of a lightweight structure in the historical context of Yazd at the art& architecture Faculty of YAZD University. This experiment follows on from previous experiences, the report of which was published in Kerpik's 2022 article [1]. The core concern of the authors of these papers is how to transfer specialized theoretical knowledge in the direction of solving design problems. in particular, the implementation of structural knowledge into the architectural design process.

Kerpic 2022paper was 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 (Photo 1). The construction of a structure to preserve the valuable historical building of the Shirazi courtyard on the site of the 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, the 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.

Figure 1. Constructed structure 2020, kerpic2022

The new project is following same educational goals. This article reviews the construction process of a new structure that was built in the Shirazi courtyard. The court of Shirazi is located in the historical city of Yazd and is part of the Faculty of Art and Architecture of the University of Yazd. Some traditional houses in the historic context of Yazd such as Lari's house, Rasoolian's house, and Sima Rasoolian's house surrounds Shirazi's court. This yard was a sports area which was not used for a long time. To revive it, students decided to create a shadow for a portion of this field. After the field survey, the students concluded that it would be preferable to have this shadow on the wall where the windows of Lari's house open.

With this goal in mind, the goal of maintaining a constructive lesson plan was also followed. As a result, the course description "CONSTRUCTION III" has been compiled based on constructive learning. The objective of this course plan was to understand the basics of statics and the concepts learned in the structure courses and then reach the stage of designing and building a lightweight structure as a shaded portico. In this sense, Bloom's taxonomy of educational objectives theory has been used in the field of structural teaching for architects. [2]

2. COURSE DESCRIPTION OF THE "CONSTRUCTION III" IN A CONSTRUCTIVIST MANNER

Revision of Bloom's taxonomy theory was published in 2001 by Anderson & Krathwohl. Bloom leveled the cognitive levels from memory to production in a pyramid, which is shown in Figure 2. The revision of the taxonomy of educational objectives of Bloom 2001 (BTR) is a taxonomy of knowledge and cognitive processes that transfer knowledge from Remember to Create (Anderson and Krathwohl, 2001). This theory is about transferring the theoretical content taught to solve ill-defined problems, including design.

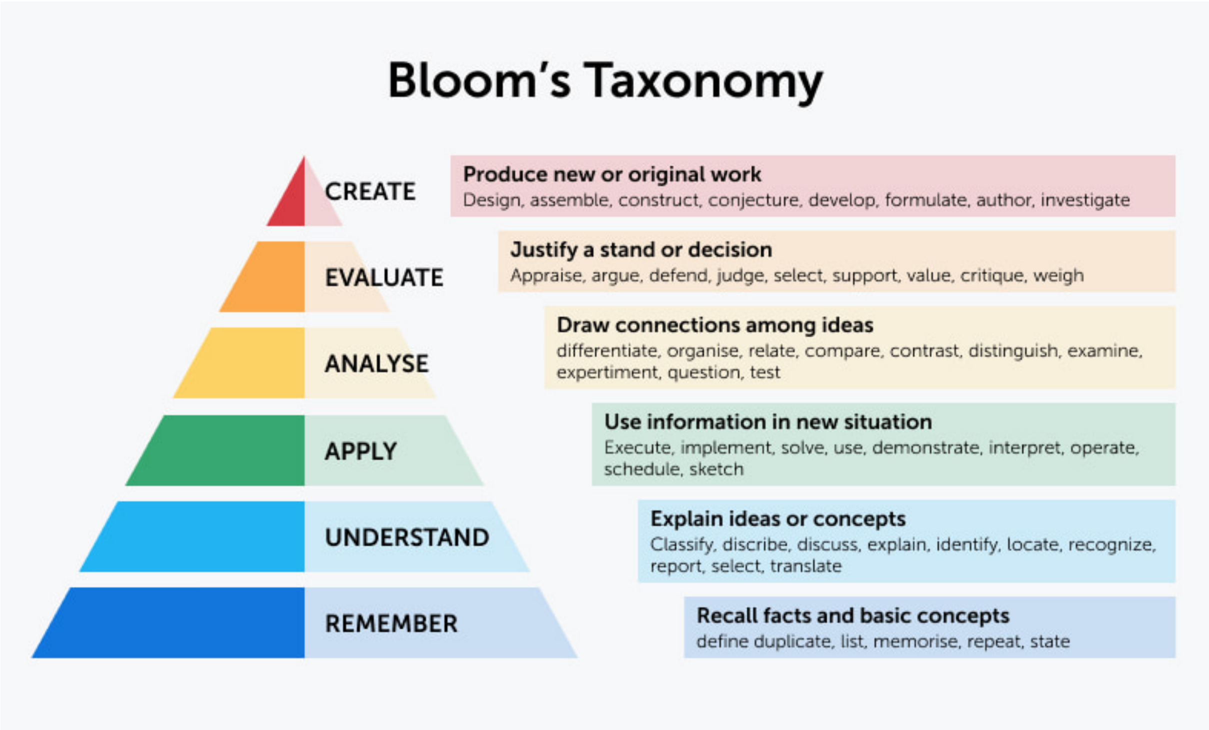

Figure 2. Revision of blooms taxonomy 2001(RBT).

Zinalli In her Ph.D. thesis, extended (BRT) into the architecture domain and the subject of structural knowledge. This theory, wich called " meaningful learning of structure in architectural design" is in the field of constructivist learning. Meaningful Learning of Structures in Architectural Design, Explanation of a theoretical model of the dimension of the structural cognitive process, which describes the cognitive process and the dimensions of structural awareness from remembering to implementation in architectural design.. The course description is in accordance with this theory.

2.1 Construction Iii Course In B.Arch

The CONSTRUCTION III course is one of the courses that have been scheduled to integrate the technical material taught and architectural design practice. This course provides educational conditions for the theoretical courses to be memorized, understood and applied. Based on Bloom's theory First, the content taught must be understood and then applied within the design process. The effort in this lesson was to conceptualize the lessons learned in statics and then design and build a structure. Consequently, due to the existence of appropriate contexts for the integration and application of structural knowledge into architectural design, this course was chosen.

B.Arch. Students in the 7th semester take the CONSTRUCTION III 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.

This course was held in person and allowed the students to experience field study, teamwork 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.

2.2 Foundation Exercises in Course Cescription

Macdonald has defined the role of structure in environmentally sustainable architecture. It depends on the relationship between the form and performance of the 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. [4]

For designing an efficient structure, it was necessary to convert the prior knowledge on basics of structure to conceptual knowledge.[5] Conceptual knowledge is very important in applying the teachings in the design process and achieving innovation. Professionals are the people with more conceptual knowledge [6], [7].

All about 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.

Theoretical and prerequisite knowledge of structures has 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.[8]

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 Marquette.

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 Marquette 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.

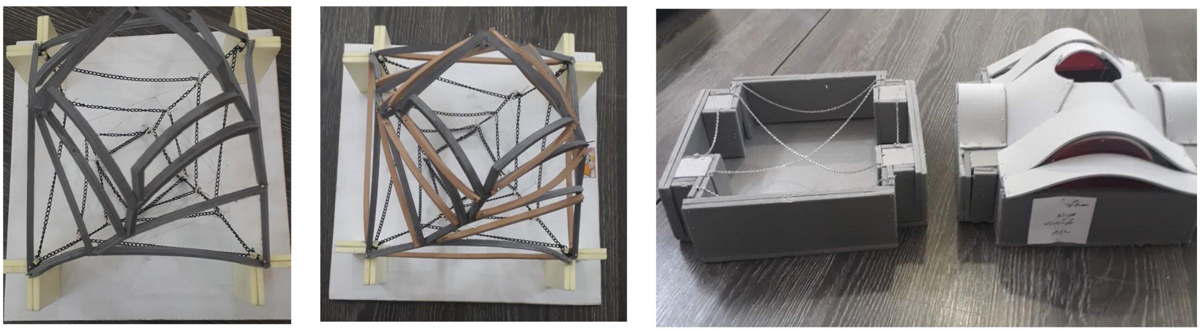

Figure 3. Basic exercises of students

3. FINAL PROJECT: DESIGNING A LIGHTWEIGHT STRUCTURE FOR SHIRAZI COURTYARD

The final exercise was designing a portico for Shirazi courtyard. A structure like a roof which con covered the pathway and be resistant against wind, rain, and sunlight radiation and Also be lightweight. In addition, according to the yard, this portico must be 14*3 m dimension and haven't any post in the middle of pathway.

The final exercise began based on students' previous knowledge of samples and using sketches and structural drawings and physical models. Students build some cases similar to their structures in groups during the initial design. 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. Shirazi courtyard in architecture faculty of yazd.

3.1 Design final project

In groups of two, students proposed eight alternatives all of which had structural creativity and genius. One proposed design was selected from among the 8 finalized designs by students to be constructed in a real scale.

The selected design was a latticework structure with tensile and compression elements in a truss shape. the initial structure was a tensegrity but in the developing process, it became a truss structure that 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.

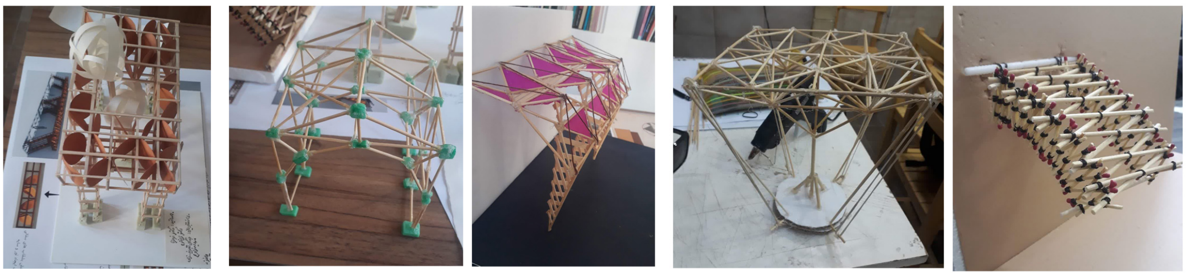

Figure 5. Students altenative for shirazi final structure

In the following, Structural calculations were done in SAP software and choose the materials based on it. 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.
Then, students in new groupings began designing and drawing the executive details of the structure, Numerical calculation and Structural form analysis, and financial and executive estimates of the construction.

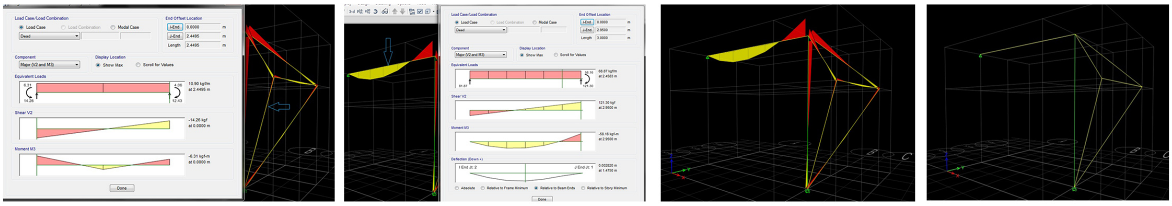

Figure 6. Structural calculations

The selected structure was constructed with wooden rod members and tongue and groove joints and glue. It is built on a 1:4 scale in the construction studio of the Faculty of Art and Architecture in a period of one month from late December to January 2023.

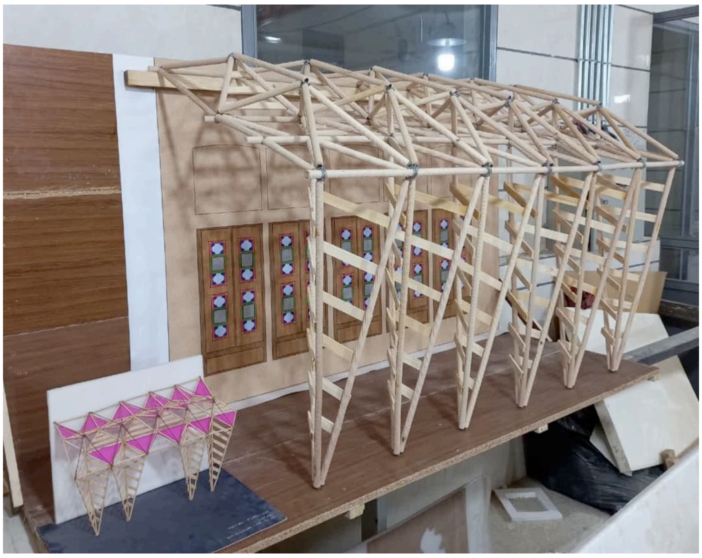

Figure 6. Constructed structure with 1:4 scale.

Figure 7. Construction process of the selected structure, in the workshop of Rasoolian's house (art & architecture faculty of Yazd).

4. CONCLUSION

A report on the construction of a Portico Shading With a LightWeight Structure in the Shirazi yard in Yazd was reviewed. The purpose of building this portico was to bring prosperity to an isolated and remote yard in a historical context. The educational goal of this constructivism course description was to help students transfer their knowledge and cognition from remembering to designing and producing. The constructed structure as a product of this project is seen as lesson in a constructivist manner. In addition to building a structure and learning the fundamentals of structures through a design-based method, students also understood and implemented the basics of structures during this process.

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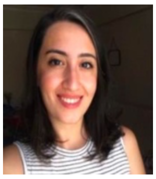
Paper Number: 54

Examination of Earth Structure Production in Sustainability




Pınar Koçlardan, Gamze Özmertyurt,
Serhat Ulubay, Dilek Ekşi Akbulut

Yildiz Technical University, İstanbul

koclardanpinar@gmail.com
gamze_ozmertyurt@hotmail.com
serhatulubaygmail.com
dileksi@yahoo.com

ABSTRACT

Considering the fact that more than 50% of the world population lives in cities and in the course of the following 50 years this ratio will increase by approximately 60%, it is estimated that this growing population will increase resource consumption leading to an increase in the amount of the emissions and wastes. Land usage changes with urbanization and this causes pressure on the natural resources and ecosystems.

Throughout the world, day by day more countries adopt the ecological design principle and prefer environmentally friendly materials in building construction. In this regard, the systems in which the wastes are used as raw materials (industrial ecosystems) and the ecological design principle at the architectural scale have a positive effect on achieving energy and resource efficiency. Energy and resource usage and material selection are important parameters in ecological design. The materials that will be selected should be in compliance with the ecosystem and should not return as waste. Throughout its life cycle, the environmental effects of every material used in the building construction must be well known. In this context, soil-based materials are considered as economic, ecological, and non-waste-producing materials that comply with the ecosystem criteria and provide energy and resource efficiency.

In Turkey, the excavation soil observed to be increasing with the urban transformation activities can be considered to be used in construction of the modern earth structures within the concept of ecological design. Excavated soil can be included in the building construction to form a loop and if its structure is suitable it can even be used in industrial areas where the soil is the raw material.

In this study; it is aimed to investigate the soil structures that are constructed via different construction techniques within the concept of building life cycle. In this regard, it will be attempted to define the ecological characteristics of the soil material used as a building material.

Keywords: Ecological Design, Natural Resource Consumption, Industrial Ecosystem, Earth Construction Techniques, Earth Construction Standards and Regulations.

1. INTRODUCTION

"Treat the Earth well. It was not given to you by your parents. It was loaned to you by your children."

Kenyan Proverb

Given the rapid depletion of energy resources and the resulting increase in environmental issues, energy consumption and management have become increasingly important. When examining the sectoral distribution of energy consumption, the construction sector follows industry and transportation.

The rapid urbanization occurring worldwide, with more than 50% of the global population currently living in urban areas and an expected 60% increase in urbanization over the next 50 years, is anticipated to lead to heightened resource consumption, increased emissions, and greater waste generation. This shift towards urbanization brings about changes in land use patterns, putting additional pressure on natural resources and ecosystems.

With the increasing industrialization and urbanization, the consumption of natural resources has accelerated. At this point, ecological designs have gained importance in order to minimize the impact of human activities on the natural environment. Material selection is one of the most crucial factors to consider in ecological design. Therefore, an ecological design approach should be adopted, taking into account all stages from the production of preferred materials to their useful life and eventual reintegration into the production cycle. When examining the commonly used materials in building construction such as concrete, steel, aluminum, and wood, it is observed that wood, being an organic construction material, consumes less energy compared to other materials. Similarly, another organic material, soil, emerges as an environmentally friendly and energy-efficient ecological building material. Soil structures were predominantly preferred in rural areas in periods preceding the production of new construction materials. However, with the progress of the construction industry and the proliferation of new building techniques, soil structures were largely abandoned. Nevertheless, in today's world, with the growing emphasis on economic conditions and ecological design principles, soil structures have become a widespread research topic worldwide [1].

In order for a soil structure to be considered modern, it should not only rely on past teachings in its construction techniques but also benefit from innovations brought by contemporary technology. Adobe, a natural and sustainable soil building material, possesses thermal and sound insulation properties. However, it has disadvantages such as low compressive strength and vulnerability to water, which hinder its widespread use. In many parts of the world, these limitations have been addressed by improving the weak aspects of adobe through modern construction techniques. Examples of soil construction techniques that have been used since ancient times and have been modernized to meet the needs of today include "rammed earth technique, compressed earth block technique, on- site cast earth technique, lightweight soil technique, stabilized earth technique, and PISE technique."

The "rammed earth technique" is one of the modern soil construction techniques where soil bricks are formed by compacting the soil using high-pressure machines. Bricks produced with the addition of a stabilizing material such as cement are called "stabilized rammed earth blocks." The Telenor office building in Islamabad, Pakistan, constructed by Sirewall Consulting Inc., a Canadian construction firm, is an example of this technique (Figure 1). The tower, reaching a height of 30.5 meters, was built using rammed earth blocks made from the local soil material of Islamabad, setting a new record. In Pakistan, where the labor force is abundant but mostly unskilled, special training protocols were developed, and workers were trained by first building a practice wall (Figure 2). This training equipped the workers with skills such as formwork construction, proper mixing and assembling of materials, and the use of measuring tools [2].

Figure 1. The Telenor Office Building in Islamabad, Pakistan (URL 1).

Figure 2. Training phase during the construction of Telenor Office Building, Islamabad (URL 2)

2. SUSTAINABILITY OF THE EARTH MATERIALS

The term "sustainability" has its origins in forestry. In forestry, the practice of replanting a tree for every tree harvested ensures their replenishment. Sustainable development, on the other hand, refers to social and economic development that meets current needs without compromising the ability of future generations to meet their own needs [3].

The increasing population and urbanization pressure, particularly in sourcing building materials from the natural environment, have led to the depletion of natural resources. To prevent this loss, there has been a growing emphasis on sustainable material usage worldwide in recent years. The use of sustainable materials is important both in the manufacturing process and throughout the building's life cycle [4]. The Building Research Establishment (BRE) Environmental Assessment Method (BREEAM) has issued a certification (Item No. 1006220010-1006220013) recognizing compressed earth as a sustainable building material with an A+ rating, acknowledging its ability to meet the specified criteria (Building Research Establishment (BRE)). Due to its high thermal mass, which contributes to building performance and recyclability, earth material is considered a sustainable building material [5]. The "Building Life Concept" encompasses strategies that cover the entire life cycle of a building, from planning and construction to operation and eventual demolition (Figure 3). In this context, the use of earth material can contribute positively to the sustainable continuation of this cycle. The utilization of earth materials is also an important parameter for ecological design [6]. Especially in rural areas with traditional settlement patterns, earth has been used as a historical building material, enabling communities to achieve maximum efficiency with minimal energy consumption. Proper maintenance of adobe structures can meet ecological design criteria by providing protection from cold weather in winter and hot weather in summer [7]. The traditional use of earth material in rural areas highlights its potential for application in modern cities as well.

Figure 3. Schematic representation of the Building Life Concept (URL 4)

The United Nations Sustainable Development Goals (UN SDGs) and many global policies have content related to land and soil materials (Figure 4). In particular, initiatives such as the UN Sustainable Cities and Communities, the EU Green Deal, and other global commitments to improve the collective future of the world also support the exploration of material sustainability in the construction sector, including the possibilities of using soil materials.

Figure 4. Substances with which SDGs and soil material have a direct and indirect relationship (URL 5)

2.1 Reuse of Soil Material in Earth Structures: Examples from Around the World

Promoting the sustainable use of soil materials and construction techniques related to soil is of paramount importance for the future of the world. It is crucial to examine the methods used, especially in their application to meet modern needs. As part of this paper's focus on modern soil constructions, examples of sustainable use of soil materials will be explored. The acquisition of materials is also a component of ecological design, which is part of the Building Life Concept. Due to the increasing pressures of urbanization worldwide, it is recommended to source soil for new housing developments from excavated soil that is lost and can be recycled for suitable purposes. Excavated soil can be reintegrated into the construction cycle by being used in the building's structure. Such applications can be particularly preferred in industrial areas where soil is the primary raw material. The practice known as "urban mining" has become increasingly prevalent, especially in European cities in recent years (Figure 5). Benefits:

- Meeting material supply needs in construction projects, particularly in response to population growth.
- Addressing the urgent material stock needs in rapidly growing cities.
- Offering an environmentally friendly approach as the practice has a low potential for greenhouse gas emissions.

With more sustainable practices, it has the potential to reduce annual greenhouse gas emissions by approximately 40% by 2050 compared to 2020 [8].

Figure 5. Compressed Earth Blocks made of excavated earth (Resource: URL 6)

By implementing appropriate purification and quality control measures, excavated soil can be transformed into a resource for sustainable development, minimizing the need for raw materials and reducing environmental impacts. The on-site evaluation of this material, in addition to its recyclable nature, enables on-site material usage, aligning with modern needs and designs. This supports sustainability without the need for energy-intensive practices such as transportation, handling, and production. Some examples of the reuse of soil material in the construction sector have been examined worldwide.

For example, in France, the research group CRAterre focuses on the development of earth construction techniques, with a specific focus on the use of excavated soil in modernizing local systems [9]. Satprem Maini, who works on the reuse of excavated soil by benefiting from CRAterre's courses, established the Auroville Earth Institute (AVEI) in India. The institute has constructed a type of compressed earth block using a mechanized block press. They have also developed techniques based on the use of stabilized soil for vaults and domes [10] (Figure 6).

Figure 6. The example of integrated quarries by AVEI and the Auroville Earth Institute on the left was built entirely with stabilized soil (URL 9)

In European countries like the Netherlands and Germany, there is compliance with legal decisions regarding the separation and reuse of excavation waste materials in buildings produced in urban centers, in line with the concept of "New Horizon Urban Mining." The use of these materials is supported in mass housing projects [11]. In Turkey, besides the inclusion of excavation soil in landscape areas such as garden walls in cities, there are also examples of its use in building structures. An example of this is the kindergarten and dining hall structure built in the village of Turunç in Marmaris in 2012 (Figure 7).

Figure 7. A kindergarden building in Marmaris Turunç (Akbulut Archive, 2012)

3. CONCLUSION

In the Anatolian region, the diversity and easy availability of soil materials have been evident throughout history in construction. It is known that the architecture in Konya Çatalhöyük, one of the oldest settlements in the world, was created by combining materials such as mud bricks, wood, and reeds. This architectural form continued to be used in the region and its surroundings for many years. Although there was a pause in the use of soil materials in construction techniques due to modernization, the possibilities of using earth construction techniques and materials have come back into focus in recent years with the increasing trend towards ecological design. The increasing attention to climate change and the rise in natural disasters worldwide have played a leading role in this direction. Soil materials are frequently used in construction in many parts of the world, along with modern construction techniques. Examples of these techniques include rammed earth technique, adobe technique, in-situ cast earth technique, lightweight earth technique, compressed earth technique, and PISE technique.

In our country, which is rich in soil resources, it is of great importance to utilize soil materials as a traditional building material, mainly in rural areas. Especially in large cities, the pressure of urbanization, along with the amount of waste material generated by production and demolition, necessitates the use of sustainable materials through their reuse advantage. For example, it is stated that Istanbul has a daily average circulation of 150,000 tons of excavated soil, with up to 20% losses in its utilization [12]. In Turkey, there are specific regulations and standards for the preparation of adobe blocks related to adobe applications with soil materials. These include regulations and standards such as Earthquake Regulation (Deprem Yönetmeliği), TS 2514, and TS 2515. When examining the standards, it can be observed that the single technique specified as the production and technique for earth construction is limited to adobe. Some provisions in the Earthquake Regulation are seen to impose restrictive measures on earth construction. This situation inadequately supports the use of soil as a building material in Turkey, despite the abundance of soil from a climate and geographical perspective [13].

Recent earthquakes in our country have shown that, although soil material may be seen as an outdated and easily destructible material with maintenance challenges, it is once again being considered due to its advantages such as rapid production, lightweight nature, and its potential for eco-design by improving climatic conditions. For example, in the earthquakes that occurred in cities like Malatya and Elazığ, many traditional houses built with adobe techniques in rural areas were destroyed (Figure 8). Considering the characteristics of these regions, the possibility of using the excavated soil generated after the destruction in the field could be explored for temporary or long-term housing solutions after earthquakes.

Figure 8. The situation of Malatya Balaban Village after the earthquake (29.04.2023, Ulubay Archive)

It is important to support the possibilities of using soil structures by complementing them with new technologies. In recent years, examples made with 3D printer printers, using soil materials, have become significant, enabling faster construction. For instance, the CRAterre research group based in France has conducted research on earth casting, raw soil and plant fiber mixtures, prefabricated compressed earth, and 3D-printed earth structures. In our country, which is prone to earthquakes and struggles with urbanization issues, it is important to utilize and promote these technologies. Especially in the construction industry, consumer demands shape the applications that will be implemented. To generate interest among consumers in modern earth structures, organizing educational programs and providing more comprehensive information about the material are necessary steps.

4. ACKNOWLEDGMENTS

If included, acknowledgments should appear before the list of references. Grants, other financial aid, and assistance may appear under the heading Acknowledgements, which has to be placed before the list of references.

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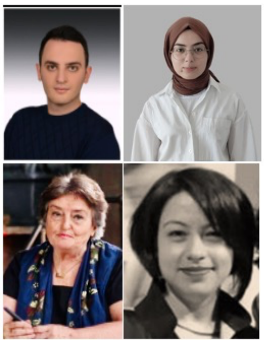
Paper Number: 55

Heating And Cooling Loads of Building Compared with Concrete Block Wall and Earth-Alker Wall



Rahman Sertyamaç[1], Havva Koca[1], Bilge Işık[2], Merve Tuna Kayılı[3]

[1]Karabük University, Institue of Graduate Sciences
[2]İstanbul Technical University
[3]Karabük University, Faculty of Architecture

isik.bilge@gmail.com

ABSTRACT

The increasing urbanization around the world has brought attention to the energy problem and negative environmental impacts, making the choice of building materials more important than ever. In Turkey, kerpiç or adobe is frequently used, especially in rural areas, due to 1-its low environmental impact, formation energy, and ability to create a healthy indoor environment. Adobe is a building material made of soil, water, and 2-plant fibers. To improve its strength and duranility, reduceing its sensitivity to moisture, as well as to prevent it from disintegrating in water, various additives such as cement, lime, have been added to the Adobe. Material known as alker is gypsum-stabilized adobe. Compared to traditional adobe, alker has significantly improved physical and mechanical properties. It is more resistant to water, pressure, cracking, and deformation, and has a lower thermal conductivity, which prevents heat loss in buildings. In addition, its high heat storage capacity, phase-shift time, and damping factor significantly reduce the heating and cooling loads during winter and summer, respectively.

In this study, the impact of alker and concrete block materials on the heating and cooling loads and energy performance of an office building in second degree-day regions in İzmir, was analyzed. Using a simulation program, the results showed that in hot climate regions, alker walls reduced heating loads by 60.08% and cooling loads by 26.19%, and primary energy demand by 29.31% compared to concrete block walls. These gains observed in alker walls with high heat storage and low thermal conductivity without the need for any additional insulation show that alker alone can make significant contributions to the energy performance of buildings and to reducing global environmental pollution by using fossil fuels.

Keywords: Alker, energy efficiency, cooling/heating loads.

1. INTRODUCTION

The increasing demand for housing worldwide has led to a significant rise in the demand for construction materials, making material selection in construction increasingly important. Adobe, which is one of the materials with the lowest environmental impact, is frequently used due to its regional availability and its ability to create a healthy indoor air quality. Approximately one-third of the population in Turkey and various countries around the world resides in adobe buildings [1,2]. Adobe, by its nature, is a building material primarily composed of earth, water, and plant-based components. Over the years, the local or regional additives within adobe have changed, and since the 1980s, traditional straw-reinforced adobe has been replaced with "Alker," which is strengthened with gypsum. Alker is a construction material obtained by adding 10% gypsum, 2% lime, and 20-24% water depending on the moisture content of the soil [3]. The rapid setting of gypsum in Alker ensures that it gains sufficient strength when removed from the mold. In contrast, traditional adobe construction involves block cutting and drying, followed by transportation to the construction site for drying, which requires labor and time. Alker, on the other hand, offers the advantage of being used without the need for extensive labor and drying space.

The rapid setting (hardening) of gypsum in Alker prevents the normal shrinkage that clay would undergo during drying and prevents cracking and shape changes in the structure when drying is not balanced. This results in increased strength and resistance to water absorption [4]. Alker stands out from other wall filling materials due to its environmental impact, embodied energy, and strength properties.

While there are studies in the literature on the durability, application method, technology, and earthquake resistance of Alker [5-8], there are no studies on its energy efficiency in buildings. In this context, this study aims to determine the impact of using Alker and concrete blocks in the walls of a building in a hot climate on the energy performance of an uninsulated wall. The study aims to model the village office as a sample and determine its energy consumption in a dynamic simulation program. It is expected that this study will provide guidance to architects, designers, and decision-makers.

2. MATERIAL AND METHOD

The study focuses on the construction of a neighborhood office building in İzmir, which has characteristics of a hot climate. In order to determine the impact of using Alker or concrete blocks in the building envelope on the energy performance of the structure, a model of the building was prepared in the DesignBuilder program. Climate data, material thermophysical properties, and parameters such as the number of occupants were input into the program to conduct energy consumption simulations for the building.

2.1 Material

The structure of the neighborhood office considered in the study is a building with dimensions of 6.00 meters by 6.00 meters in length and a height of 3.00 meters. The building is oriented in all directions. The south facade of the building houses the secretariat, the west facade contains the office unit, the east facade includes the kitchen unit, and the north facade accommodates the wet area. The ground floor plan and the AA section of the building are illustrated in Fig. 1.

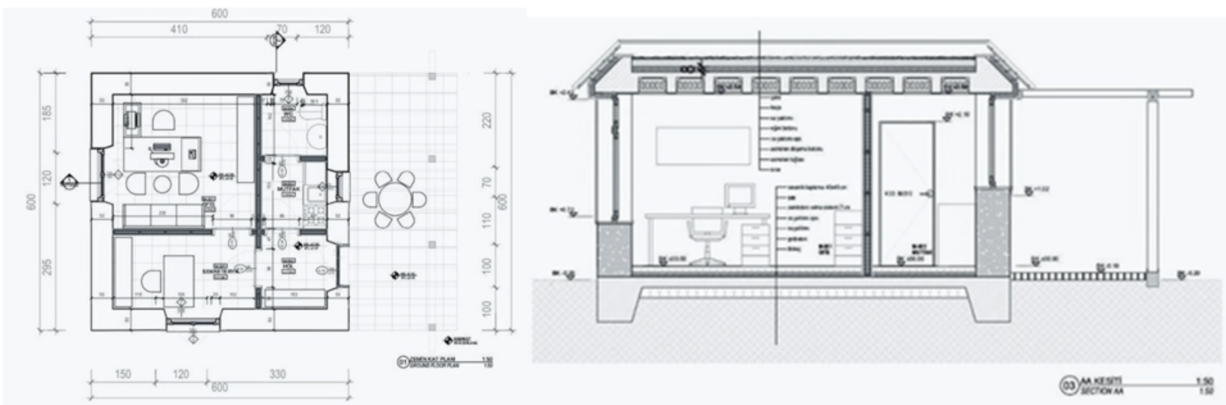
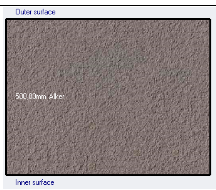
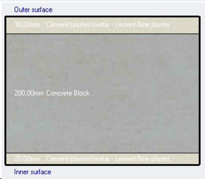


Figure 1. Plan and section.

Alternative options for the use of external wall materials, which constitute the shell component of the building, have been proposed as Alker and concrete blocks. The thermal properties of the recommended materials are presented in Table 1. It is known that the thermal conductivity value of the wall (U wall) will not be the same due to the unequal wall thicknesses of the materials. However, in this study, the focus has generally been on the thicknesses of the materials used in the wall, aiming to determine the resulting performance differences accordingly.

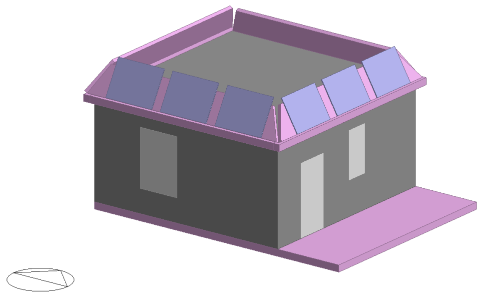
Table 1. The thermal-physical properties of alker and concrete block materials.

	Layers	Thickness (cm)	Conductivity (W/mK)	Specific Heat (J/kgK)	Density (kg/m³)
ALKER		50 cm Alker	0.40	1000	1700
CONCRETE BLOCK		3 cm cement plaster 20 cm concrete block 2 cm cement plaster	0.84	800	1700

2.1 Method

In the scope of the study, a model of the building was prepared in the DesignBuilder program to determine the energy performance of the structures. Various parameters such as climate data specific to İzmir, building envelope components, office working hours, number of occupants, heating-cooling system, heating-cooling temperature range, and heated-cooled spaces were kept constant for both wall filling materials. Subsequently, an energy consumption simulation was conducted using the "DesignBuilder" program. The data entered into the "DesignBuilder" program and the model prepared for the building can be seen in Table 2.

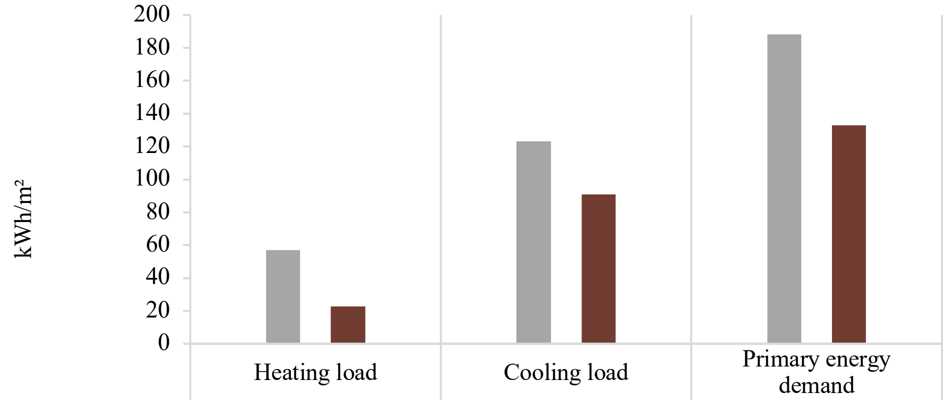
Table 2. DesignBuilder programına girilen veriler ve yapının modeli.

Parameters	Situation
Number of Occupants	2 people
Temperature range	18 °C – 24 °C
Mechanical system	Underfloor heating+split air conditioning
Heating months	November-March
Cooling months	April-October
Heating hours	5 gün / 08:00-17:30
Cooling hours	5 gün / 10:00-17:30
Spaces Subject to Heating and Cooling	Secretary's office, office, lobby, kitchen
Model	

3. RESULTS AND DISCUSSION

In the study, energy consumption values were examined in relation to changes in the wall material of the neighborhood office building located in Izmir province, Turkey. When concrete blocks were used as the wall material in the building, the heating load was determined to be 56.79 kWh/m², the cooling load was 123.19 kWh/m², and the primary energy demand, including heating, cooling, and lighting energy expenses, was found to be 188.21 kWh/m².

On the other hand, when Alker was used as the wall material in the building, the heating load decreased by 60.08% to 22.67 kWh/m², the cooling load decreased by 26.19% to 90.92 kWh/m², and the primary energy demand decreased by 29.30% to 133.06 kWh/m². The energy performance graph obtained based on the use of concrete blocks and Alker as wall materials in the building is shown in Fig. 2.



	Heating load	Cooling load	Primary energy demand
Concrete Block	56,79	123,19	188,21
Alker	22,67	90,92	133,06

Figure 2. The energy performance graph of the building to be constructed using concrete blocks and Alker materials.

The reason for the poorer energy performance of concrete block material can primarily be attributed to its high thermal conductivity values. Another contributing factor is Alker's high specific heat value and the use of greater thermal mass due to its wall thickness, which enhances energy performance. Additionally, it should not be overlooked that these values are achieved with an uninsulated wall envelope.

In regions characterized by hot climates, thermal mass can significantly contribute to thermal comfort. Therefore, building materials with high specific heat and mass are highlighted as wall filling materials in settlements located in hot climates. Alker, with its high specific heat values, can also be considered a suitable building material for such settlements. Being produced from natural materials and, consequently, having a low environmental impact will contribute to both the energy performance and the reduction of environmental effects of the building.

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Review of Utilization of Biopolymer in Earthen Construction Materials

Bugse Ilman[1], Ayşe Pekrioglu Balkis [2]
[1,2] Cyprus International University, North Cyprus
[1]bilman@ciu.edu.tr
[2]apekrioglu@ciu.edu.tr

ABSTRACT

Interest in earth materials has gained popularity since 1970, as it is intended to provide the growing need for housing with low-cost materials. In recent years, earthen constructions have gained popularity with green credentials. With its characteristically low carbon footprint, usually, earthen constructions are considered sustainable forms of construction. Fine fraction, sand, and gravel are needed to obtain earthen construction materials. Earthen construction materials are of great importance in terms of having natural and sustainable properties. In addition, Gallipoli D. et al (2017) and Lax C. (2010) have proven that earthen constructions have become remarkable in modern construction due to their sustainability, low energy, and recycling characteristics. The main purpose of improving the earthen construction material is to provide them not affected by disasters such as heavy loading situations, earthquakes, or landslides. Bio-stabilization of earthen construction material is defined as the products or biological processes used to improve earthen construction material properties. Bio-stabilization techniques (e.g. biopolymer stabilization) are recommended as a potential alternative to chemical stabilizers. Polymers synthesized by biological processes are known as biopolymers. Earthen constructions are usually stabilized with stabilizers such as cement; biopolymers may be the green options available. Though bio-stabilization techniques have been used historically for improving the strength and durability performance of earthen materials, the use of biopolymers for stabilization in modern earthen construction is a novel idea. In this research, the utilization of biopolymers in stabilization for earthen construction materials is being reviewed and its advantages were discussed by considering the literature research that have been conducted up to the present day.

Keywords: Bio-stabilization, biopolymer, chitosan, earthen construction material stabilization, guar gum, xanthan gum

- Theme: Traditional materials and current research

1. INTRODUCTION

Today, increasing air pollution, energy shortages and concomitant global warming make research into renewable energy sources in power generation more and more important. In particular, with respect to solar energy, heating technology, the increasing use of solar cells in roofs and facades of buildings in harmony with architecture, renewable building materials, low-cost energy consumption, and materials that do not harm nature through their use. The trend toward buildings continues with proper heat, sound, water, and steam insulation. Clay building materials, which are collected from the natural world and molded and used manually, continue to maintain their position as the only building materials that do not leave waste in the natural world even after they have completed their role. However, today only a very limited number of new civil engineering materials are used. In recent years, the technological developments that have hit every country in the world have affected all sectors, while also causing environmental pollution that nature can no longer repair at high-tech costs. Practitioners and designers who prioritize environmental protection are therefore looking for materials that consume no energy or require little energy to manufacture and that provide comfortable conditions with minimal energy input during use. [1-8].

In recent years, two distinct trends have been found prevailing in the choice of materials in the construction sector around the world. The production of modern building materials with high-tech products plays a major role in the development of environmental problems. The negative environmental impact of these materials continues not only during the production stage but also during their use in buildings and consumption. In this case, measures to prevent environmental pollution are indispensable in order to leave a livable environment for future generations. While traditional materials are being abandoned and the use of modern materials is widespread, the impact on the environment and human health should not be ignored. Traditional construction materials are environmentally friendly and ecological building materials that consume the least amount of energy from the production stage to the usage and consumption stages.

It is known that soil, which is made from soil, is one of the materials that humans have used for housing since ancient times. Due to the nature of the earth, it is a preferred material because it is light and ubiquitous. Aside from comparing structures made from soil to structures made from other materials, this is in many ways more useful.

The use of land as a building material will contribute to the prevention of environmental pollution by allowing energy savings. The earth-building system, which is found only in the countryside, should not be considered a rudimentary system used for regions and places where modern materials are not available. On the contrary, this is the type of construction that meets the highest comfort requirements, greatly reducing energy and costs. In developed countries, for reasons such as energy shortage, environmental pollution is increasing; In developing countries, the problem is just to consider that a solution can be provided in this way, which tends to build the earth all over the world. Although earthen construction has a very ancient past, it cannot meet all today's requirements. For this reason, research and investigation to improve the earth's structure continue [9-12].

2. STABILIZATION OF EARTHEN CONSTRUCTION MATERIALS

The stability of earthworks can be described as a change. Stabilization engineering is applied to improve the technical characteristics and performance of earthworks. Stability includes various factors. At the beginning of the elements, improving the building properties with earth is used to increase the performance of the technique. Stabilizing earth-building materials involves adding cement or other chemicals to improve building properties. Land construction, like other types of structures, has some objectionable aspects. These are either eliminated altogether by taking the necessary measures and respecting the pre-determined conditions, or at least they can be minimized.

Stabilization should be done if it aims to produce a higher quality earthen construction than a normal earthen construction. Improved earthen construction is more durable, less sensitive to water and moisture, does not create dirt, is more susceptible to mold and drying, and does not crack on drying or very little. The most important matter of the earth is two repulsive aspects: Its compressive strength is low and its sensitivity to moisture is high. Cement, lime, gypsum, and some other additives are added to the soil to obtain a better earthen construction material i.e. better pressure resistance, less sensitivity to moisture, and non-dispersible in water, smooth surface, and dust-free earthen construction material. Moreover, the addition of some fibrous additives such as rice straw; at the same time increasing the flexural strength of earthen structures, which can rapidly reduce the problem of shrinkage that can occur before drying [13-22].

Polymers developed by living organisms are called biopolymers. The existence of biopolymers in the world dates back billions of years. Furthermore, biopolymers play an active and important role in the environment. For example, biopolymers contribute to energy storage. Currently, it is observed that biopolymers are used in the stabilization of earth-building materials. Biopolymers are preferred because they are green alternatives that can be used in place of additives such as cement. The use of cement, lime, and synthetic products that increase greenhouse gas emissions due to global warming has been a major concern in recent years. Cement is one of the sources of CO_2 emissions, contributing about 8% of CO_2 emissions. A 23.8% increase was recorded in cement production from 2010 to 2018 [23-25].

To reduce the use of cement, researchers have begun using inexpensive and environmentally friendly biopolymers to stabilize the earth's building material. With the current level of civilization, all kinds of utilities, the simplest, cheapest, and energy-saving, it is believed that earthen building materials, which can bring higher quality, will make an important contribution. emphasis on construction, especially in rural areas. In this study, the use of biopolymers in stabilizing earth-building materials is being investigated and its benefits are discussed taking into account the literature studies that have been conducted up to date.

3. TYPES OF BIOPOLYMERS USED IN EARTHEN CONSTRUCTION MATERIALS STABILIZATION

Detailed information on biopolymers used in the stabilization of earth-building materials is given in this section. There are three main classes of biopolymers classified according to the monomer units used and the structure of the biopolymer formed: vegetable origin, animal origin, and biopolymers produced by microorganisms. When considering the studies done to date, biopolymers used when stabilizing earth-building materials can be listed as chitosan, carrageenan, guar gum and xanthan gum. The biopolymers used in the improvement of earth-building materials are given in Table 1 [26].

Table 1: The biopolymers used in earthen construction materials improvement.

Plant-based biopolymers	Animal-based biopolymers	Microorganism-based biopolymers
Guar Gum	Chitosan	Xanthan Gum
Carrageenan	Chitin	

Carrageenan is a complex member of the polysaccharide family. It is a linear polymer and consists of about 25,000 end-to-end galactose derivatives, clear but extremely regular, it is formed in such a way that it is aligned. The 23 basic repeats in carrageenan are galactose Figure 1a. The reason the carrageenans are different is that they contain 3,6 anhydrous-D-galactose Figure 1b. It is the number, number, and position of the sulfate ester groups. Accordingly, the chemical structure and formula of carrageenan can be represented as follows.

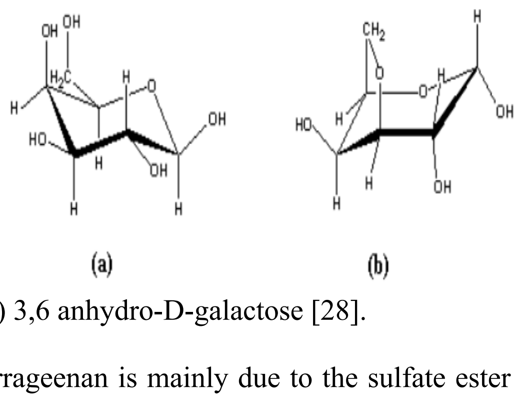

Figure 1. (a) D-galactose (b) 3,6 anhydro-D-galactose [28].

The chemical activity of carrageenan is mainly due to the sulfate ester groups they contain which have a strong ionic structure. Carrageenan is commonly used as sodium, calcium, potassium salts, or a mixture of them. The function of carrageenan in many applications stems primarily from its rheological properties. Carrageenan forms extremely waxy aqueous solutions because it is a linear, water-soluble polymer. This is mainly due to their unbranched linear giant molecular structure and their polyelectrolyte nature. The mutual repulsion of a large number of negatively charged sulfate ester groups around the polymer chain causes the molecule to remain very tense, while water remains around them due to their hydrophilic nature, forming a shell. encapsulate its molecules. Both of these effects contribute to flow resistance. Carrageenans exhibit hydrophilic properties, i.e. they are soluble in water and insoluble in organic solvents. Their solubility varies depending on the sulfate group they contain, which is more hydrophilic, and the amount of 3,6-anhydrous-galactose, the less hydrophilic group [27-30].

Guar gum is a natural non-ionic polysaccharide composed of mannase and galactose. This polysaccharide is a chain of 3-D-mannopyranose units joined together by 3-D-galactopyranose units (1-4) linked to the mannose framework by a glycosidic bond (1-6). Guar gum is made by randomly replacing the poly-mannose sequence with galactose units in a ratio of 1.8 to 1.0 mannose galactose. Due to its basic structural properties, guar gum is used in various industrial fields and is a biopolymer that provides extremely viscous solutions at low concentrations. This biopolymer, which is non-toxic and biodegradable, is easily available economically or can be produced in a laboratory. Figure 2 shows the chemical structure of guar gum [31-33].

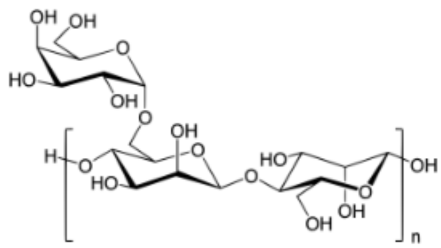

Figure 2. The chemical structure of guar gum [32].

Chitin and chitosan are polysaccharides found in marine organisms. After treating crustacean waste (such as shrimp, crab, and squid) (from the food industry) with HCl and NaOH, chitin was obtained, chitosan was also obtained by deacetylation of chitin (hot, with 40-50% NOH). Chitosan makes a very good film; It can be shot in fiber. The tensile strength of chitin and chitosan is between 122.62 and 32.68 MPa. When annealed at 120°C, it hardens with the formation of intermolecular hydrogen bonds and turns into a material that is three times stronger (~235 MPa). Chitin is the most abundant natural polysaccharide after cellulose; It is a polymer of b-(1,4)-N-acetyl-D glucosamine. Although structurally similar to cellulose, there are acetamide groups at the C-2 position. Chitosan, polymer b-(1,4)-D glucosamine is a biopolymer used in the fabrication of novel materials with special functions; it has a structural form that allows for chemical and mechanical transformation. It is a polymer used especially in biomedical and pharmaceutical applications [34].

Chitosan consists of linear nitrogenous polysaccharides; it is a natural homogenizer, biodegradable, biocompatible, and non-toxic. It is produced commercially by deacetylation of chitin. Chitin acts as a copolymer due to reasons such as variability and incomplete deacetylation; because the number of repeat units of N-acetyl glucosamine and N-glucosamine is different. Figure 3 shows the chemical structure of chitosan [34].

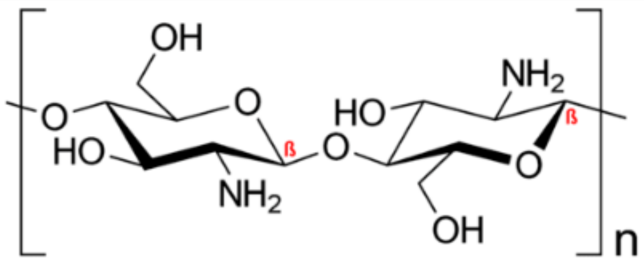

Figure 3. The chemical structure of chitosan [34].

Xanthan gum is a polysaccharide obtained from glucose or sucrose by fermentation with Xanthomonas campestris bacteria. Xanthan gum, a microbiological heteropolysaccharide, consists mainly of a main polymer skeleton containing 1, 4-bonded β-D-glucose units, as well as cellulose. In the side chains connected to this skeleton, there is a Decarbonized trisaccharide consisting of one D-glucuronic acid residue between two D-mannose residues. The polymer also contains O-acetyl groups at a rate of 4.7% and purivic acid at a rate of 3.0-3.5%. The properties and benefits of xanthan gamma are that it forms visibly clear solutions even at high concentrations, dissolves in both hot and cold water, gives high viscosity to solutions even at low polysaccharide concentrations, it is soluble and stable in both acidic and alkaline solutions it can be counted in the form. Figure 4 shows the chemical structure of xanthan gum [35-36].

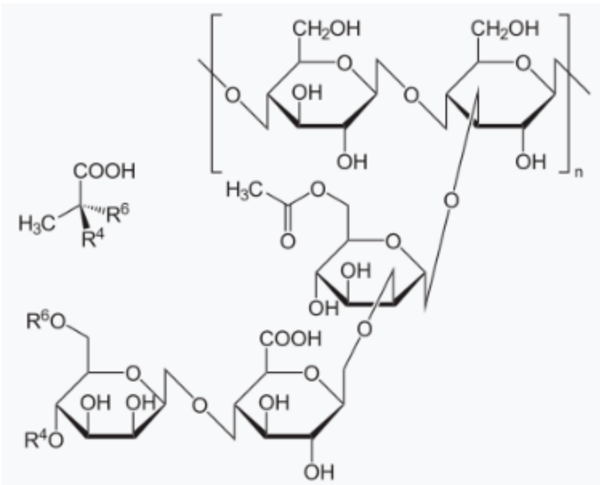

Figure 4. The chemical structure of xanthan gum [35].

4. GEOTECHNICAL PROPERTIES OF BIOPOLYMER STABILIZED EARTHEN CONSTRUCTION MATERIALS

Based on the literature review, important aspects of the stabilization of earth-building materials with biopolymers are summarized here. The use of biopolymers for stabilization is a new ideology for modern earth building. Typically, biopolymers have been used as green substitutes to replace chemical stabilizers to improve soil mechanical properties.

For example, low-plasticity clay, used to produce earthen building materials with up to 3.0% chitosan biopolymer, was used by Aguilar et al. (2016). It was found that 3.0% chitosan was sufficient to improve the mechanical properties and durability of earthen building materials. In addition, uniaxial compression test results yield a coefficient of variation of 12.4% and 16% for stable and unstable biopolymer samples, respectively. In addition, the results of the split tests give coefficients of variation between 23.1 and 24.2%. In addition, coefficients of variation of 24 to 51% were reported for the three-point bend tests, slightly higher than the 19% obtained from the unstable samples. Figure 5 summarizes the results of the study's mechanical behavior tests. Durability test results show that the chitosan coating protects the sample from water therefore they are more durable than unstable samples. Figures 6 and 7 summarize the durability test results obtained from the study [37].

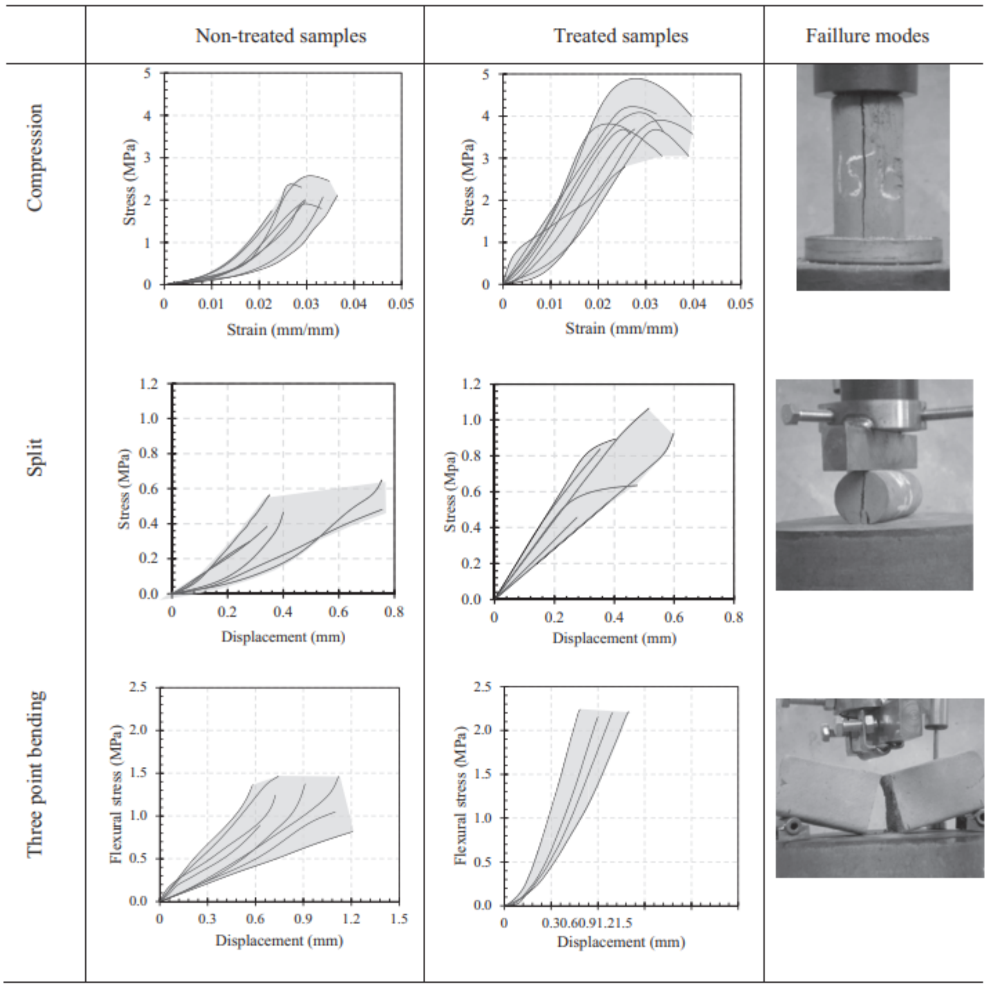

Figure 5. Summary of the mechanical tests results for unstabilized and biopolymer stabilized earthen construction materials [37].

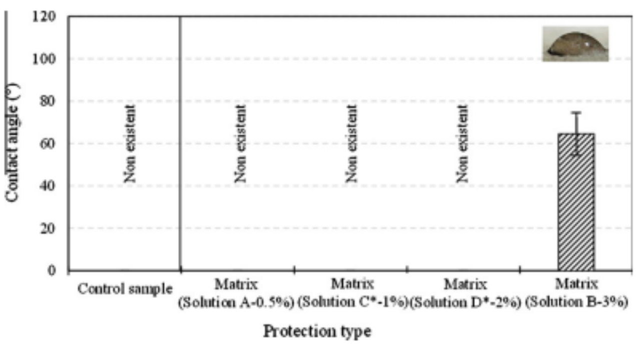

Figure 6. Contact angle tests results for unstabilized and biopolymer stabilized earthen construction materials [37].

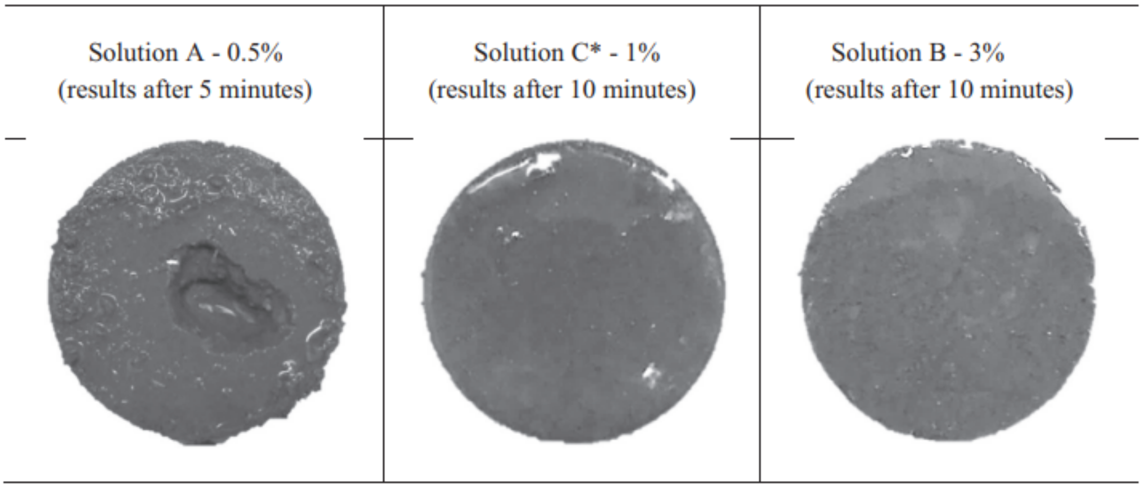

Figure 7. Drip erosion test results for biopolymer stabilized earthen construction materials [37].

Soil with the same properties was used by Aguilar et al (2016) and Nakamutsu et al (2017) by using carrageenan biopolymer. It was concluded that the strength and durability properties of the samples stabilized with 2.0% carrageenan were significantly increased compared to the control samples. Durability test results showed that the carrageenan coating protects the sample from water since erosion starts near the edge, where water can penetrate the unprotected sample. When the mechanical test result was checked, the average strength increment was 85%, 33% and 52% for the compression, split, and bending tests, respectively in comparison to the strength registered in the unstabilized samples. Figure 8 summarized the mechanical test results of the study [38].

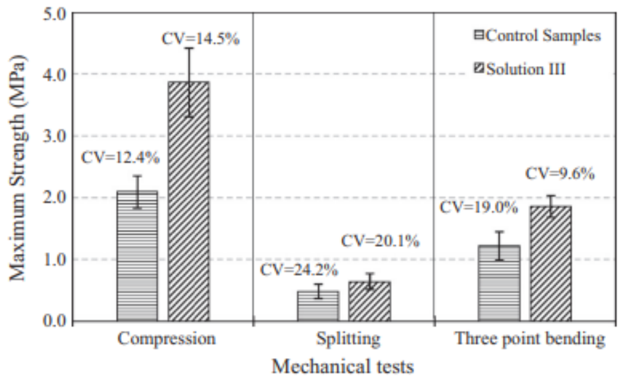

Figure 8. Summary of the mechanical test results [38].

S Muguda et al. (2019) investigated the use of guar gum and xanthan gum biopolymers as stabilizers in earthen construction materials. One of the advantages of guar gum and xanthan gum biopolymers is that they have embodied energy. At 28 days, the strength of the 2% xanthan gum-treated soil exceeds the cement-treated soil by 38%. As a result of the research, it has been proven that both biopolymers have mechanical, durability, and hygroscopic behavior characteristics acceptable for earthen construction materials. When the mechanical test results were analyzed biopolymer stabilized samples approximately 30% higher after 7 days and 35% after 28 days. Figure 9 explains the stress-strain behavior in unconfined compressive strength.

Durability tests were as low as 2.0 mm for biopolymer-stabilized earthen construction materials, while for unstabilized samples it was in the range of 8.0–10.0 mm. When the hygroscopic behavior test results were analyzed, the moisture buffering values for the specimens tested in this study varied from 0.55 to 1.05 g/m^2 %RH. These values most of the samples tested can be classified in the moderate category [39-40].

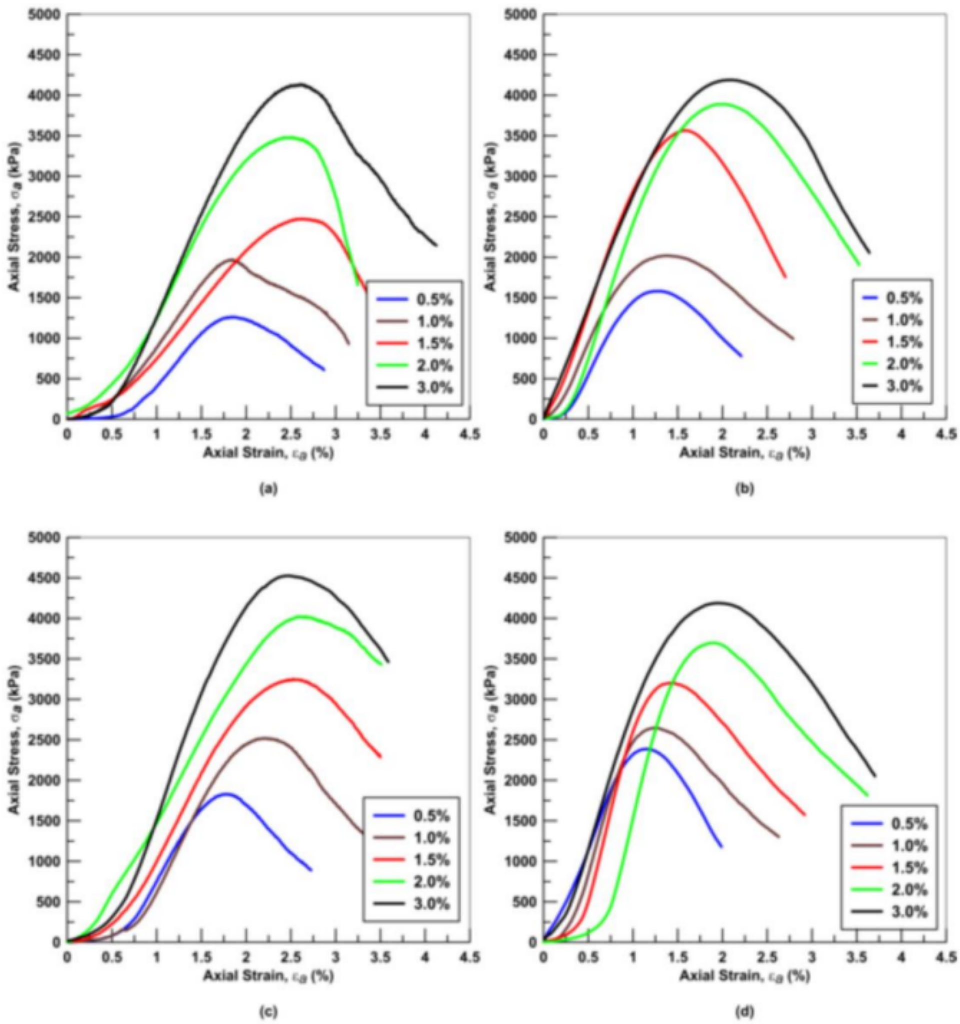

Figure 9. Stress-strain behaviour in unconfined compressive strength [39].

Unfortunately, when reviewing the research in the literature, it can be seen that there are few sources associated with the use of biopolymers when stabilizing earth-building materials. For this reason, this study was prepared to highlight the importance of using biopolymers when stabilizing earth-building materials.

In addition, it has been proven through research that earthen construction materials with biopolymer stabilization have better mechanical and durability engineering properties than earthen construction materials without stabilization and stabilized with additives such as cement. It has been proven through research that there are green alternatives that can be used during the stabilization of earthen construction materials instead of biopolymers, cement, and similar additives.

5. CONCLUSIONS

In the study of earthen building materials, the mechanical properties and durability have been improved so far by the addition of biopolymers, which can be summarized as follows: low plasticity clay, used to produce earthen building materials with up to 3.0% chitosan biopolymer, used by Aguilar et al. (2016) tried to improve it. It was found that 3.0% chitosan was sufficient to improve the mechanical properties and durability of earthen building materials. A soil with the same soil properties was used by Aguilar et al (2016) and Nakamutsu et al (2017). But this time the biopolymer carrageenan was used and the study concluded that the strength and durability properties of the samples stabilized with 2.0-carrageenan were significantly increased. S Muguda et al. (2019) investigated the use of biopolymers guar gum and xanthan gum as stabilizers. As a result of the study, both biopolymers have been shown to have acceptable mechanical properties, strength, and hygroscopicity for earth-building materials.

Especially in improving earth-building materials, biopolymers play an important role. In this study, the effects and benefits of biopolymers in improving earth-building materials were examined. In addition, biopolymers used in stabilizing earth-building materials were investigated in this study. Furthermore, the use of biopolymers in the stabilization of earth-building materials has been considered and its benefits discussed in the review of literature by researchers that have conducted testing up to date.

Adding a biopolymer to the soil is one of the best solutions for improving earth-building materials. Biopolymers are green substitutes that can be used in place of cement and calcium-containing binders in improving earth-building materials. Biodegradability of stabilized earthen need to be studied and if needed improved.

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The Earth as the Raw Material: Can the Earthen Buildings Be an Alternative Solution to The Climate Change And Energy Crises?

Nurettin Ekinci, Veysi Altuntaş, Evrim Solhan

KNC Mimarlık, İstanbul/Türkiye
ekincinurettin@gmail.com,
veysialtintas@gmail.com,
solhan1evrim@gmail.com

ABSTRACT

Problems such as climate crisis, ecological destruction, increasing population, urbanization and sustainable use of natural resources cause a global crisis. In particular, the concrete-based construction sector, which is not long-lasting, is one of the reasons that triggers these crises. Considering that buildings are responsible for approximately 40% of global energy consumption, 25% of water consumption and one-third of carbon emissions, the importance of reducing the environmental impact of buildings becomes more evident. In this context, the importance of reusing the earth, which is a forgotten material, as a building material becomes vital. Earthen structures have superior advantages over reinforced concrete, steel etc. structures in terms of economy, energy saving, sustainability, health and comfortability. In the studies, it is stated that while the carbon emission of earthen structures is close to zero, it is a hundred times higher in a reinforced concrete structure. The thermal conductivity coefficient of earthen structures is 0.6-0.9 W/mk, providing a high level of energy savings, while the thermal conductivity coefficient of reinforced concrete structures reaches up to 0.8-2.5 W/mk [1]. It has been determined that the indoor temperature in earthen structures is 5 degrees warmer than the outside temperature in the winter seasons, and the indoor temperature in the summer season is 7 degrees cooler than the outside temperature. Again, in relation to the carbon footprint, the process-related embedded energy of earthen structures is 15 giga joules, while it goes up to 210 giga joules for reinforced concrete structures [2]. Therefore, it stands before us as an important nature-based alternative to the environmental, economic, ecological and energy crises we are in. The aim of this study is to evaluate the developing importance of earthen structures in the context of climate crisis and energy crisis, to mention the role of earthen structures in the creation of ecological and healthy cities, to make an evaluation through the life cycle and systemic thinking approach through the 1000-unit earthen container project developed for earthquake victims.

Keywords: Earthen building, earthen structures, earthen architecture, sustainability, earthen structure and energy efficiency, ecological planning.

1. INTRODUCTION

One of the oldest and most important building materials used by humanity has been earth. Earth as a basic building material used throughout the ages in Anatolia, as well as all over the world.

With the industrial era, the use of new materials such as concrete and steel has brought new conveniences to the construction sector, and the importance of traditional building materials such as earthen building material has decreased significantly, especially in urban life all over the world. Since the impact of the energy crisis that emerged in 1970, the importance of traditional building materials such as earthen building material has increased, and various studies and applications related to earthen building material have been carried out in many countries, and opportunities for benefiting from the material continue to be developed [3].

Earth-based materials are still widely used in the countries around the Nile, Mesopotamia, North Africa, Morocco, Iran, Iraq, Mali, Afghanistan, Yemen, China, India, Spain, Sweden, England, Denmark, Germany, France, Portugal, Mexico and South America as in the past [4].

In scientific research conducted on earthen structures, it is known that about a third of the world's population still lives in earthen structures [5].

Since the 21st century is the age of crises, the search for alternative and sustainable-oriented solutions is starting. The main ones of these crises are the climate crisis, ecological destruction, destruction of ecosystems, increasing population, urbanization rate and non-sustainable use of natural resources. In particular, the intensive use of raw materials and energy in the construction sector is one of the most important problems that trigger these crises.

The construction sector is responsible for about 50% of the waste produced in EU countries and 40% of CO2 emissions. Natural waste materials such as earthen and stone make up about 75% of the wastes extracted for construction, which are considered earth excavation waste and produced [6]. However, the earthen, which is now considered as waste today, has been used by people for housing and shelter construction since the Neolithic era. Therefore, the use of excavation soil resulting from construction activities, that is earth, will significantly reduce this wastefulness.

The world is engaged in joint initiatives to create solutions to these crises that are occurring, to create action programs and to protect the planet against these crises. In particular, common goals and areas of action have been defined within the framework of the Paris Climate Agreement and the UN Sustainable Development Goals in order to reduce the harmful effects of the climate crisis and ensure sustainable development.

UN Turkey and its partners are working within the framework of the 17 Sustainable Development Goals set for the solution of the main problems facing the world and are creating solution areas at the national and local levels to implement these goals by 2030. Especially, within the scope of the 11th goal "Sustainable Cities and Communities", the sub-goals of accessible public spaces for everyone, healthy and comfortable housing areas have been defined. In the realization of these goals, the creation of living spaces from earthen, which is a highly economical, ecological, comfortable and healthy material, constitutes an important area of opportunity.

Within the framework of the Paris Climate Agreement, the zero-carbon development approach has become a priority rather than the low-carbon development approach. In this agreement, increasing environmental problems, ecological destruction and the climate crisis are defined as common problems of humanity, and countries are trying to develop "decarbonization" policies in all areas of life in order for all countries to fulfill these commitments by 2050.

When the trends and dynamics adopted against the ecological, economic and environmental crises occurring worldwide are taken into account, it is seen that the importance of ecological structures for a sustainable and livable structural environment increases.

Earth structures have a tremendous potential in terms of low-energy housing, energy efficiency, thermal comfort, ecological architecture, climate sensitivity, affordability and recyclability. Earthen construction offers many advantages, including the opportunity to use locally available materials, low environmental impact, and the ability to be healthy from the nature of the material. For this reason, earthen structures, which are the oldest type of building used in local architecture to be developed today. It is also the right resource for sustainable architecture.

When the concept of sustainability, which is becoming increasingly important today, is examined, it comes to the fore with the energy that a material spends throughout its entire life cycle. In this context, less energy is spent when producing a structure with an earthen building material than with other materials. When we look at the formation of the material, the earthen obtained from nature can be returned to nature again, since it is a completely natural and local material, and the transportation problem is eliminated. Since earthen is also used for the maintenance of the material, which has a lower cost than other materials during the production and use stages, the need for additional costs and labor necessities. It is observed that the earthen building material has a balancing behavior within the limits of comfort and health in terms of moisture and has a high resistance in terms of thermal permeability. Taking into account the climatic characteristics, it can be said that the inclusion of this material in the design also plays an important role in preventing heat losses. Due to its weight, mass and structure, its sound insulation performance is evaluated as high.

Alker (gypsum mud brick) construction technology, developed by ITU to give the highest performance with a mixture of earthen, lime and gypsum, constitutes an important window of opportunity for earthen structures. Alker has higher pressure and tensile strength and lower sensitivity to water than traditional adobe structures. Due to the fact that it takes shape very quickly, the shrinkage effect (crack formation when dry) is low and the impact resistance is higher. When the compression method is used, its production is very fast and does not require much maintenance during use.

2. WHY EARTH BUILDING?

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a. Development Earthen Structures in the World

Today, while conducting experimental studies on the areas of use of earthenware building materials, various conferences and workshops are organized related to the increasing use of the material. Together with the studies carried out in many countries of the world, it is aimed to expand the use area of earthen structure and improve the technical characteristics of the material by establishing international connections with different institutions and individuals.

Important studies are being carried out in the world aimed at developing earthen structures and improving their forgotten materials and workmanship. One of the most important of these projects is the "Building with EARTH" project implemented in China, which received UN-Habitat's World Habitat Awards award in 2019. The "Building with EARTH" project, which was implemented in Gansu, China in 2011, started by building 32 houses from earthen in Macha village and has spread to 23 cities as of 2020, and as of 2020, houses have been built from earthen for 1636 villagers [6].

The main objective of the project is to support and develop earthen construction techniques in rural poor communities as cheaper, environmentally more sustainable and earthquake resistant alternatives to existing construction methods. The project has been successfully implemented and at the end of the project, very important results have been observed from a social, economic and environmental point of view. At the end of the project, it was found that earthen houses remained 5 degrees warmer during the winter than reinforced concrete structures. This also provides a very significant energy saving. In the same way, it has been measured that earthen dwellings are 7 degrees cooler than reinforced concrete structures during the summer [6].

Due to these healthy and comfortable conditions provided by the elderly, women and children, it has been found that they spend more time at home and are better protected from diseases such as cardiovascular diseases. Together with the fact that local people learned construction techniques, this situation created employment. An income increase of more than 80% has occurred in their annual income, and it has been found that the migration of the rural population to the city has been prevented due to work [6].

Therefore, the economic resilience of the local has been increased and less waste has been created by supplying the material directly from the local, a significant reduction in carbon emissions has been achieved and, most importantly, the economic benefit created has been ensured to remain local [6].

Intensive urbanization, increasingly decreasing living and breathing spaces, factors such as the climate crisis and global warming, epidemics and seismicity are pushing people to live in more comfortable housing today.

In order to meet this need, developed countries in the world have issued earthen structure standards and regulations in order to promote earthen structures and improve construction techniques and regulate their legal infrastructure. These prominent countries are Germany, France, New Zealand, England, America, Spain, Italy, Australia, Brazil and India. In addition, similar standards and regulations have been established in many countries of Africa.

b. Development Earthen Structures in Turkey

As in the world, various studies have been carried out and continue to be carried out in Turkey in order to develop earthen building material and to spread its use. But in 2011, while there were a number of legal standards for adobe structures, they were repealed. Due to the fact that some criteria contained in the current earthquake regulation restrict the production of earthen structures, it is observed that earthen structure production remains at a certain level, despite being suitable for the climate and geography of Turkey.

In order to popularize its applications in Turkey, first of all, it is necessary to regulate and develop the regulations and standards in such a way as to cover earthen structure production techniques other than adobe.

NKNC Architecture and Modern Earth Structures Platform has been carrying out studies and producing projects on earth structures for 12 years. In this context, our work on the design and implementation of structures such as housing, education, cultural facilities, educational, social reinforcement spaces, library, nursery, meeting hall by using the material in order to spread the techniques and technologies related to earthen structures, which tend to develop rapidly in the world, in Turkey, continues [Figure 1].

Figure 1: Earth Building Applications by NKNC Architecture Office

3. TEMPORARY SHELTER PRODUCED IN TURKEY USING EARTH MATERIAL

After the February 6, 2023, earthquakes that affected our 11 provinces, some studies were carried out by the Modern Toprak Construction Group and NKNC Architecture in order to create alternative and sustainable solutions to temporary housing.

It was decided to produce a temporary housing structure as an alternative to the container structure. In this study, ALKER (Gypsum Adobe) building material, which is an improved adobe material that is also used in other productions and greatly reduces the disadvantages of traditional adobe building material, was produced using compression technique [Figure 2].

Figure 2: Compression technique

a. Aim of Project

When comparing the temporary housing structure produced with container and alker building material, it has been seen that alker structure has superior advantages compared to container in terms of comfort, health and thermal conductivity along with costs.

It is difficult to stay in a container produced with a light steel system in climatic regions that are hot in summer, and the internal temperature in an earth structure that does not use any active air conditioning system can remain 7 degrees cooler in summer and 5 degrees warmer in winter compared to the external temperature. In addition, the breathing structure and low thermal conductivity of the earth structure from the material of the structure allow it to create more comfortable spaces.

b. Process of Project

Due to the fact that it allows fast production and healthy construction, negotiations were held with different institutions to implement it within the scope of the project prepared for the development of living units from the earth.

In relation to this issue, a call was made to the institutions and organizations that carry out direct and indirect studies in the earthquake zone by publishing the "Temporary Living Unit Production Manual in the Earthquake Zone" study on social media [Figure 3].

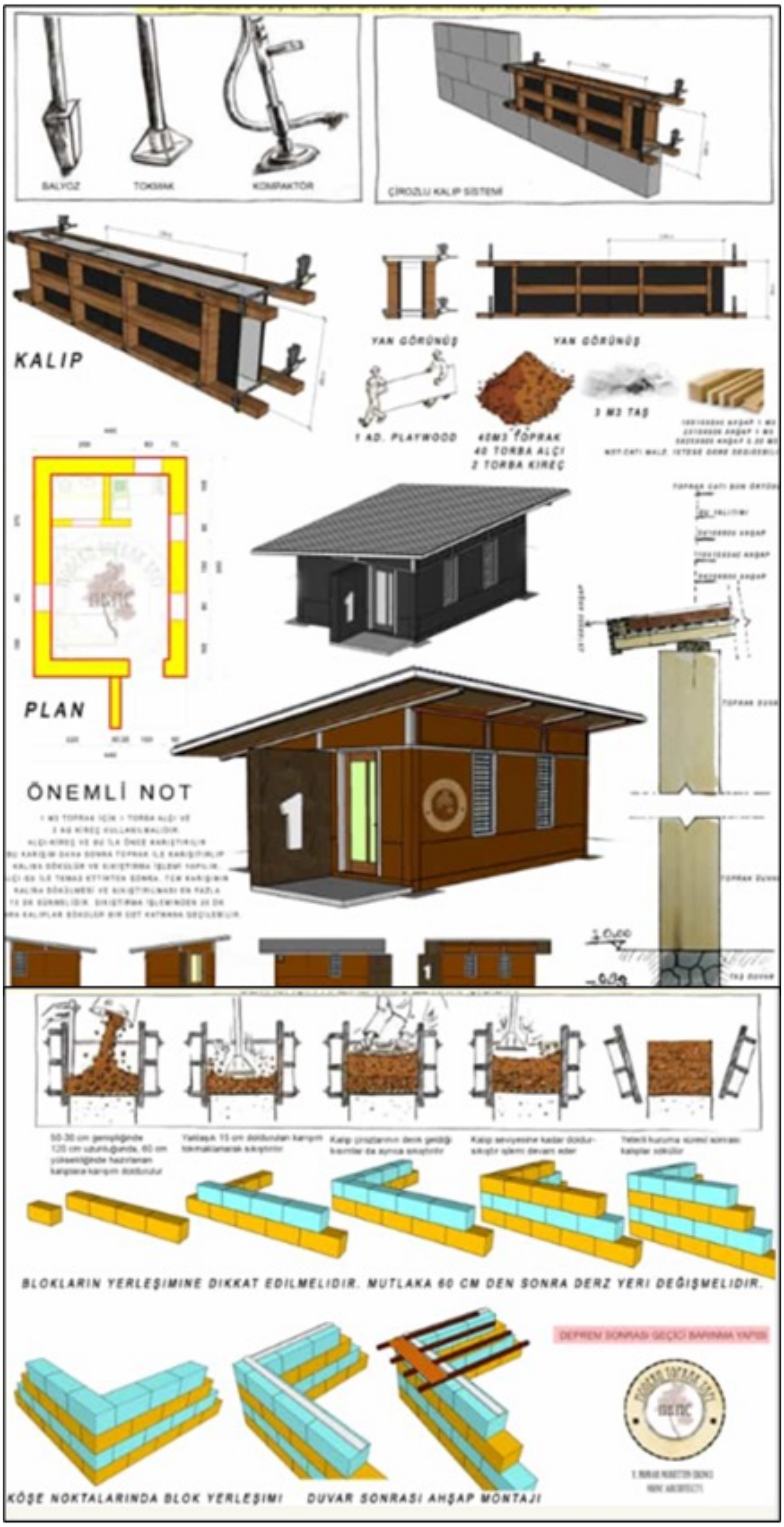

Figure 3: Handbook prepared by NKNC Architecture for temporary shelter areas to be produced from earth.

In the prepared manual, the construction process is extremely easy and organized in such a simple way that everyone can do it with their own means.

After the application manual was published, the first prototype study, which will be applied in Tuzla, Istanbul, was started [Figure 4].

Figure 4: Temporary shelter plan and 4-module system produced from earth

In order to respond to the need for housing in a short time and to be able to compare with the cost of container construction, it was decided to produce in the container sizes currently used.

Due to cost reduction and a number of social and physical needs, 4 pieces module system has been developed for different user groups [Figure 5].

Figure 5: Temporary shelter plan produced from earth, 4-module system and the final version of the temporary shelter

In the preliminary study, it was determined that the total construction cost of a unit is almost half of the container construction cost. In addition, it has been seen that labor and equipment costs can be reduced with some interventions.

It has been calculated that if sufficient equipment is provided, 40 units can be completed per day with 10 teams of 10 people for each unit.

4. CONCLUSION AND SUGGESTIONS

As a result, it is becoming important to use earth material to take action at the local level for the social, economic and ecological crises occurring in the world. There is no doubt that in the future the earth will be the material of the future. Since today, all actors at the national and local levels have important tasks to make our cities and living spaces more ecological, livable and healthy.

The importance of earthen structures in response to the ecological crises the world is facing is increasing. Significant developments are beginning to occur in earthen structures in Turkey. Its use will increase further as alternative techniques for earthen structures develop. The state, private sector and academia have important duties in this regard. In order to achieve the goals determined within the framework of global agreements, these actors should take initiatives to develop earthen structures and this will contribute to the creation of healthy cities.

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Paper Number: 59

Historical Timber and Earthen Constructions in Norway Vapour Permeable Surfaces –Restoration Challenges

Hauke Haupts
Trøndelag fylkeskommune, regional cultural Adminsitrta authority, N-7735 Steinkjer, Fylkets hus, Postboks 25 60
Postboks 2560 7735 Steinkjer
hauha@trondelagfylke.no
haupts27@msn.com

ABSTRACT

Weather protection and thermal insulation are major challenges in the restoration of historic timber and earthen structures in the Nordic coastal climate. Vapour impermeable surfaces and thermal insulation in historic timber and earthen buildings have increasingly been causing problems in Norway since the early 1970s. A disturbed water cycle and faulty ventilation have led to mould and wood rot. Healthy buildings have become sick: Sick Building Syndrome (SBS) has spread in Norway's humid coastal climate. The Norwegian Passive House Standard poses the danger that these risks will now increase.

Earthen surfaces, earthen infill and earthen mortars in Norwegian timber constructions have been proven to provide heat retention and moisture stabilisation over centuries of Nordic tradition. Their optimal function depends on the type of heat source, the layout of the building in relation to the local climate, the sun and the heat radiation properties of the building components.

Water, in its continuously changing physical states, serves as a natural regulator and plays a central role in the thermodynamics of our historical architectural heritage. In the future, more attention must be paid to the building physics of the natural water cycle when modernising historical timber and earthen buildings.

Modern buildings increasingly depend on technical improvements such as vapour barrier layers, ventilation technology, non-vapour-permeable coatings and heat pumps to regulate their interior climate. The consequence of these technical changes is that the physical system of the enclosure functions like a machine instead of a breathing organism, subject to the principles of building biology.

Keywords: Material properties, Building physics, Restoration practice

1. INTRODUCTION

This paper describes the energy transfer in all buildings that results from solar irradiation in our atmosphere, taking into account the principles of hydrometeorology.

The paper looks at the role of fundamental laws and natural principles in building physics and describes the conditions necessary for a constructive energy interaction between heat transfer by thermal radiation and the water aggregate cycle in enclosed buildings. The paper argues that these natural processes are beneficial for the interior climate of buildings, in turn reducing the need for mechanical cooling and ventilation and lowering energy consumption and costs. The properties of constructions and chemical structures that enable these natural energy cycles to function properly in buildings are presented and discussed.

In summary, the paper describes how traditional earthen structures with vapour-permeable surfaces are uniquely placed concerning building physics. Most importantly, through the way that water is bound by clay minerals, to support natural heat radiation behaviour and the changing cycle of water aggregates.

The risk of "negative water" should not be underestimated when restoring historical timber and earthen buildings, especially in conjunction with thermal upgrading measures. "Negative water" denotes the undesirable accumulation of water in any physical state at the wrong place at the wrong time, regardless of the type of building. Water penetration may be a product of insufficient or faulty sealing, or a lack of capillary-breaking layers in the foundation, especially in earthen buildings. Similarly, an "over- or underload" of indoor humidity usually produces the wrong energetic effect and can have a negative health impact. For positive energetic water, one needs a largely self-regulating, balanced air humidity. "Positive water" is the energy potential which moves freely and naturally in a heated or unheated space, which positively influences energy transfer in the natural thermodynamic phase cycle: cooling in summer during the day and warming in winter and at night. Earth, as a part of a building construction, always interacts thermodynamically with the natural physical state change of water in each climate zone. It is therefore imperative for engineers and builders to adapt building physics to the conditions of the local climate surrounding the construction. The importance grows as climatic changes become more rapid and volatile. The climate in Norway is extreme and changeable, especially in the north and along the coast. Traditional vernacular architecture has adapted to these conditions over thousands of years. Durable surface treatments are therefore an important historical building technology topic. In traditional Nordic vernacular architecture, the balance between weather protection and necessary water vapour permeability is provided by natural materials: linseed oil, tar oil, cod liver oil, glue-oil emulsions. In the 1960s, however, more and more water vapour impermeable materials were introduced, mostly carbon-based solutions. Building physics problems such as Sick Building Syndrome (SBS), which emerged in the 1970s, have become increasingly apparent since then. The weather facade of the residential building at Smedbakken 5 has.

Figure 1. The façade of Smedbakken 5 in Trondheim built in 1846: approx. 40-year-old paint that acts as a vapour barrier and visible damage to the building physics caused by disturbed micro-meteorology: frost wedging, cracks and flaking of the paint (source: Adresseavisen)

Figure 2. All of the geometric envelopes of the 175-year-old residential house are affected due to the micro-meteorological reversal of the vapour permeability and the following change of the dew point. (Source: Author)

been "weatherproofed" at least twice using a closed vapour impermeable solution. The restricting effect on the state change of water from liquid/gaseous to solid when freezing is irreversible: the natural water cycle was out of control. Wooden and earthen materials in a construction attract and release moisture by way of naturally occurring capillary processes. However, unnaturally concentrated condensation may create a dew point at the coldest layer of the walls, floor or ceiling of an enclosure. Over time, the moisture will accumulate at the dew point, consequently leading to strain and damage on the whole structure, sometimes as severely as shown at Smedbakken 5.

Modern building physics and indoor climate "remedies"

Comprehensive modern technical solutions for regulating the artificially controlled indoor climate can be found, for example, in Wang's "Handbook of Air Conditioning and Refrigeration" (second edition, 2000). The solutions it describes attempt to control the micrometeorology of various types of buildings, including that of the residential building at Smedbakken 5.

The "negative water" caused by a lack of circulation in conjunction with the SBS syndrome, is mentioned in the introduction as a problem in building physics: "The Sick Building Syndrome (SBS) received public attention from the 1970s after the energy crisis as a result of a tighter building and a reduced amount of outdoor ventilation air". (Wang, 2000, p. 27)

The strategy proposed in this textbook – like every building physics textbook since then – is to employ artificial and independent mechanical indoor air quality and heating/cooling systems. Water, in all its physical states and changes, is considered the greatest threat: "[…] The key factor is water. […] The result is a 'damp building' which is characterized by dampened materials, damp surfaces, mould, and microbial growth." (Wang, 2000, p. 4)

Modern mechanical systems mimic natural meteorological exchange processes based on changes in the state of water aggregates in relation to a certain air pressure. However, artificial mechanical water vapour circulation systems require continuous maintenance, and their life span is subject to various limitations. Furthermore, that water and metal do not work well together due to oxidation. Vernacular natural ventilation and heating/cooling systems withstand degradation via solar radiation, weather or climate cycle effects, as they allow meteorological cycles to occur in the building structure in interplay with its environment. But as soon as non-vapour-permeable coatings became involved, building physics changed dramatically: “breathing building organisms” got “sick”. Typical symptoms include either too dry or too high humidity (evaporation and condensation disturbance), mould, extreme temperature changes, and “strong turbulence” as a product of disturbed air circulation resulting from ventilation problems. With the introduction of structural measures for modern thermal insulation came a corresponding rise in “damage resulting from ignorance of building physics processes and, as a consequence, damage caused by inappropriate heating and ventilation.”

“Vapour permeable coatings allow for the evaporation of moisture penetration. It must always be ensured that the outside of the building component (e. g. windows) is coated using more diffusion-open methods than the inside of the building component. If this is not observed, moisture accumulates in the cross-section of the timber.” (Source: Building renovation: Identification and repair of structural damage, Michael Stahr; 6th edition, 1999/2015)

Controlling heat and humidity levels based on “thermal resistance” (R- values) has become a universal design means of regulating the transmission of thermal energy that is entirely “independent” of the local climate and all meteorological activity. The case study of the renovation of the house at Smedbakken 5 will show the different approaches that nature, vernacular architecture and modern “*machines for living*” (a term created by Le Corbusier in 1923) take to make micrometeorology work. In science, the term meteorology is used to describe various physical processes in our atmosphere and usually includes the interaction of evaporation, sublimation, and precipitation. Water plays an important role in all these aggregated change processes. The phase change of water by sublimation and deposition occurs in its physical and chemical processes on a change of water by sublimation and deposition occurs in its physical and chemical processes on a micro scale in any gas-filled space and as an interaction with the environment in all conditions with different temperatures, humidity, and air pressure. From a technical point of view, the latent evaporation or condensation energy manifests itself in every part of a building structure in its situational performance in relation to the heat transfer and storage properties of the materials used. Thus, nature regulates the heat transfer of thermal radiation, both in terms of cooling and heating, through mechanisms based on the transfer of energy by absorption, emission, reflection, translucency and change in the state of water aggregate. In modern building physics, however, abstract and calculated technical and mechanical manipulations are used to control these processes, while almost all vernacular architectures have tried to imitate natural heating, cooling and ventilation processes for thousands of years. A simple description of this natural interaction can be found in Wang’s work: “It is well known that temperature also has an influence on the moisture content of many building materials. When a building material absorbs moisture, heat as heat of sorption is evolved. If water vapor is absorbed, then the heat released […] is given (by an addition) where one factor is the latent heat of condensation expressed in the equation by kj/kg. Heat of sorption of liquid water (factor) varies with equilibrium moisture content for a given material.” (Wang, 2000, pp. 12-13)

Wang determines: “At a certain time instant, moisture migrating from any part in the building envelope to its surface must be balanced by convective moisture transfer from the surface of the building envelope to the ambient air and the change of the moisture content as well as the corresponding mass concentration at the surface of the building envelope. Such a convective moisture transfer is often a part of the space latent heat cooling load” (Wang, 2000, p. 14).

Any type of fireplace in a traditional house causes this air pressure-moisture transfer effect. The more the heating and cooling of a given space allows for convection, the more low and high air pressures compete. For example, colder surfaces in spaces in combination with warmer humid air always cause natural condensation. The effect is a well-known challenge in construction design and building physics: the “feared” cold bridge or thermal bridge. A company that often encounters micro-meteorological problems, Versaperm Permeability Meter, describes the problem: “The building and construction industry relies heavily on vapour barriers to meet the stringent water and air tightness requirements of modern building practice. But not only can barriers such as paints, films and membranes work differently in changing weather or structural conditions, the results you get in the real world are often far removed from the theoretical published values. […] The flow of moisture can affect both the building's structure and the health of the people who live or work inside. Not only that but it has a considerable effect on thermal insulation: getting it wrong can cause mould, rot, and decay, which have been linked to the rise in asthma and other medical conditions." (Source: www.versaperm.com/applications/paint.php)

In the German-speaking world, expressions such as "barracks climate" or "plastic bag climate" have come to denote such poor examples of building physics. In modern-day "living machines" the natural meteorology is disturbed and manipulated, leading to symptoms of "disease", e. g. SBS syndrome, as well as possible negative effects on our climate due to disrupted heat transfer from heat radiation: "The urban heat island is partially caused by changes in albedo. The concrete, buildings, and metal have a lower albedo than rural areas with trees and vegetation. There is also less evaporative cooling or transpiration cooling from concrete, buildings, or metal."

"[…] In the atmosphere, there are regions with an excess pressure and those with a deficit pressure. Regions with an excess pressure are termed high pressure and those with a deficit, low pressure. To equalize the pressure, nature moves the air from the high pressure toward that of the deficit low pressure." (Source: Jeff Haby: Theweatherprediction).

2. MICROMETEOROLOGY IN NATURE, TRADITIONAL ARCHITECTURE AND MODERN-DAY "LIVING MACHINES"

In the Encyclopedia of Vernacular Architecture of the World, in the chapter on climate and its interaction with traditional architecture, we read that architects and engineers have had experience with climate since ancient times in non-traditional architecture: "Since Vitruvius (c. 90-20 BC) prominent architectural theorists have often included select climatic parameters as design determinants without being comprehensive. This continues to be appropriate since designs or performances based on broad climatic type are strongly modified by microclimate. It sums up: climate integrated factor net effects determine a macroclimate or a regional climate."

Figure 3. Traditional type of vernacular Nordic timber and earthen construction (earth mortar layer between squared timber in wood framing) with "rapping" (a type of Norwegian clay plaster on wooden surfaces), in the house Smedbakken 5 from 1845/46 in Trondheim, Norway (source: author)

Traditional architecture has reflected the macro-meteorological processes in the atmosphere in all cultures for thousands of years: "Evaporation of water, especially over the oceans initiated a hydraulic cycle. Water vapour transport and precipitation transform solar energy. Winds are major equalizing and dissipating mechanisms of global irregularities in solar radiation. The westerly jet stream in the upper atmosphere is imperceptible at ground level where the general pattern is of warm air flowing toward the poles and cold air from the poles moving toward the equator. The movement of these air masses largely determines local climate." (P. Oliver 1997).

"Vernacular constructions balance temperature and air pressure by strictly adhering to the laws and principles of nature. This human-creative action has been termed a "vernacular response" (P. Oliver 1997).

3. ENERGY TRANSPORT IN THE ATMOSPHERE: ISOBARIC, DIABATIC, ADIABATIC, ISOTHERMAL, AND ISOCHORIC PROCESSES AS BACKGROUND FOR DAMAGES CAUSED BY DYSFUNCTIONAL "MICRO-CLIMATE" IN ALL BUILDINGS

In meteorology, energy exchange and distribution in the changing aggregate state of water is manifested through evaporation and condensation. In our gas filled thermodynamic system, latent heat and sensible (i. e. felt) heat always play a role as part of the element water in its three known assumed states – gaseous, solid and liquid. The ratio of sensible heat and latent heat is expressed by the Bowen ratio. The more gas-filled the environment and the higher the air pressure, the more these processes dominate thermodynamic transfer or interaction. The change of the overall state is the moment of distribution of thermal energy in both forms: cooling and heating. Evaporation, sublimation, and condensation are the processes that trigger energy transfer in nature. Latent heat is involved in melting and evaporation (boiling). The degree of influence in these energy transfers is based on the unusually high amount of potential energy in water and its chemically and physically unusual behaviour in relation to thermal radiation. Energy transfers are caused by continuous heat radiation from the sun and its passive interaction in a particular environment or situation. Therefore, all passive heat radiation is affected at any given time by changes in air pressure, relative humidity, and precipitation of all physical systems inside and outside an enclosure. The character of an enclosure, its hemispherical position, its ability to handle water throughout its change cycle, and the sun's response to thermal radiation are the main factors that describe the actual heat transfer (as a thermodynamic equilibrium process) between objects and their environment. Convection processes have significant effects due to the natural micrometeorological processes in any gas-filled enclosure with physical exchange with its environment. Any heating and cooling system is most efficient if it can maintain the natural thermal equilibrium as long as possible in a given thermodynamic environment or system. The distribution of actively emitting thermal energy must always be as slow as possible. The passive radiation-emitting space must do the same and maintain the energy charge (as latent heat) as long as possible. The faster each active system distributes itself and the smaller the actual radiating surface is, the more it disturbs the heat balance: meteorological phenomena like diffusion, high condensation and evaporation occur at the wrong place at the wrong time, and turbulence occurs. The lighter and less vapour-permeable an enclosure becomes, the greater the need for temperature and moisture management, for example through vapour barriers, heat pumps and increasingly complex ventilation systems. This cycle of water aggregate state change always occurs in all directions through phase transitions: latent heat of fusion, latent heat of evaporation/condensation, enthalpy/sublimation heat and sensible, perceptible heat. The phase transition is always unsteady. Energetic changes occur continuously at any moment, based on the actual interaction in a given climate and its meteorological cycle. This cycle is always determined by one absolute source of radiation: the sun. Artificial spaces have two main alternatives: natural ventilation with free water vapour transport, or mechanically controlled convection and water vapour control. What degree of automation does a vernacular wooden and earthen construction require? Is "*Une maison est une machine à habiter*" (Le Corbusier 1923) given the historical experience of SBS syndrome the goal that should be pursued?

The more a surface is sealed, the more the natural exchange of energy through "transfer", "charge" and "emission", which are controlled by the cycle of water aggregate state change, is disturbed. The amount of energy depends on the thermodynamic transfer in relation to the geometrical configuration, the heat radiation emission value of the material (as liquid, gaseous and solid matter), the surface character in relation to water in its aggregate state behaviour and the air pressure. As in macro-meteorology, the physical system tilts towards or is "forced" to maintain a thermodynamic equilibrium. At any given time, it tries to stabilize the energy transfer through adiabatic and diabatic processes. A good indicator for an artificial space is therefore a balanced relative humidity through undisturbed natural water vapour transfer. Every convective heating or cooling system also increases destructive diffusion. The air flow follows adiabatic and diabatic processes: the higher the pressure and humidity increases, the more the humid air seeks equilibrium. The total amount of energy required to balance these balancing processes is not expressed as "heat loss", but rather in the cooperation between natural micrometeorology and the interaction between active and passive radiant heaters. Due to unsteady micro- and macro-meteorological conditions, the total amount differs at any given time depending on the position, the thermophysical character of the object and the weather conditions/heat radiation input from the sun. A kind of constant factor is the potential thermal mass of the building, i. e. the capacity of latent heat storage by the natural and artificial energy transfer cycles that occur over a certain period of time. Moisture transfer depends on the geographical position and the capacity of the space.

The more vapour-permeable and heavy a geometric object with a low thermal radiation emission value is, the better the energetic balance works according to the principles of micro-meteorology. Ventilation plays an important role due to the natural transport of saturated vapour. It is a physical system that can react extremely flexibly to water vapour pressure and rising and falling temperatures. Experience has shown that clay and wood fibres with surfaces open to vapour diffusion manage these extreme diabatic and adiabatic processes well. These natural building physics instructions were already detailed in ancient times by Vitruvius in "De decrem libri de Architectura". This fundamental knowledge about the micro-meteorological transfer of thermal energy is documented in all vernacular architectures of the world. Clay and earth as one of the oldest building materials "produced" by nature has proven this throughout history: it has its own heat radiation "DNA", high heat capacity (thermal mass) and is able to alternate the aggregate states of water positively in cooperation with the thermodynamic interaction with the sun in every climate zone.

4. CONCLUDING CONSIDERATIONS

Thermodynamic processes in real situations in nature and in all building structures, both vernacular and high-tech, must be strictly adhered to when restoring buildings, as in the case of the house at Smedbakken 5 with its historic timber and earthen construction.

The equilibrium cycle of the changing aggregate state of water, which is caused by all kinds of heat transfer through active and passive thermal radiation, requires particular consideration. As Smedbakken 5 shows, vapour diffusion resistant coatings on timber and earthen constructions should be examined with a critical eye in this context. Bending nature's own physical reality to "match" our mathematical descriptions and scientific models only results in a misguided attempt to improve an already functioning historical traditional building method like the construction at Smedbakken 5. Traditional architecture is practical knowledge conveyed "by hand", which applies the thermodynamic principles of nature (the vernacular response, described by P. Oliver) in a practical manner without the need for intellectually abstract calculations, thus proving its role.

All earth and timber constructions in traditional architecture of all climate zones react through micrometeorology caused by radiant thermal heat transfer in all buildings, following the principles of nature, their specific geometric spatial proportions, and their thermal radiation behaviour.

The actual geometric radiant thermal surface in the aggregate state of water change cycle regulates the entire energy transfer process at any given time. The behaviour of water in its states of aggregation and heat radiation in our atmosphere and its interaction with all kinds of artificial spaces, from vernacular architecture to high-tech machine à habiter, requires more attention in future research, engineering and, most importantly, in practical maintenance.

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Analyzing Adobe Buildings in the Kayseri, A Study of Traditional Earthen Architecture in Zile Town


Masoumeh KHANZADEH, Gözde KUZU DİNÇBAŞ

Nuh Naci Yazgan University, Kayseri, Turkey,
mkhanzadeh@nny.edu.tr, ORCID: 0000-0003-4606-0490
gkdincbas@nny.edu.tr, ORCID: 0000-0002-5112-4930

ABSTRACT

The emphasis of this new study title is still on traditional earthen architecture, particularly the adobe structures in the Kayseri, Zile District. The subject stresses the need to preserve the authentic living spaces and regional knowledge found in these magnificent structures. The study aims to explore the cultural and architectural relevance of adobe structures and decorations while also emphasizing the insights they provide for modern architectural thinking and design.

This study focuses on adobe structures found in Zile Town of the Develi District of Kayseri in order to explore the rich history of traditional earthen architecture. Earthen architecture, which is closely woven with the local culture, is a tribute to eco-friendly building techniques and traditional knowledge. The purpose of this study is to explain the architectural and cultural value of adobe houses, shining light on the complex relationship that exists between dwellings and regional knowledge.

This study uses an interdisciplinary method to draw on anthropological ideas, historical study, and architectural analysis. The project aims to comprehend the spatial arrangements, building methods, Interior architectural decorations and cultural narratives encoded within these adobe structures through site visits, extensive architectural documentation, and interaction with local residents. The study also seeks to uncover the hidden lessons that these dwellings contain, which are comprised of regional customs, beliefs, and teachings.

It is anticipated that the results of this study project would advance both architectural knowledge and efforts to preserve and revive cultural heritage. This study aims to inspire modern design strategies that honor the past while solving the problems of the present by revealing the innate wisdom contained in conventional earthen construction. In the end, learning about the adobe structures in the Kayseri, Zile District opens a door to comprehending the enduring relationship between design, culture, and the built environment's resilience.

Keywords: Adobe, Earthen Architecture, Traditional Buildings, Vernacular Architecture, Zile Town

1. INTRODUCTION

1.1. Background and Context:

The study examines the traditional clay architecture of the Kayseri area in its historical and cultural context, with a concentration on the Zile Town of the Develi District of Kayseri. This district, which is a part of the larger province of Kayseri, has a rich history that is firmly based in several civilizations that have left their marks on its cultural fabric. Zile District's architecture, social dynamics, and way of life have all been influenced by several civilizations throughout the course of its history, including the Hittites, Romans, Seljuks, and Ottomans. The study acknowledges the lengthy history of the area as a background to its architectural traditions and tries to analyze how this historical foundation interacts with the building methods and cultural values expressed in its traditional earthen architecture. The study explores the unique characteristics of traditional clay architecture in this area, with a focus on the Zile District. The study highlights the use of locally derived materials, like as clay and straw, that have shaped architectural practices in this region for generations by concentrating on adobe structures. It aims to comprehend how the adobe house's design, building techniques, and structural characteristics have been affected by the local environment, climate, and resources. The study also acknowledges the sociocultural importance of these structures within the neighborhood. The project attempts to uncover the complicated relationships between the traditional earthen architecture of Zile District, its history, and the surviving cultural values that underpin it via a thorough examination of the historical background, architectural methods, and cultural symbols.

1.2. Research Questions:

Examining the historical, cultural, and environmental influences on the creation and design of adobe houses in this area is one of the study issues that underpins this study. In order to shed light on how the historical setting and available resources have influenced these behaviors, the study aims to identify the precise methods and materials used in the construction of adobe dwellings with concise research questions:

- What lessons may be drawn from the adobe architecture of Zile for modern design and preservation projects?
- In a changing society, how might cultural understanding guide the preservation and modification of Zile's adobe houses?

1.3. Significance and Purpose:

This study tries to look into the historical, cultural, and natural elements that have influenced the building of adobe homes in the area. The study focuses on these structures' function as archives of regional values and memories by examining their construction processes, materials, and sociocultural importance. Understanding both the material and immaterial characteristics of historic structures, defending them against modernization, and promoting a better sense of community identity are all goals of the study. The study is organized with a thorough investigation of the pertinent literature, a thorough methodology for data gathering and analysis, and a focus on historical context and social significance. In the end, this study helps to preserve cultural heritage while shedding light on the complex connections between history, culture, and architecture.

2. LITERATURE REVIEW

2.1. Theoretical Framework:

The theoretical underpinnings of the subject include cultural anthropology and preservation of historic buildings. The study explores the cultural importance and socioeconomic factors influencing adobe dwellings in Kayseri's Zile District by using principles from cultural anthropology. Local construction methods, materials, and design reflect historical customs, ideologies, and environmental concerns, illuminating the complicated relationships between local culture and architectural styles. With this strategy, heritage preservation efforts are strengthened by highlighting the dual functions of buildings as functional structures and archives of cultural memory. The study reveals the complex interactions between cultural practices, socioeconomic conditions, and architectural forms that influence the creation of adobe houses and their ongoing relevance within the Zile District's cultural fabric. Its foundation is in line with heritage conservation and sustainable development goals.

2.2. Relevant Literature:

In order to offer a thorough knowledge of the pertinent variables influencing the traditional earthen architecture of the Kayseri region, notably in the Zile District, this study draws on a wide range of literature. The literature study covers a range of topics, such as historical customs, cultural beliefs, and architectural influences. Writings by Acpayaml [1,2,3,4] illuminate the prevailing habits, beliefs, and behaviors in Turkey, including subjects like childbirth and the evil eye. Understanding how architectural decisions may have been impacted by regional conventions is based on this cultural background. In addition, research by Eker [5] and Küsat [6] explores the idea of the evil eye in Turkish culture, which is important to understand in order to place possible symbolic and practical components of earthen construction in the area. Insights into how cultural beliefs might be entwined with architectural traditions can be gained from Gürlek's [7,8] investigation of traditional practices relating to cloth tying and the evil eye. The literature also contains investigations of larger cultural settings, such as those by Gürlek [9] on the religious history of the Turks and Ülken [10] on the ancient cultural impacts on Anatolian traditions and customs. By providing insights into the interactions between cultural values, historical customs, and architectural decisions that influence the traditional earthen architecture in the Kayseri region's Zile District, these works collectively add to the conceptual framework.

The purpose of this study is to examine local earthen architecture in the Kayseri area. The literature review part looks at a wide range of studies on adobe construction methods, traditional earthen architecture, and the region's architectural history. The chosen literature offers an international perspective on earthen architecture, considering diverse nations and their distinctive methods for environmentally friendly building. For instance, Mousourakis et al.'s study [11] examines earthen architecture in Greece and its revaluation, while Rael's book "Earth Architecture" [12] offers insights into various earth construction processes. The research also examines particular instances, such as the modern usage of earthen building in Sri Lanka Dayaratne, [13] and the traditional earthen architecture of Konya Karakul. [14]

The literature review also includes regional studies, including those on traditional earthen building methods in Central Asia by Fodde[15], bioclimatic strategies in traditional earthen architecture by Balaguer et al. [16], and the evaluation of earthen architectural heritage in a global context Mileto & Vegas López-Manzanares [17].Mileto et al.'s work on the Iberian Peninsula [18] explores the effects of regional conditions on traditional clay construction. Additionally, the literature covers more general subjects as the undervaluation and valuing of clay architecture [19] and the sustainability of earthen construction methods in Egypt [20].The literature study also includes studies on the usage of traditional earthen methods in seismically sensitive locations [21] and chemical analysis to identify organic chemicals in earthen architecture [22].The review offers a thorough framework for the study's analysis of Kayseri's adobe structures and their relevance in relation to traditional earthen architecture.

2.3. Gaps and Limitations:

The understanding of the architectural principles, historical context, and cultural significance of adobe constructions in the Kayseri region is hampered by a lack of extensive recording of these monuments. It is yet unknown how earthen construction interacts with its surroundings, including climatic and topographical factors. The project seeks to close these gaps by taking a holistic approach that considers architectural, historical, cultural, and environmental viewpoints. It makes use of thorough documentation and study to offer insights into construction techniques, architectural characteristics, and socio-cultural situations. Additionally, by examining the relationship between earthen architecture and the environment, the study aims to identify sustainable preservation techniques. The initiative offers insightful understandings into Kayseri's ancient earthen architecture, laying the path for subsequent conservation efforts despite obstacles including restricted access and historical gaps.

2.4. Rationale:

It is vital to do study and record these adobe houses because of the underrepresentation and lack of knowledge on the cultural and sustainable relevance of earthen building. The goal of the study is to fill in information gaps regarding the methods, supplies, and socio-cultural situations that influenced these constructs. With an emphasis on providing information on historical, cultural, and environmentally friendly construction techniques, it seeks to maintain, defend, and promote the local heritage of clay architecture in Zile. The study highlights the ecological and cultural significance of earthen construction by drawing on both international and local literature on the subject. This study emphasizes the critical need of recording and maintaining the architectural, cultural, and historical worth of earthen structures in the Zile District, which is in line with earlier studies like Ronald Rael's "Earth Architecture" and other related works [11].

3. METHODOLOGY

3.1. Research Design:

This study uses a thorough study methodology that mostly relies on a case studies technique. In this instance, the study focuses on traditional earthen architecture in Develi's Zile Town with the intention of examining the building's construction methods, architectural heritage, and cultural importance. By using a case study approach, researchers use techniques like field observations, interviews with locals, and the investigation of historical records to acquire rich and thorough data. This method enables academics to examine the complexity of traditional earthen construction within its distinctive socio-cultural and geographic context, facilitating a comprehensive examination of the subject. The flexibility to investigate the intricate interaction of elements that contribute to the evolution and maintenance of earthen architecture is made possible by the case study technique adopted for this research design. It facilitates the collecting of qualitative data to unearth subtleties and insights that quantitative approaches would ignore while also enabling the in-depth analysis of particular situations, in this example, adobe structures in Zile District. The method also fits with the study's goal of gaining knowledge that can aid in the preservation and sustainable growth of conventional earthen building. The study aims to give a thorough analysis that might guide future interventions and policies in the preservation of this priceless architectural legacy by probing the regional techniques, materials, and cultural values related to adobe construction.

3.2. Sample:

A thorough and precise examination of 100 Zile adobe houses was the goal of the study's rigorous selection criteria for the interior architecture aspects. The criterion prioritized houses that kept their original adobe construction and conventional interior decor in order to maintain architectural authenticity and historical value. This method provided insight into how interior design methods, supplies, and techniques have changed throughout time. Another important factor was spatial variety, which allowed for the analysis of how people have adapted to diverse functional demands through varying room configurations and layouts as well as functional areas like kitchens and ceremonial rooms. This variety demonstrated how flexible adobe building is.

A number of techniques were used to obtain the data, including field surveys, observations, measurements, photos, and drawings. In addition to qualitative information on interior elements and architectural aspects, this multimodal method also collected quantitative information regarding room arrangements, usage patterns, and preservation initiatives. The study's primary focus throughout was on ethical issues. Participants gave free-will permission after receiving information about their rights, including privacy and the ability to withdraw. Participants' interior settings were solely photographed with their permission, protecting their privacy and preserving their cultural history, and anonymity was upheld. These moral guidelines increased confidence, protected privacy, and guaranteed the accuracy of the study.

4. RESULTS AND DISCUSSION

In the Kayseri region, especially in the Zile District, traditional adobe houses have a variety of architectural characteristics that are described in detail. These homes' front entrances are often double-winge (the courtyard doors) to accommodate various objects and animals. Additionally, the doors contain windows for ventilation and lighting (window in the head of main entrance doors to admit natural light). The homes are made to fulfill a variety of functions, including housing a Tandır for basic cooking and baking bread or Fireplaces (Şömine) for and water heating, a chicken coop, a restroom (Hela) and storage areas.

The design of the homes is described in full in the research, including the courtyard, barn, space used for cooking grape molasses, covered areas, winter quarters, and higher stories. Upper floors of houses are utilized to accommodate visitors' "guests", while ground floors of houses like "Cağ" as an indoor fitting; are set aside for ablution. Traditional techniques like grape crushing and vinegar making are also included into the building. Logs, reeds, clayey mud, and dirt are used to construct the roofs, and particular methods are used to handle snow and rain. Storage-related outbuildings are built, and handmade looms for making carpets and kilims are typically found in homes.

It examines security measures, courtyard amenities like Tandır units and stoves, courtyard facilities like double-winged entry doors with forged iron lattice patterns, and storage rooms, barns, and grape molasses regions. It also looks at practical additions such outbuildings and textile weaving, as well as dwelling areas like Trabzans and upper chambers. The purpose of this study is to identify the cultural and architectural relevance of these buildings (Table 1).

Table 1: Categorized Key Architectural Features and Facilities of Adobe Houses in Zile

Category	Description
Entry and Access	Entrance doors are mostly double-leaf, allowing for the passage of various loads. Double-winged doors with windows for light and ventilation, made of ornamental ironwork with lattice patterns. Security systems, support struts and sliding locking are behind the doors.
Courtyard Facilities	Tandır unit for baking bread and cooking. Stove for quick cooking and heating. Poultry house with feeding areas, accessed through stone stairs (Just the first three steps of the wooden stairs leading from the courtyard to the upper floor are made of stone, with a small alcove beneath them. Restroom ("HELA") with a sewage system, located in the initial courtyard.
Storage and Functional Spaces	Recessed cabinets with hinged doors for storage, suitable for various rooms. Barn equipped with feeding troughs, harness racks, and storage for animal care. Grape must area including processing, mashing, and boiling pots. "ÖRTME" (Enclosed space) for winter Tandır use storage and workbench.
Living Spaces and Amenities	Trabzan's (railings) separating upper and lower compartments with utility shelves. Upper compartment of the room, hosting gatherings and dining. Summer room (head room- başoda), Sallık for guests and socializing. Winter room with cupboards storage and specific sections. Roof structure, ceiling, and roof details including thatch and roofing materials.
Functional Extensions and Utilities	Outbuildings ("Müştemilat") for storage, specifically for hay, straw, kindling, and firewood. The hayloft (samanlık) and woodshed (odunluk) are in different locations. The woodshed is inside the house, while the hayloft is outside the house. Istar; loom for carpet, rug and savanna weaving.

	* *Savanna: A thickly woven small rug, mat, or cover made from thick cotton thread, goat's hair, camel hair, wool, or a haphazard mixture of these materials.*
	Shopfronts with roller shutters.

One hundred adobe buildings in Zile's interior architecture were analyzed, and the results shed light on the distinctive qualities that characterize their functional design and spatial arrangement. According to the study, the entrance and access components are essential for fitting different weights and providing security through unique door characteristics. The tandoor unit and stove that are integrated into the courtyard space highlight the importance of food preparation and social interactions there. Additionally, the existence of the restroom and poultry house underlines the attention paid to practical necessities within the home. Recessed cabinets, barns, and grape molasses areas—all necessary for both residential storage and industrial processes—are examples of the rigorous thought that went into the construction of the storage and functional spaces category. The use of "Trabzan" s for spatial separation and the idea of "Sallık" for social gatherings offer insights into the cultural and social facets of everyday life in terms of dwelling arrangements and facilities. The vision of a thorough architectural environment that combines purpose with tradition is completed by the structural characteristics of roofs, the incorporation of outbuildings, and utilities.

4.1. Comparative Analysis with Prior Research

The results of the current study add to the body of knowledge on rural architectural history by providing a thorough and methodical investigation of the interior design of adobe homes in Zile. The distinctive qualities of Zile's adobe houses, such as the incorporation of particular storage facilities like the grape molasses area and the utilization of Trabzans, offer unique insights into the cultural and climatic context of the region, despite some similarities with other traditional dwellings in various regions, such as the importance of communal spaces and functional divisions. This study adds fresh perspectives to our knowledge of rural architecture, particularly in terms of how the built environment interacts with local cultural activities. The thorough classification of components highlights the interrelationship between architectural aspects and daily home activities in addition to offering a holistic picture of the layouts of the dwellings.

4.2. Limitations and Suggestions for the Future:

It's critical to recognize the study's inherent limitations. The generalizability of the results might be impacted by the possibility that the sample of 100 adobe houses in Zile does not accurately reflect the complete range of architectural variety in the area. The study also restricted the examination of the social and cultural components that may have further enhanced the interpretation of the findings by concentrating on architectural documentation and classification. The conclusions drawn from this study have wider relevance notwithstanding these restrictions. The study aids in the preservation of cultural assets and provides guidance for architectural conservation efforts by revealing the complex interaction between architectural components and the daily lives of people. The results can also be used as a starting point for urban planners, architects, and decision-makers who want to build rural communities while balancing tradition and modernity.

By combining anthropological techniques, resident interviews, and further investigations of the cultural importance connected with each architectural component, future research initiatives can expand on the findings of the current study. The knowledge of how these places are used and appreciated by the occupants would be enhanced by the inclusion of this qualitative feature. Additionally, cross-regional comparisons of related architectural styles might provide a broader perspective on the distinctive characteristics of Zile's adobe homes. Additionally, the effects of evolving lifestyles and technology on how these spaces are used might be researched, perhaps directing solutions for adaptive reuse that guarantee the continuity of these legacy structures while satisfying current demands.

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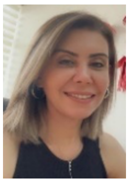
Paper Number: 61

Simulation of Passive Thermal Technique and Renovation of an Existing Reinforced Concrete Residential Building: A Case Study of a Building on Tokha Municipality, Kathmandu, Nepal





Kshitiz Pandit[1], Prachand Man Pradhan[2,3], Sefika Ergin[4]
[1] Kathmandu, NEPAL
[2] Dean, School of Engineering Manmohan Technical University, Morang, NEPAL
[3]Professor, Kathmandu University, Dhulikhel, Nepal
[4]Assoc. Professor, Dicle University
erginsefika@gmail.com
[1] kshitiz.pandit16@gmail.com

ABSTRACT

The transformation of conventional buildings towards an energy efficient buildingis soaring in the urban development of Nepal.Since, Nepal is considered as highly seismic zone, the buildings are seriously concerned to seismic resistant design mainly after Gorkha earthquake 2015 AD. Aged buildingswhich have withstood several earthquakes and have fulfilled its serviceability to the occupants undergoes renovation now days for athermal comfort.

This study focuses on the retrofitting of an existing building with passive technique for thermal comfort along with strengthening. Based on e-mail and field surveydata the simulation in ECOTECV11and ETABSV18 were carried out for energy modelling and structural analysis. The energy consumption for spaceheating and coolingon applying passive thermal retrofitting techniques were compared before and after retrofitting based on climatic data. Only four retrofitting techniques are used in this simulation; replacement of brick infill wall by EPS panel on top floor, use of insulation on ceiling and floor, reduction of infiltration and application of windows glass. Similarly, after energy retrofit, analysesof base frame, frame with infill wall and retrofit frame were studied comparatively based on fundamental time period, Base/story shear and Story displacement taking bare frame as a reference case. The susceptible structural elements – few beams and columns were retrofitted through reinforced concrete (RC) jacketing and fiber reinforced polymer (FRP) jacketing.

Results showed that infillwall and window alternation with change in orientation, size and material type enhances the thermal aspect of the building but affects the strength of the building against the future earthquake. It concluded that if any alternation in an aged building is made to enhance the thermal comfort of the building through passive technique the building must be strengthened.

Keywords: Building energy efficiency, Thermal Comfort, Passive retrofit, Simulation, Strengthening.

1. INTRODUCTION

Building construction in Nepal is evergreen sector with the adaptation of varied architectural design now days. The replacement rate of existing buildings by new construction is only 1-3% annually[1]. Since, Kathmandu valley is prone region to earthquakes, buildings are more focused to seismic resistant design mainly after the massive causalities of human life and devastation of buildings which were not structurally sound and having several deficiencies in buildings during the Gorkha earthquake 2015[2]. The governing Nepal Building Code (NBC) and guidelines NBC: 206:2015 for architectural requirements and NBC: 105:2020 for seismic considerations were then revised and regulated by Department of Urban Development and Building Construction (DUDBC), Government of Nepal (GoN) prioritizing the structural safety only whereas the concern on building's energy efficiency guidelines and regulation is still unheeded. Now-a-days, peoples choose to refurbish the buildings for thermal comfort andenergy efficiency as well as to prolong building's serviceability age. The presence of distinct seasonal and climatic variations within a small range of geographical belt urges the thermal comfort of the building as a substantial parameter in building design and construction [3] across the country. In spite of world's action on energy efficiency and building decarbonization Nepallacks the integrated guidelines, regulations and codes for building energy efficiency and structural safety.

Variouspassive retrofitting strategy were explored for thermal comfort which leads the reduction on energy consumption utilized for space heating and cooling[4].Certain researches had pointed the need of simultaneous strengthening of the structure for future earthquake on enhancing the thermal comfort by increasing the thickness of brick infill wall [5] similarly, alteration with infill walls leads the change in thermal and seismic performance of the building [6]. Any new infill materials used for energy intervention for thermal comfort in an aged buildings which is vulnerable to seismic excitation should also improve its seismic performance [7] , additionallyit hadbeen found that brick infills essentiallyassist in enhancing the strength of structure during earthquake events by resisting the lateral forces resulting less damage as compared to bare frame [8].

This paper conducts a study on an existing residential building with an energetic interventionfor thermal comfort which ultimately required the strengthening for structural strength to address future seismic events.

2. SITE SELECTION AND METHODS

The survey study was conducted in Budanilkantha and Tokha municipality which lies in northern part of the Kathmandu valley. This area was chosen to study because this region is densely populated with rampant urbanization, and was tagged as a vulnerable place for seismic event after the Gorkha earthquake2015 as shown in Fig. 1. The survey was conducted through e-mail survey and field visit interrogation based on the questionnaire prepared to assess the prevailing building conditions from an architectural and structural aspects, building thermal comfort and energy efficiency. The email survey and field visit were conducted with the obtained sample size of 110 for the population size of 57207 with the confidence level of 95% and 10% precision level based on the Yamane and Solvin's formula [9]. The responses were scrutinized and based upon it one of the existing buildings was chosen for research as a representative building which resides in Tokha municipality.

Figure 1. Extensive urban settlement following the contemporary design buildings in the Tokha municipality of Kathmandu, Nepal.

The existing reinforced concrete residential building selected for study is shown in Fig. 2. Data on building materials, architectural features, structural conditions, thermal comfort, energy consumption and inhabitant's interest for upgradation of the buidling, were recorded along with the building drawing and measurement which arerequired for simulations. The building informations are tabulated in [Table 1, Table 2].

a

b

Figure 2: Picture of East elevation (a) and South elevation (b) of an existing residential reinforced concrete building, Tokha, Nepal.

Table 1. General Architectural Description of an Existing Building.

Architectural	Description
Environment Setting	Urban
Building Design	Residential, Contemporary style, 3.5 Storey, RCC
Construction Date	2004 A.D.
Building Orientation	South-East facing
Building obstruction	In North and West by 3 storey, In South and Eastopen
Wall material	Solid Brick infill

Table 2. General Structural Description of an Existing Building.

Structural	**Description**
Column size **(Ground, First, Second, Third and Top floor)**	0.23m x0.23m
Beam size	0.23m x0.33m
Slab size	0.1m
Floor-to- Floor height	2.8448m
Foundation Size	1.524mx1.524m
Foundation depth	1.98m

2.2 Building Energy Modeling
Meteorology and (GoN) Government of Nepal was used in climate consultant software to predict out thermal comfort range and psychrometric chart based on which the thermal simulation was performed. The comfort range of 21 ^{0}C – 25^{0}C was accounted to maintain the indoor thermal comfort.

Initially, the model was built based upon the plan as shown in Fig 3. and the data including building orientation and building materials on floors, ceilings, doors, windows, walls, and roof along with their properties were define and internal design conditions inclusive of occupancy, internal gains, infiltration rate, parameter such as clothing, lighting level were set based upon the actual conditions of the buildingas shown in [Table 3, Table 4]. Active system in a mixed-mode, which synchronizes the effect of both natural ventilation and AC, with an efficiency of 95% was set assuming it's 24 hours operation. Occupancy schedule was considered identical for both summer and winter. Then, the model was simulated for base case scenario calculating the annual heating and cooling load whose results were compared with retrofitted model. Retrofitted model consits of an air tightness to 0.35ach, single glazed tinted window with 6mm glass, insulation on ceiling, and replacement of brick infill wall with light weight EPS panel in Top floor room as shown in Fig 4. and properties in [Table 5].

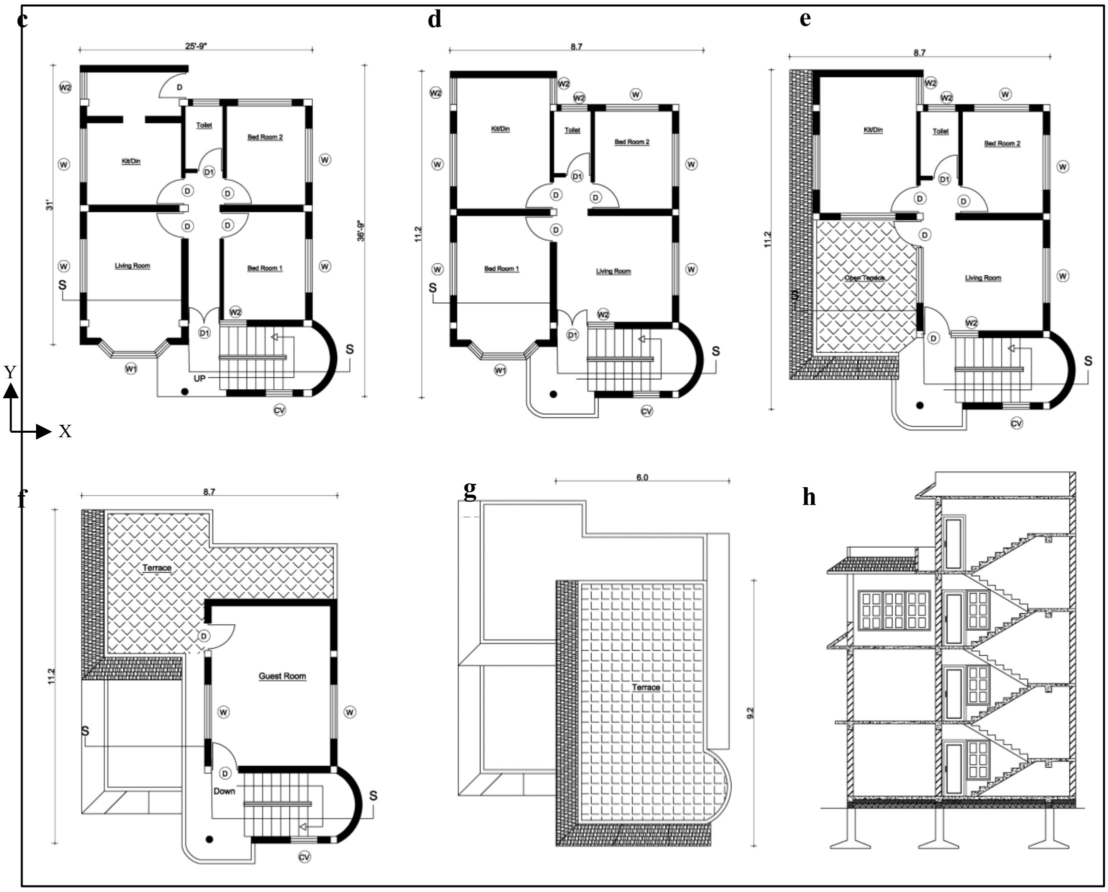


Figure 3. Existing plan view of building with solid brick as an infill wall: Ground floor (c), Second floor (d), Third floor (e), Fourth floor (f), Roof (g) and Section (h).

Table 3. Details of zone setting for base case model representing the existing building conditions.

Type of System	Mixed-Mode System
Comfort Band	21 ^{0}C – 25^{0}C
Thermal Zones	9 heated and cooled zones (Bed room & Living room) with 3 occupied passive zones (kitchen & Dinning)
Infiltration Rate	0.5 ACH
Solid Brick wall	0.23m
Window Glass	0.003m Normal glass

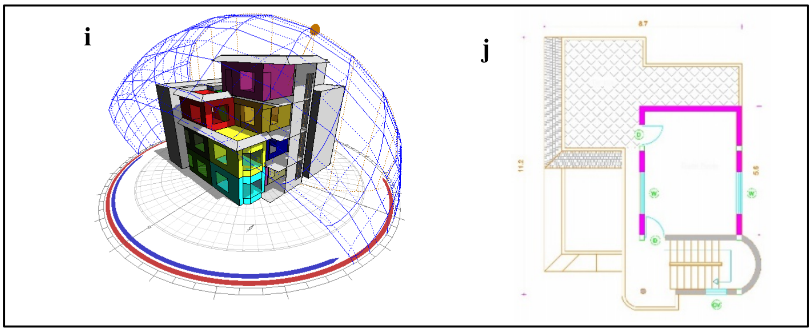


Figure 4: Ecotect model (i) for thermal comfort simulation, and brick infill wall replaced by light weight EPS panel in three sidesindicated with pink color (j).

Table 4. Materials used to define existing building in Ecotectmodel with their properties.

Materials	Components	Composition	Thickness (m)	Overall U-Value (W/m²K)
Solid Brick Wall	Externall wall	plaster both side	0.230	1.39
Solid Brick Wall	Internal wall	plaster both side	0.110	1.81
Concrete	Floor slab	plaster+carpet	0.1	1.28
	Ceiling slab	plaster+Tile	0.1	2.82
	Roof	plaster	0.1	3.040
Glass	Window	Single glass pane + timber frame	0.003	5.53
Wood	Door	Solid core timber	0.032	3.690

Table 5. Retrofitting materials with their properties.

Materials	Building Components	Composition	Thickness (m)	Overall U-Value (W/m²K)
Expanded polystyrene (EPS)	Infill wall Ceiling	EPS EPS	0.15 0.01	0.148 0.64
Extruded polystyrene (XPS)	Roof Slab	Concrete+XPS	0.14	0.528
Single glazed VT tinted glass	Window	Single glass pane + timber frame	0.006	3.7 (SHGC 0.4)

2.3 Building Structural Modeling

Structural analysis was performed in EtabsV18.1 to assure the strength of the building based on the data as shown in [Table 2, Table 6]. Building possesses the mass irregularities and strength related check was performed which is shown in Table 7. The load assign followed the Indian standard code IS 875:1987 part I, part I. The load combination was done for seismic forces acting horizontal direction only.The simulationwas based on the criteria for earthquake resistant design of structure [10] and seismic evaluation and retrofitting guidelines [11], [12].Building is generally designed for bare frame whereas in practical scenario the existing infill wall contributes in seismic performance of the building. The infill was model using thestrut in the frame [13], [14]. Columns and beam member in bare frame as well as after energy retrofit in infill wall frame were inadequate in strength and resulted failure in simulation as shown in Fig 5. 12 column member among 44 were strengthened with RC jacketing and 2 beam member were strengthened with FRP jacketing.

Table 6. Data of structural elements in existing building.

Material properties	Base case	Retrofit case
Concrete Grade	M15	M20
Rebar (Stirrups & longitudinal bar)	Fe250, Fe415	Fe415, Fe500
Masonry (E)	3920 MPa	3920 MPa
Section Properties		
Column	0.23mm x0.23mm	0.43mm x 0.43mm
Beam	0.23mm x 0.33mm 0.23mm x 0.23mm	
Rebar Properties		
Slab	10 mm dia.	
Beam	6-12mm dia.	
Plinth beam	6-12mm dia.	
Column	4-16 dia,4-12mm dia. & 8-12mm dia.	
Clear cover (Slab, Beam, Column) resp.	15mm, 25mm, 30mm	
Stirrups	8 mm	

Table 7. Summary of Check for Strength

Summary	DCR(Demand Capacity Ratio)
Column flexural capacity	check unsatisfied
Column shear capacity	check satisfied
Beam Shear capacity	check unsatisfied
Story drift	check unsatisfied

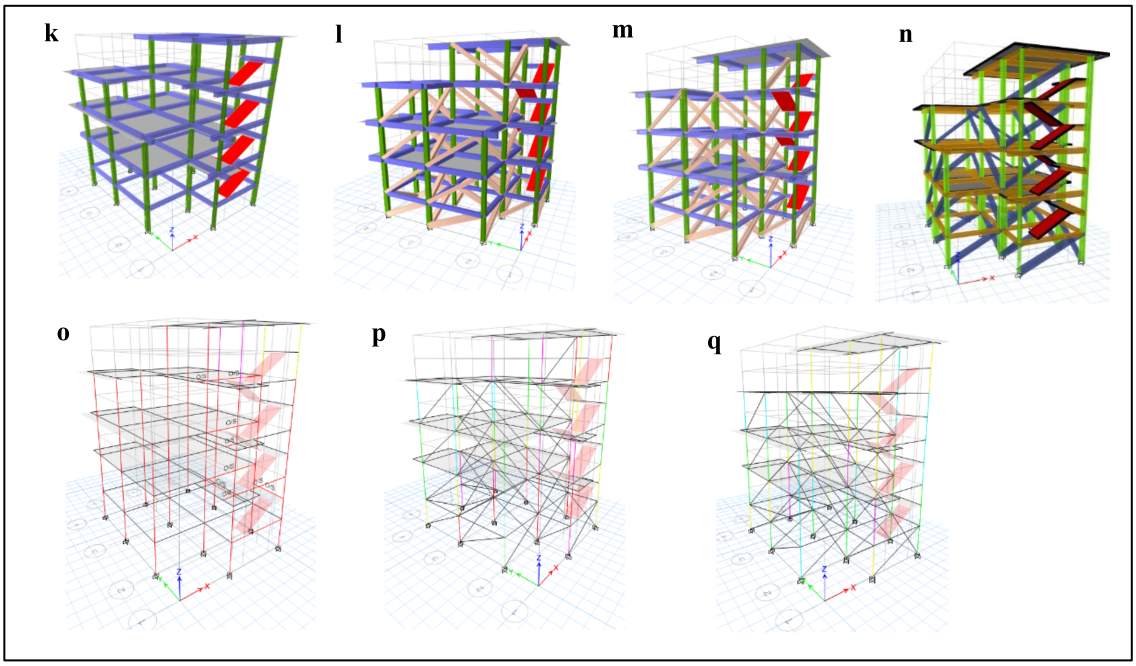


Figure 5. Structural simulation Etabs model:In bare frame (k), brick infill wall frame (l), EPS wall panel frame after energy retrofit (m),column retrofitted model (n), Failure of column and

beam member in bare frame (o), Failure of column member after energy retrofit in infill wall frame (p) and strengthen column and beam member after RC jacketing and FRP jacketing.

In this study space heating and cooling load before and after thermal simulation is compared and basic parameters base shear, story shear, story displacement and fundamental time period before and after retrofit is compared.

5. RESULTS AND DISCUSSIONS

Survey results showed that 84% of the buildings are RC framed among which 41% consist of (0.23mx0.23m) column size. 40% of the buildings were constructed in the involvement of civil engineers whereas 18% of the buildings wereowner supervised without involvement of engineers. 72% and 44% buildings were thermally discomfort in both day and night in winter and in summer respectively, which was based on the tenant's perception spending maximum time in house.Study resulted that majority of the buildings lacks the consideration of architectural aspects for energy efficiencywith passive technique as shown in Fig 6. along with structural aspects making building vulnerable to seismic excitation.76% of the building's inhabitants showed the readiness to retrofit their building for energy efficiency apart from the retrofit model and financial concerns.

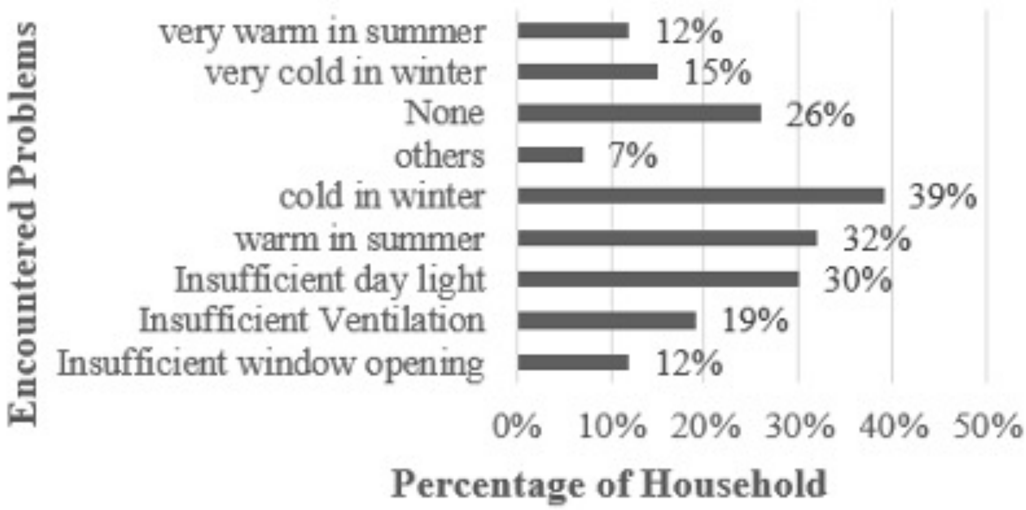


Figure 6: Architectural deficiencies encountered in buildings influencing the thermal comfort.

Ecotect simulation resulted that in top floor room, alteration with only EPS wall panel reduces the annual heating load by 11% and annual cooling load by 13%. Where with EPS panel, roof insulation, glaze window and reducing infiltration to 0.35 ach makes a significant reduction in heating and cooling energy consumption by 55%.Similarly, in second floor with ceiling insulation, glazed window and infiltration reduction cutoff the annual energy consumption for space heating by 80% and cooling by 45%. Likewise, in first floor room with ceiling insulation, glazed window and infiltration reduction, the annual heating load curtails by 82% and annual cooling load by 62% as shown in Fig 7. It signifies that passive retrofit strategy adopted in this building is much effective for reducing the heating load making building thermally comfortable in winter relatively more than the thermal comfort in summer.

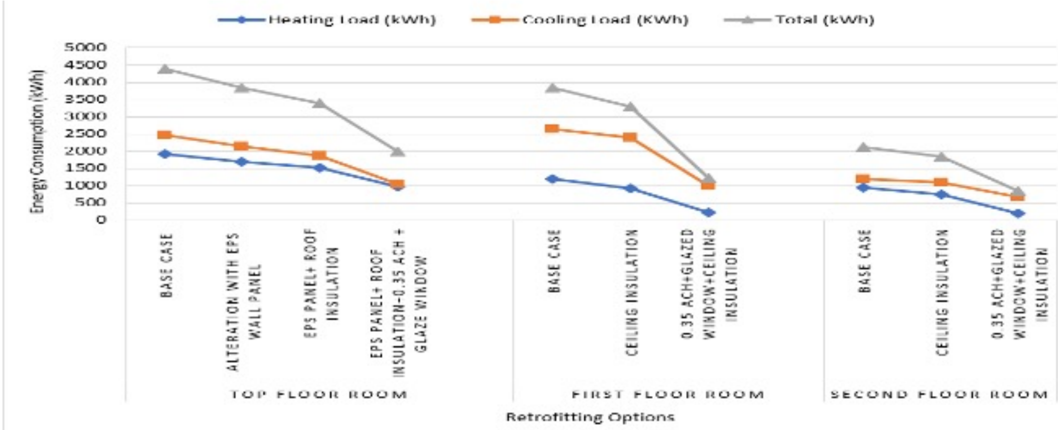


Figure 7: Comparison of annual heating and cooling load in a base case scenario with different passive techniques adopted in a building.

On strengthening the building after energy retrofit for thermal comfort, basic parameters base shear, story shear, time period and story displacement are compared as shown in Fig 8.

The time period is found highest in bare frame while least in frame after seismic retrofit. After energy retrofit with infill wall replaced by EPS panel the time period reduces to 0.48s. It showed that reducing the building weight with light weight infills makes the building mass regular and enhances the global stiffness of the building. Story shear in each floor in X-direction and Y-direction are same. The base shear is highest in bare frame and infill wall frame with value 304.189 kN. After the energy retrofit,the base shear is reduced to 294.89 kN and on strengthening the column base shear increased to 301.73 kN. It showed that decreasing heavy infill mass reduces the base shear and story shear which leads the building less susceptible to earthquakeforces attraction during earthquake excitation. In both X and Y direction, the story displacement is highest in bare frame where with infill wall it reduced tremendously. It represented that building is less stiff and is susceptible to earthquake failure in bare frame condition, where with infill walls the building stiffness increased such that building is withstanding the earthquake events without major damages. Similarly, in y-direction the story displacement in top floor with infill wall is minimum making building stiffer but after energy retrofit the stiffness decreases. It showed that infill alteration in either direction should be made stiffer to be able to withstand earthquake.

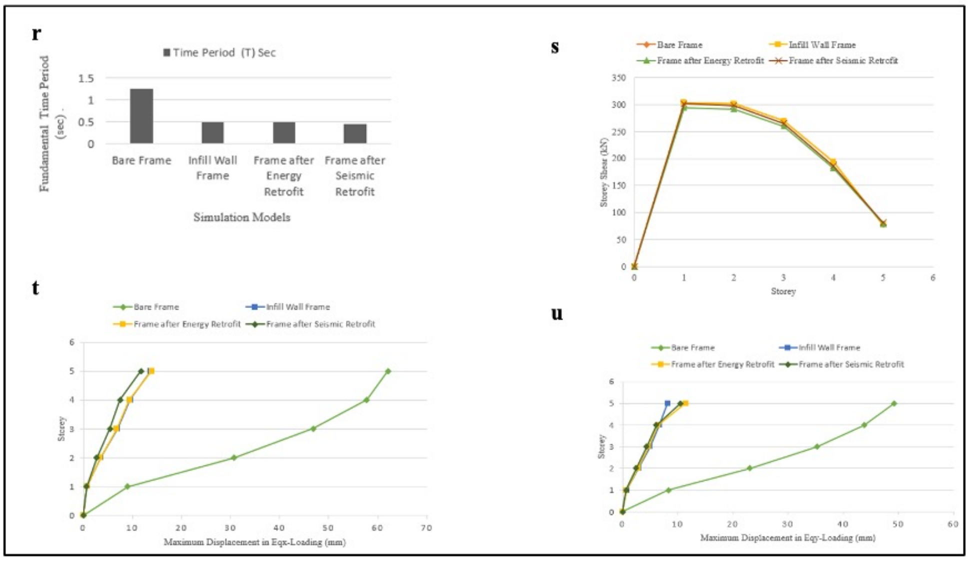


Figure 8: Comparison on fundamental time period (r), Story shear (s), Story displacement in X-direction (t), Story displacement in Y-direction(u) of all cases.

6. CONCLUSIONS

This study conducted in Budanilkantha and Tokha municipality through survey showed the inadequacy of architectural and structural features in existing building which were constructed several decades ago. Those aged buildings are still good in their serviceability function withstanding several earthquakes such as Gorkha earthquake 2015 in surging rampant urbanization but it has gone reduction in strength and several deficiencies present has made building vulnerable to future earthquake. Retrofitting for thermal comfort with passive techniques specifically with ceiling insulation, glazed windows and brick infills replaced by light weight infills enhances the overall thermal comfort of the building reducing the annual space heating and cooling load by 50% and also endorse reducing the seismic weight of building, correcting the building mass irregularities and stiffness makingless susceptible to earthquake damages. This study suggests that energy retrofit for thermal comfort with any alterations or modification incurred by infill wall mass addition or reduction in an aged building affect the building strength and performance to seismic excitation which ultimately requires strengthening to increase its strength.

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Paper number: 62

Improving Physical Properties of Gypsum Stabilized Adobe (Alker)


İbrahim BAY, Benjamin Simwanza IMUSHO

Department of Civil Engineering, European University of Lefke, 99728, Lefke, via Mersin 10, Turkey, North Cyprus
ibay@eul.edu.tr, 194134@std.eul.edu.tr

ABSTRACT

Gypsum stabilized adobe, also known as Alker (an acronym for the Turkish terms for gypsum and adobe), is a building material that combines traditional adobe with gypsum to improve the structural strength and durability of the adobe bricks. The addition of gypsum reduces water absorption and increases erosion resistance, making the bricks more suitable for usage in damp and swampy regions. Gypsum stabilized adobe has several other advantages, including being eco - friendly (has a lower environmental impact than many other building materials), shrinks by just 2% compared to typical non-stabilized clay. It is also flexible and can be moulded into different shapes, making it suitable for a wide range of architectural designs. In general Gypsum stabilised adobe is a sustainable building material that has various advantages over ordinary adobe bricks, especially in dry, arid areas. However, there are some challenges associated with using gypsum stabilized adobe, including the need for skilled labour to manufacture the bricks and the potential for higher production costs compared to traditional adobe brick. Furthermore, Alkers physical qualities fall short when compared to alternatives such as reinforced concrete. In favour of enhancing and promoting the use of Alker as a more durable option for construction, fundamental information about its physical qualities had to be investigated. Specifically, flexural, compressive, (thermal and sound) insulation, and moisture permeability properties. This was accomplished by using appropriate testing methods to determine the current properties of Alker, analysing the results to identify areas for improvement and implementing changes to improve these properties. While continuously monitoring and improving these properties over time. The overall objective is to enhance its mechanical, (thermal and sound) insulation qualities and to ensure that Alker can successfully resist moisture. Hence yielding a sustainable and cost-effective alternative for creating earthen structures that function well in a variety of situations.

Keywords: Gypsum stabilized adobe, Alker, Physical properties, Sustainable, (Thermal and Sound) insulation, Flexural, Compressive, Moisture permeability properties.

Paper number: 63

A Summer Internship in Traditional Adobe Building Construction




Aden Sena Gülüşken[1], Azize Akyıldız[2], Çağlar Nergiz[3], Rana Fidan Akman[4]
Dicle University, Diyarbakır
adensenagulusken@gmail.com,
azizeakyıldız02@gmail.com,
nergiscagla2564@gmail.com ,
ranafidanakman@gmail.com

ABSTRACT

In order to leave liveable environments to the future generations, not only durable materials are used in the building production system but also it is necessary to choose environmentally friendly, recyclable, low energy consuming and affordable materials. As it is easy, economical and requires the least energy, adobe materials is one the preferred building materials. But due to the increase in buildings that made with modern materials, adobe buildings, which is one of the traditional materials, decreasing day by day. On this regard, tendency can be increased by raising public awareness. With the required awareness raising, people learned that living in adobe buildings is healthy and they moved towards it. With the awareness raising, it is aimed to teach traditional construction stages to the architecture students during their education life. In this respect, it is important to increasing tendency towards these structures with experiencing adobe building construction during internship periods. During the internship periods construction techniques are learned more accurately through these experiences. For that purpose, the single-storey adobe structure that located on the border of the Güzel Köy Karaçalı road in the Karabaş village of Diyarbakır's Sur district, has become a sample to architecture students of Dicle University about internship experience. The traditional structure that experienced with the is-situ method, has provided a chance for hands-on training to the architecture students outside of the theoretical courses. Awareness is raised about traditional buildings by taking part students in this type of work in architectural education. And this plays an important role in transferring and disseminating these structures to the future.

Keywords: Adobe, İnternship, Experience

Paper number: 64

Keeped Alive by Children's Hands Traditional Adobe House Workshop: "Children's Adobe House Workshop" Creating sustainable living spaces for children"

Macide Işık

Bahçeşehir Kindergarten, İstanbul / Turkey

maci6262@gmail.com

ABSTRACT

Day by day, we talk more frequently about the negative conditions affecting the planet we live in, the climate crisis. Most importantly, the reason for this is that we, human beings, see themselves at the top of the ecosystem and act with the idea that resources are unlimited. To date, 108 billion people have lived on our planet and we can still use the resources of our world. Different cultures, different climatic conditions, ancient knowledge and experiences have been transferred from generation to generation through stories, myths, songs, etc., and today we continue our lives by benefiting from them. We want to be the right guide, guide and model for children to raise sustainable generations today and tomorrow and to "live in harmony with nature".

In this sense, we carry out many studies in our School. First of all, we achieve our goal of becoming a zero waste environmentally friendly school, meaning "There is no waste in nature, there is a cycle", by utilizing all the waste around us without harming nature. We produce our own garden soil and grow our own plants. We share our garden with many live animal species. We produce our drawing papers from waste papers.

. We use natural resources. We collect rainwater from the roofs and use solar energy with solar panels.

The publication of "Adobe House - Workshop", one of the natural structures that is indispensable for our living space, was the biggest of our dreams. Today, we wanted to build a natural structure for the new generation of children who watch nature from windows, between four concrete walls in huge buildings in big cities, and who have little time and are separated from nature in tiny parks.

"Tiny Adobe House" in the Natural Garden, which spreads happiness and where children can instantly step in and embrace nature, whether inside or outside.

They are earthen structures that represent the power of nature. Soil was formed by the cooperation of many living and non-living entities during its formation phase that lasted for years. The power of nature appears before us once again. Nature is invincible but renewable. Soil represents life, its breathing and its combination with this beautiful texture connect us to itself. It reminds us that we are part and parcel of nature. Because we, human beings, are a part of nature and we cannot remain separate from it.

Inside that lumpy house, children's voices, laughter, songs come to life again, because it is life itself. During the journey of the construction research process of this Workshop, he was taken to

our teacher Prof. Bilge Işık, who is an expert on very valuable mud brick houses and has a lot of knowledge and experience.

As a result of many consultation meetings, with the support of our valuable teacher, the construction of our Adobe Adobe Workshop started in 2023 and was completed in a very short time. A concrete foundation was laid on the floor of our workshop. Since the soil in our region is very clayey, we brought soil from the Istanbul Technical University campus to our school in cooperation with the Metropolitan Municipality. The soil was mixed with lime, plaster mixture and a little water, and wall molds were made using the tamping method. The wooden molds were oiled, and the soil mixture was poured in, and the soil was compacted with each stroke of the tamper. The soil in the mold was left for a few days during the drying phase. Concrete pillars were erected. The molds were removed a few days later. Perfect walls appeared. We completed our workshop in a short time by taking rapid steps.

We provided the opportunity for our children to see every step of the workshop construction phase in person and gain opportunity and experience. We gave our children the opportunity to think about the construction of such a special Adobe House, synthesize information, develop different ideas, and develop their investigative skills. When they grow up, they may find opportunities to take this knowledge further and use it in different fields.

Our Adobe House Workshop has become one of the best examples of natural structures in the Bahçeşehir Region where we live and in our country. Students from different schools and universities visit our school. We hold many events here. Our first event started with the celebration day of the abundance of our country Turkey - "Locally made" special agricultural products. With this example study, it is important to explain and teach us how we can design our own living spaces and live in harmony with nature, starting with small steps.

We want these works to inspire many people and spread synergy for a sustainable World. The world is our home. Our existence depends on his existence. We must be in harmony together. The earlier children start working on natural design, the more they develop a positive awareness of nature. When they become adults, they will respect nature and all living things, prefer to evaluate rather than throw away, and will work to prevent our world from being destroyed by human hands.

Achievements of the project:

1.To provide a different perspective in early childhood education.

2. Gaining many experiences by doing and living. To ensure active participation. Taking responsibility. Working collaboratively. Increase your sense of self-confidence.

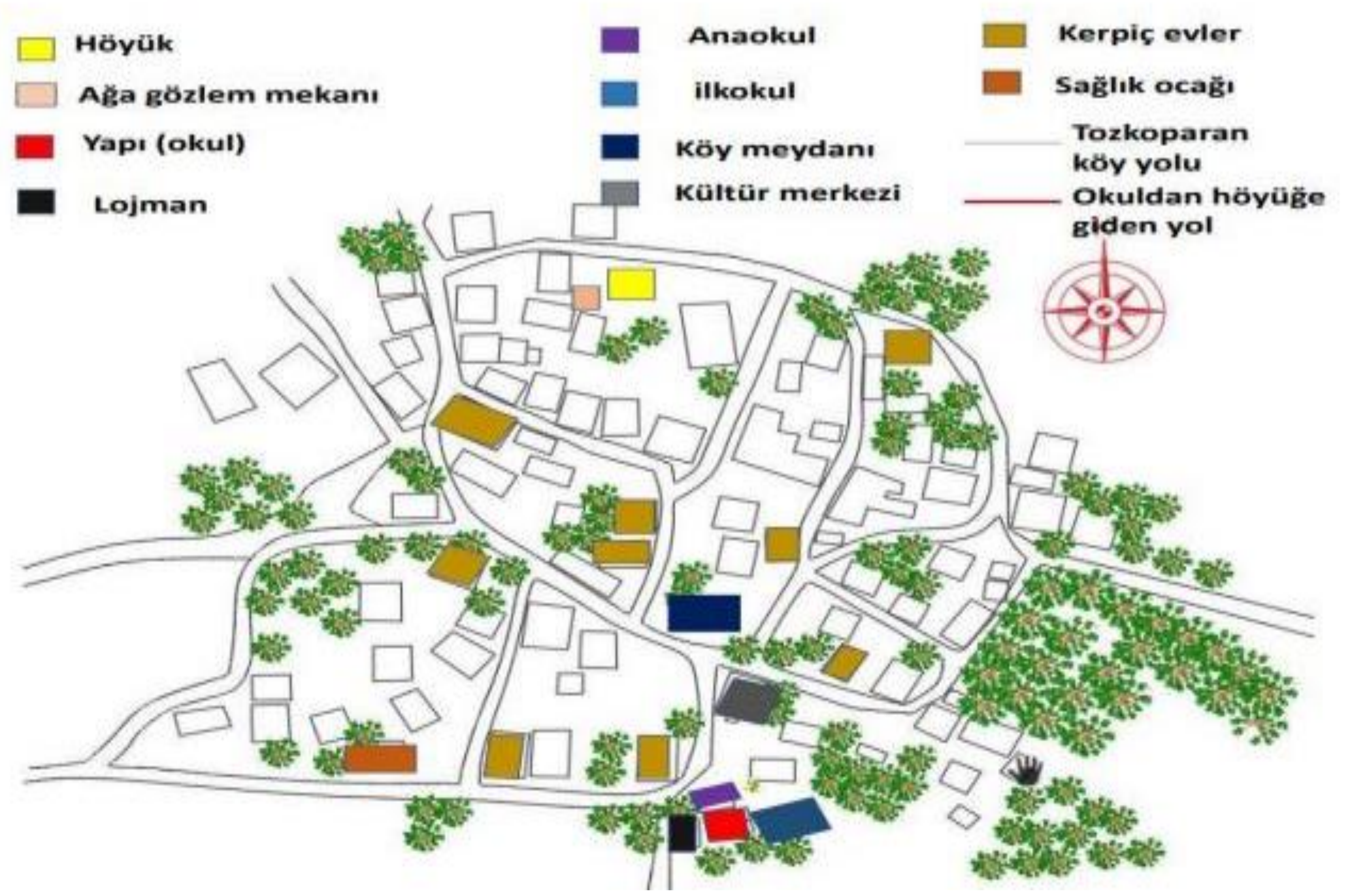
3. They learned about what nature provides us with, its importance in our lives, that soil provides food and living spaces for us, about working one-on-one with soil, and about adopting the culture of re-evaluation.

Suggestion: To carry out joint project studies with preschool and university students.

Keywords: Children's Adobe House, adobe, alker,

From Traditional Texture To Rural Design Guide: The Case Of Tunceli-Tozkoparan Village

Authors: Gizem Nur ÖZCAN, Ebru Nalan CEYLAN
Affiliation: Munzur University
City/Country: Tunceli / Turkey
E-mail: gizemgungor@munzur.edu.tr



Tozkoparan Village

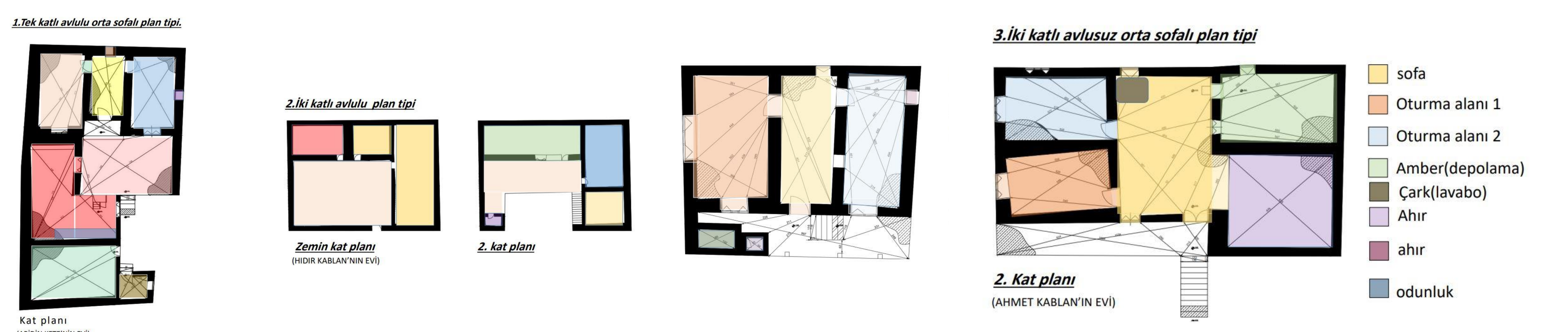
It is known that Tozkoparan village, which is connected to the Pertek district of Tunceli province, used to be an Armenian settlement. According to the verbal interviews with the people of the village; there was a landlord system in the village in the past and the people of the village mostly worked as farmhands. After the aghas sold the lands over time, the village spread from the castle, which is known as the first settlement, and reached its present area.

General Architectural Texture of the Village

The houses are concentrated on a flat area due to the topography. The general typology of the village consists of single and two-storey houses. As a result of the survey work carried out in the area;

- Single-story courtyard plan type
- Two-story courtyard plan type
- Two-story type without courtyard

Houses were analyzed in three different typologies. There is usually a central sofa at the entrance of the houses and the distribution to the rooms is provided from this area.



** These drawings and visual materials were created by Munzur University Department of Architecture students Amal Ismaeil, Deniz Ortaş and Sihem Kenan during the spring semester of the 2022-2023 academic year, under the supervision of Assistant Professor Ebru Nalan Ceylan and Research Assistant Gizem Nur Özcan within the scope of the «Rölöve II» course.*

The Importance and Potentials of Tozkoparan Village for Preparing a Rural Design Guide

- Tozkoparan has historically been one of the most populous villages in the city. Therefore, with the tradition of imece in the village, the number of shared open and closed spaces is higher than in other villages. However, today, the general decrease in the population in the city has also affected Tozkoparan.

- Tozkoparan is the only example of textured traditional architecture of this scale in the city. The village consists of mudbrick houses with yellow colored mudbrick plaster. In addition, the use of stone and mudbrick is seen together in a few buildings such as the historical school building. Tozkoparan village offers an important study area in this city where there is not enough data and studies on traditional buildings.

- There is a mound in the village where Tunceli's first scientific excavation was carried out after 1968. Excavations are still ongoing at Tozkoparan Mound, where architectural remains dating back thousands of years are found. While this situation increases the tourism potential of the village, it also reveals the necessity of conservation plan design.

POTENTIALS

- The only example of the original architectural texture that has survived to the present day in the city
- It contains the original raw material source for traditional construction systems (yellow colored soil used in mudbrick construction)
- The old adobe masons who built the buildings in the village still live in the village
- Architectural elements such as original niches, doors and windows have survived in some houses
- Tozkoparan Mound, the first scientific excavation site of the city in a long time, is located here and active excavations continue

SUGGESTIONS FOR RURAL DESIGN GUIDE FOR TOZKOPARAN VILLAGE

Rural design guidelines are a regulatory tool, particularly in relation to the preservation of the character of a place. This regulatory tool is used in the UK as the Village Design Statement, in Ireland as the Rural Design Guide and more recently as the Village Design Report (Eminağaoğlu, 2004; Çevik and Eminağaoğlu, 2005). Village Design Guides (Reports) provide detailed spatial recommendations to strengthen the rural identity of the settlement and differentiate it from other settlements. Rural design guides with different contents are planned for different geographies. General decisions for Tozkoparan village;

- **Axes to be emphasized** (street of traditional houses with courtyards between the mound and the square)
- **Centers** (village median)
- **Village-specific architectural elements** (adobe construction technique and original architectural elements such as niches and windows)
- **Landscape assets** (monumental mulberry trees)

According to these decisions;

- The general appearance of the village consists of yellow colored plastered adobe houses. This appearance adds a unique characteristic to the village. Care should be taken to preserve this characteristic in the repairs to be carried out on the houses in the village and in the new architectural structures to be built.

- According to the oral interviews with the people of the village, the yellow color of the plaster comes from the soil brought from an area above the village. The fact that this area still exists means that production can continue. By utilizing this potential, it is suggested that mudbrick workshops be organized in the village in order to both carry out repairs and revive the tradition of mudbrick production.

- During the fieldwork conducted in the village, it was observed that the mudbrick masons of advanced age still live in this village. The mudbrick production workshops to be organized with the participation of these masters will contribute both to the revitalization of the tradition of imece in the village and to the realization of a production that is about to be forgotten within the scope of "sustaining cultural heritage".

- It is suggested that the village square be used as an open space for adobe production activities and the historic primary school building in the village be restored and used as a closed space.

- It is also suggested that the historic primary school building could be used to host events such as exhibitions of traditional productions in the village (such as cacim, basket weaving techniques), especially during the summer season when tourism is lively, and meetings related to the mound in the village.

- The mound is not only important for the city of Tunceli but also for the village of Tozkoparan. This potential should be included in the conservation plan. In this context, with the idea that the road from the square in the center of the village to Tozkoparan Mound will be a promotional feature for the village; this road is proposed as a cultural walking route for the village. In this context, an information board indicating the routes to be followed should be placed at the entrance of the village.

Abstract

Although there are documented traditional mudbrick structures and many academic studies in cities such as Elazig and Malatya, which are close to the province of Tunceli, there are not enough field studies on this subject in Tunceli. This study focuses on the lack of work in the city on the subject and focuses on the production of adobe and the use of adobe in buildings in Tozkoparan Village of Pertek district of Tunceli province.

In the city where traditional buildings are quite scattered, Tozkoparan village creates a unique texture with its earth plastered mudbrick structures. The village was chosen as the study area because of this feature. The plaster of adobe houses was obtained using a yellow soil type from a nearby area. The houses plastered with this soil exhibit a characteristic appearance in the color specific to the area.

According to the oral interviews with the local people, the settlement in the village first started with a castle located at the foot of the mountain. After the destruction of the castle, the settlement area moved towards the lower levels. The mudbrick masters in the village built the houses with traditional adobe production using adobe blocks 30 cm & 15 cm (analı-kuzulu). Generally, masonry construction system and mixed system were used in the residences in the area. The lower floors of the houses, which were mostly built as two floors, were used for sheltering and storing animals. On the upper floor are the living areas. In addition, houses with a courtyard plan scheme, which is not a common type of plan in Tunceli, were also identified in the area.

Taking inventories of the mudbrick structures in the area is very important for the city of Tunceli, where there is not enough detection work and study about traditional construction systems. After this inventory study, it is aimed to develop conservation plans for the area. While this planning is being made, Tozkoparan Mound, which is still under excavation, will shed light on the past of the region and has a 5500-year history according to current information, will also be considered as an important potential. In addition, it is foreseen that the information to be obtained from this inventory study can be used as a base for the creation of a rural design guide for this city where ecological life is at the forefront.

KAYNAKLAR

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The aim of the conference is to gather the findings and knowledge regarding the theme **"Gain Information from the Traditional Earthen Architecture"** and transfer these to the new generation.

Since 1978, Kerpic Network has been conducting research on seismic response and comtemporary production techniques of earthen construction. The durability research is based on gypsum 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. Bilge IŞIK

Dicle University
www.dicle.edu.tr

DICLE UNIVERSİTY FACULTY OF ARCHITECTURE

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DICLE UNIVERSITY FACULTY OF ARCHITECTURE
DİYARBAKIR BÜYÜKŞEHİR BELEDİYESİ
T.C. SUR BELEDİYE BAŞKANLIĞI
HANCI
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